USE OF THESES

This copy is supplied for purposes of private study and research only. Passages from the thesis may not be copied or closely paraphrased without the written consent of the author.
LIST OF ERRATA

Page 6, line 28, delete 'consideration of the'
Page 12, line 15, for 'perennially' read 'perennially'
Page 37, line 2, for 'its' read 'their'
Page 48, line 20, for 'when labourers are paid $20.0 per bushel, actual wage costs...', read 'when labourers are paid $20.0 and 60 bushels in kind for per year and the market price of rye is $2.0 per bushel, actual wage costs...'
Page 75, line 8, for 'terms situation and intensity rents' read 'terms of situation and intensity rents'
Page 93, line 12, for 'description' read 'depreciation'
     line 13, for '(C-F)' read '(C-D)'
     line 15, after 'Capital and Management Income' add '(F-E-F)'

Note: Throughout the thesis, terms such as Net Farm Income, Cash Income, and Net Cash Income have specific technical meanings following the work of the Bureau of Agricultural Economics. Definitions are given in The Northern Territory Beef Cattle Industry; an economic survey, BAE, Canberra, 1968.

Page 143, line 5, for 'that' read 'than'
Page 171, line 36, for 'Growth' read 'Growth'
Page 294, Graphs A and B, ignore right-hand axes.
Page 298, line 4, for 'integration' read 'integration'
Page 303, line 18, for 'uncertainty' read 'uncertainty'
Page 341, line 31, for 'Creek' read 'Creek'
Page 362, line 2, for 'ACCESSIBILITY' read 'ACCESSIBILITY'
Page 369, line 18, for 'had' read 'and'
Page 413, line 29, for 'atypical' read 'atypical'
ACCESSIBILITY, TRANSPORTATION AND LAND DEVELOPMENT

COMPLEMENTARITY AND LOCATION RENT ADJUSTMENT IN THE NORTHERN TERRITORY BEEF CATTLE INDUSTRY

J.K. Johnson

Thesis submitted in partial fulfilment of the requirements of the degree of Doctor of Philosophy at the Australian National University, October 1970.
This thesis is dedicated to the memory of my father
Horace Darlington; a good farmer and a fine example -- he
loved the land.
Except where otherwise acknowledged in the text, this thesis represents the original research of the author.

J.K. Johnson

J.K. Johnson.
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Betty Parkes typed the manuscript very ably. Carene Klintworth gave tea and understanding. There are many other people who deserve my thanks and I hope that they will not be offended by the want of a specific mention. To forestall comment, I should state that I have driven well over 9,000 miles in remote parts of the Northern Territory on all categories of road. Any inadequacies in the thesis are, of course, mine.
CONVENTIONS

Certain terms may be unfamiliar to readers with an urban background. Among these are 'turn-off' (annual cattle production), 'scrub bulls' (uncastrated wild males), 'weaners' (seven to ten month old stores), and 'boners' (unfinished cattle which are nevertheless suitable for manufacturing beef). Other usages are introduced in the text. The names of the following organisations have been abbreviated: Northern Territory Administration (NTA); Northern Territory Administration Animal Industry Branch [since 1966, the Northern Territory Administration Animal Industry and Agriculture Branch] (NTAAIB); Commonwealth Scientific and Industrial Research Organization (CSIRO); Bureau of Agricultural Economics (BAE); Australian and New Zealand Association for the Advancement of Science (ANZAAS). First references in each chapter are given in full; second references are shortened.
PART 1

THE STUDY PROBLEM
CHAPTER 1

ACCESSIBILITY AND THE DEVELOPMENT OF THE BEEF INDUSTRY IN THE NORTHERN TERRITORY

When the [195] Summer School of the Australian Institute of Political Science discussed the subject 'How Shall We Develop Northern Australia?', there was unanimity of agreement between men most knowledgeable in this field that ... transport is the key to the development of Northern Australia.

Bell in *Australia's Transport Crisis*

The question to be answered is not whether transport is important or more important than something else, but rather in what circumstances and on what basis the supply of this ingredient of economic progress is critical.

Owen, *Strategy for Mobility*

INTRODUCTION

Investment in transport improvements is a major item of public expenditure in most states. Much of this spending is undertaken in the belief that, in addition to meeting a demand for transportation, it will generate secondary or complementary benefits through the adjustment of production activities. The likelihood of complementarity has led to particular emphasis on the transport sector in underdeveloped regions and countries though there is little reliable evidence on the magnitude of this effect in individual cases. This thesis attempts to examine some aspects of this problem by relating variations in the cost and efficiency of transport to the intensity and profitability of pastoral land-use in the Northern Territory of Australia. Here government spending has been directed to the expansion of the cattle industry and since 1961 about $30 million has been allocated for the
upgrading of 1,600 miles of road under the Beef Roads Programme. The size of this expenditure makes it desirable to consider whether resources are being deployed in an efficacious manner from the viewpoint of national welfare, while the policy of concentrating on a single industry as part of the wider national aim of developing northern Australia makes the Programme an interesting example of both sector and regional planning. Hence, it is hoped that this study, which looks at the relationship between transportation and land development before and during the process of change, will provide empirical and methodological insights which may assist in the formulation of public policy in a broad range of situations.

The relative importance of public and private investment in transport at the national scale can be judged from the following statistics. The average proportion of gross investment devoted to transport and communications in five European states in the post-war era varied from seventeen to thirty per cent.1 Data for the decade from 1950 to 1960 show that planned spending in this field in sixteen developing nations absorbed between twelve and forty-six per cent of total government expenditure.2 As a rule of thumb, transportation facilities take twenty to twenty-five per cent of total investment in countries of differing structure at all stages of development.3 In Australia in 1966-67 public authorities committed $931 million to new capital assets in transportation and communications (over forty-three per cent of their expenditure on new facilities of all types).4 These comparisons illustrate that the total resources used in this sector are

3 Tinbergen, J., 1958, p.31.
large and that over-investment may inhibit the expansion of industry by depriving new ventures of funds. It is also apparent that since much of spending is government controlled opportunities exist for planning without direct intervention in private enterprise. The allocation of public finance in this sector has two main dimensions; choices must be made between different modes, and decisions must be taken about the geographical distribution of new facilities. In Australia about half the annual expenditure on transport and communications by the Commonwealth and the States is devoted to road construction ($479 million in 1966-67). The distribution of the Commonwealth grant for roads was revised in favour of urban areas by the Commonwealth Aid Roads Act 1969, but this specified that at least thirty-three per cent of the aid should be used on non-arterial rural roads. Thus public investment in rural road improvements constitutes an important part of the pattern of expenditure in Australia and research on the complementarity effects of this spending is of wide interest. It is in this context that this study must be placed.

The problem is to assess the role of transportation in the past and future development of the Northern Territory beef industry. This thesis takes a wide view of the influence of transport technology and the cost of marketing stock on the form and scale of production at the enterprise level. Since the relative importance of the characteristics of different modes and the absolute importance of total payments for transport vary with the demand for cattle, it has been found necessary to consider the range of factors that contribute to consignment decisions. This has been done by defining a model of farm 'accessibility', which is introduced in the final section of this chapter. To isolate the impact of variations in this quality on production certain concepts from classical location theory have been adapted and refined.

Von Thünen's work showed how location rents arise through agricultural adjustment under simple assumptions about cultivation and trade. This study makes use of this theoretical background in the empirical work which examines the pattern of output in the beef industry in particular years, and distinguishes 'situation' and 'intensity rent' components. It is also possible to examine the problem by tracing the role of accessibility in development over time and in this case it has been found useful to define three production states -- the 'existing', 'immediate', and 'attainable' levels of response to improvements in the comparative locational advantages of holdings. These terms are defined at the appropriate points in the argument and have been introduced at this stage to assist in the description of the form of the thesis. It is therefore hoped that the work contributes to an understanding of the relationship between improvements in transport and the generation of economic activity in two ways -- both through the presentation of the results of the case study and through the development and application of certain aspects of location theory.

The thesis is divided into four parts. The first, which consists of this chapter alone, looks at the Northern Territory as a transport region. The physical environment and the history of the development of pastoralism and transportation are described to provide a setting for the empirical work that follows, which is restricted to a consideration of beef production between 1950 and 1967 and the assessment of emerging and potential developments from the latter date. The discussion of the limitations on mobility and trade up to 1950 also allows the identification and illustration of the components of property accessibility and this leads to the formulation of a general model of this attribute. Part 2, consisting of Chapters 2 to 5, examines the pattern of trade and production in the study industry to assess how far producers adjust their consignment and resources use decisions to take account of differences in comparative locational advantages. Chapter 2 introduces the theory of the generation of situation and intensity
rents and looks at the characteristics of the beef industry in the Territory to point up deviations from the constraints of von Thünen's Isolated State. This gives a background to the economic organisation of production and the problems that are met in processing output and survey data. In addition, the chapter lays the foundation for an evaluation of the importance of location rents in modern agriculture, and the utility of the concepts of spatial equilibrium in exchange and resource use in research.

Chapters 3 and 4 share a common structure and are concerned with the roles of rate payments for transport and net received prices for fatstock in the allocation and supply of beef cattle. Chapter 3 covers the period from 1950 to 1960 with 1957 being taken as a representative year for the decade. Turn-off data for this season is used in empirical work which attempts to measure the degree of adjustment in the industry to these two basic surrogates of accessibility. The actual consignment pattern is compared to a normative solution generated by the Transportation Problem, which provides a total least-cost definition of supply areas under linear programming constraints. This gives some insights into the behaviour of producers and buyers and the importance of the various components of total transport costs. In 1957 over ninety per cent of all movements of cattle in the Northern Territory to railheads and meatworks were made on-the-hoof. The incidence of deterioration losses on droving mobs and the impossibility of transporting various types of stock by this mode circumscribed the opportunities of producers in exchange and thus conditioned the form of station enterprises. Since the availability of markets and the quality of transport remained relatively unchanged between 1945 and 1957, the study year is taken to exemplify the adjustment of the industry to the traditional allocation pattern, in an era when differences in locational advantages were particularly important. The impact of accessibility on production scale is explored by correlation and multiple regression techniques to test the relative importance of this factor, but the
paucity of data precludes a more detailed analysis. However, the results of the work do provide a point of reference for the evaluation of similar tests on turn-off statistics for later years.

Chapter 4 examines the importance of accessibility to producers between 1960 and 1967. In this period marketing opportunities changed dramatically as a result of a general rise in cattle prices due to a strong United States demand for boner-beef, the opening of two processing plants in the Northern Territory, and the adoption of road transport. Detailed turn-off data for the 1966 season are used in an analysis of the actual pattern of exchange under the new conditions. Emphasis is placed on the role of rate payments and net receipts for slaughter stock in consignment, and the structure of marginal returns at the intersection of supply area boundaries is compared to the structure given by a total least-cost solution. This allows some conclusions to be drawn on the probability of spatial price equilibrium appearing in reality. Correlation and multiple regression techniques are employed in a search for production scale adjustment to variations in accessibility following the format established in Chapter 3. However, data are available for the five calendar years from 1963 through 1967 which permits further deductions on the effects of seasonal variations on the pattern of supply. Information from a survey of 72 stations for 1962-63 to 1964-65 by the Bureau of Agricultural Economics (BAE) is used to consider the relationship between location and resource use. Parameters of average enterprise expenditure and income per unit of area are tabulated by rate payment and farmgate price zones in a search for spatial regularities. This leads to some specific conclusions on the role of variations in accessibility in determining the intensity and profitability of land-use in the study industry, and permits a more general appreciation of the utility and assumptions of location rent theory.

Chapter 5 looks at developments in trading, transport usage, and production between 1950 and 1967. The work
considers some of the non-spatial determinants of processing capacity, modal choice, and production scale to link the studies given in Chapters 3 and 4 and to set the location rent adjustment process in the wider context of response to economic and technical change. The first section looks at the efficiency of marketing in the Northern Territory. This involves an examination of public and private enterprise in the provision of meatworks capacity and an analysis of some of the institutional and behavioural constraints on exchange. Some of the findings help to explain deviations from a theoretical spatial equilibrium. The middle section deals with the diffusion of the use of road transport to see whether consignors tried to minimise rate payments or maximise receipts when they chose between modes. It also bridges the gap between the studies of unimodal movements under droving in 1957 and road transport in 1966. The final section takes up a number of issues relating to the flexibility of output in the beef industry in the presence of variations in prices. The input structure of cattle enterprises is examined (using the BAE data) to cast light on the form of the industry production function and a multiple regression model is presented which demonstrates the importance of land quality, and capital and labour usage in determining the intensity of land-use. In summary, Part 2 is concerned with the relation between the theory of adjustment to spatial equilibria in exchange and production and the evidence of response to variations in accessibility among the enterprises of the study industry.

Part 3, which consists of Chapters 6 and 7, marks a break in the scale and reference of the empirical work. It is primarily concerned with the evaluation of the observable and potential responses of producers to the introduction of road transport and the provision of improved roads. Chapter 6 reviews the theory of road investment benefits and explores the common ground between spatial equilibrium models and the assumptions behind benefit-cost analyses of developmental road projects. The origins and official justification for the Beef Roads Programme are described and the relationship
between surface standards and road use is considered. This lays the foundation for the succeeding empirical work which looks at the impact of localised changes in transport costs on production. The adoption of road haulage for consignments permits the realisation of a range of external economies in the beef industry and the remainder of Chapter 6 is devoted to an assessment of the short-run or immediate advantages of modal change. The magnitude of the financial gains from this source is estimated from an examination of the structure and value of turn-off in 1966. At this stage the role of road improvement is disregarded and the gains are visualised as a complementary effect of innovation in transportation.

Chapter 7 is directly concerned with the evaluation of the future benefits of the Beef Roads Programme. The long-term gains that could accrue from the expansion of beef production in the study region are reviewed by considering the present structure of net returns and the physical and economic limitations on intensifying land-use. Two sub-regional case studies are then presented which demonstrate the need to scale road expenditure against the net increase in income that follows the deployment of additional resources on holdings. Optimistic and pessimistic sets of assumptions are used in a series of formal benefit-cost analyses and an attempt is made to distinguish the role of road quality in promoting adjustment. The final section of the chapter takes a wide view of the reasons for private and public interest in land development in the Northern Territory to explain some apparent anomalies in resource use. This leads to a concluding discussion on the influence of factors which lie outside the traditional theory of supply response in farm firms and the consideration of the aims of public expenditure on roads in northern Australia. Of necessity this involves a brief examination of the alternatives that are available for the expansion of beef production outside the area affected by the Programme.

The fourth and final part of the thesis, Chapter 8, synthesises the findings of the empirical work and refers back to the concepts of spatial equilibrium in exchange
and production. The conclusions are arranged in three sets. The first summarises the evidence for short-term or immediate adjustments in consignment and output to minimise total transport costs or maximise marginal revenue. These may be visualised as gains in situation rents. The second set contains the conclusions which can be drawn on attainable shifts in intensity rents and this permits some general inferences on the capacity of transport improvements to generate economic activity. Finally some of the findings are used to illustrate alternative methods of tackling the problem of poor accessibility. This suggests possible productive outlets for some of the funds that were allocated for the Beef Roads Programme and confirms the validity of Owen’s observation that

Instead of planning transport in isolation a systems approach to agricultural development is essential to link transport policy with the goals that transport is called upon to serve... 1

The remainder of this chapter is concerned with the physical constraints on mobility in the Northern Territory, and the historical development of pastoralism and its relationship to the provision of transport facilities. The discussion of the physical environment indicates that surface conditions are relatively homogeneous over vast areas which means that empirical procedures based on classical location theory might generate evidence of spatial regularities in response to distance. The description of the growth of the cattle industry between 1873 and 1950 and its developmental problems shows that poor accessibility has been repeatedly blamed for its slow expansion, though government aid in this field was restricted and selective. In addition, a brief survey of planning recommendations made during the administration of the Territory by the Commonwealth exposes a widespread belief that transport was the key to land development. However, few of the proposals were put into operation so that at the start of the study period

1 Owen, W., Distance and Development, Washington D.C., 1968, p.73.
transportation and marketing conditions had remained relatively static for decades. This makes the evidence for adjustment in 1957 particularly interesting, while the dramatic changes that have taken place since then allow a detailed appreciation of the role of improvements in accessibility in promoting more intensive land-use.

A. ACCESSIBILITY, SETTLEMENT, AND DEVELOPMENT

1. Physical accessibility

In a simple system it is possible to isolate the influence of single variables and observe how they contribute to the processes and forms of the whole. Ideally, the role of transport costs in determining the pattern of production of an agricultural crop could be examined in a case study where the conditions of production and movement were uniform. This would allow the problem to be recast in terms of the impact of distance on land-use in a homogeneous cultural environment. In reality, a multiplicity of influences obscure the operation of individual factors. Among these is the fact that commodity transfers are constrained by natural barriers, network characteristics, and the form of transportation. The study industry is no exception, but it has many features which make it reasonable to assume that processes and forms should be more obviously apparent. This section considers the influence of 'physical accessibility' on the movement of stock and goods in the Northern Territory, by the means of transportation that are currently available.

According to Lewis

Accessibility is a resource in the sense that it stems from geographical features - the surface layout of the country, its rivers, its access to the sea, the quantity and quality of its harbours and the presence or absence of impassable barriers such as high mountains, deserts or impenetrable jungle between the country and the rest of the civilised world.¹

These physical attributes condition the use of the five major forms of transport (rail, road, air, sea, and cross country) for the movement of cattle and beef. Though there are examples of the use of all of these techniques in northern Australia, two modes were of particular importance for internal transfers in the Northern Territory between 1950 and 1966. These are droving -- a cross country form, and road haulage. Hence, the brief descriptions which follow of the characteristics of the physiographic regions of the Territory will emphasise those aspects that inhibit on-the-hoof and wheeled movements. For convenience the data will be organised, in part, by the four Pastoral Districts recognised by the Northern Territory Administration (NTA) each of which is separated from the other by large areas of country not suitable for production. Each of these four districts has its own distinctive class of country and each has its own special problems of development and communications.¹

These will be grouped into two classes according to the distribution of rainfall and rugged relief.

a. The Humid Dissected Margin

The greater part of the Northern Territory is an undulating plain that can be termed the Main Plateau.² In the north this feature is terminated by a broad arc of country which stretches between the coast and the western and eastern boundaries at 18° South and 19° South respectively.

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This may be termed the dissected margin, and corresponds broadly to that portion of the Territory that receives more than 20 inches of rain per year (rainfall information is given on Map 2.2). It contains the greater part of the Victoria River and Darwin and Gulf Pastoral Districts, which share several important attributes. Both Districts have access to the sea and control the 1,040 miles of coastline in the Northern Territory. There are few good natural harbours along this shore, which is formed, in the main, of low-lying and seasonally flooded terrain. Broken ranges reach the sea in the north and west and have created ria-like basins in some instances. Darwin harbour provides the main example and has been important as an origin of settlement and a window on the rest of the world from the earliest days. Behind the coast, perennially flooded plains stretch inland for an average depth of 40 miles, and consist of landforms derived from the current Koolpinya series of cycles of erosion. Much of the area is below 200 feet and its vegetation grades with the rise in relief from bare salt flats and dunes to a dense growth of drought evading plants, including reeds and wild rice. The obvious difficulty of movement and the poor nutritive value of the unimproved pastures of the area have prevented entry by the cattle industry, and its swamps remain the haunt of feral buffaloes. Behind this zone, discussion of the features of the dissected margin can be given in terms of Pastoral Districts.

(i) The Darwin and Gulf District

Two sub-regions can be usefully distinguished in this District. The main division consists of rugged country, which stretches through Arnhem Land and follows the line of the Gulf of Carpentaria. The areas of gentler relief are covered by eucalypt open forests, while the vegetation of the remainder is extremely variable but is dominated by tree species. The natural pastures of the sub-region are characterised by three-awned spear grass associations which provide poor stock feed, and the area has remained unoccupied until recent years. Physical difficulties in
controlling cattle and building roads have contributed further detractions but these have been partially offset by the high rainfall of the area which may permit development with improved pastures. The valleys of the Roper and McArthur Rivers form something of an exception in that they contain pockets of better land, and give access to the sea, though the Gulf of Carpentaria offers no natural harbours. In the early period of settlement the lower fringes of this country and the Roper Valley were used as a route for stock movements on-the-hoof, being preferred to the relatively waterless Barkly Tableland for the trip from Queensland to the Victoria River District.

The second sub-region, the Top End, consists of the area north of a line drawn between the mouths of the Victoria and Roper Rivers, and west of the Arnhem Land Aboriginal Reserve. It contains a core which can be included in the Koolpinya land surface and this is occupied by the Daly River. Eucalypt woodland predominates, with kangaroo grass and perennial sorghum pasture species. This area is also known as the Tipperary Land System and offers potential for agriculture. Its pasture resources have been under-utilised through low stocking, but better knowledge of grazing response has prompted a re-evaluation. Sown pastures may also be important here in the future. To the east of this core lies a tongue of dissected country which stretches between Darwin and the northern apex of the arc of the Main Plateau. This has provided an important corridor of entry and is followed by the Stuart Highway and the Darwin to Larrimah railway. Its value lies in the avoidance of inundation in the Wet Season since rainfall increases in the Top End from 30 inches to 55 inches per year between Katherine and Darwin. Katherine is strategically located at its junction with the plateau edge.

(ii) The Victoria River District

The Victoria River Pastoral District contains the whole of the long-settled lands of the eastern part of the basin of the Ord River and the drainage net of the Victoria,
together with adjacent areas of the Main Plateau. In the east the separation is marked by the Murrainji Jump Up scarp. Within the well-watered core area, the overlapping of erosion surfaces in the Koolpinyah, Wave Hill, and Tennant Creek major cycles has created a landscape of broken plains and ranges. On the better higher-rainfall upland country open eucalypt woodlands dominate and pastures are mainly composed of kangaroo grass and perennial sorghum. A central area is covered by low tree species with short grasses and forbs on red earths or calcareous soils. The southern fringe consists of fingers of Mitchell grass country on heavy clay soils, broken by ridges of the Main Plateau which are covered by soft spinifex on sandy red soils. The presence of permanent water in many parts of the core area stimulated early settlement and made droving easy within the occupied lands, but stretches of rough poor country separate it from the other Districts and egress via Wyndham or Katherine. The relatively high rainfall and the need to cross major streams make road construction costly, and this has been accentuated by a tendency for the roads to follow stockroutes which must be planned to pick up the maximum number of watering points. There is a marked contrast in movement by wheeled vehicles on the black and red soils of the sub-region. The former give a good dry-weather surface but rapidly become impassable after rain, while the latter provide rougher all-weather surfaces. The large estuary of the Victoria has prompted plans to introduce barge transportation for cattle and station stores but none of these has come to fruition. In the remaining parts of the District the land is virtually unusable, though there has been some recent development of properties on the three-awned spear grass and kangaroo grass pastures south of Katherine. However, the greater part of the Plateau area is unoccupied and is covered by spinifex which predominates throughout the Tanami Desert.

b. The Main Plateau

The northern edge of the Main Plateau is the drainage divide between exoreic and endoreic streams. The latter are intermittent and rarely become barriers to movement. Many of the features of the landscapes of the plateau result from its arid climate and its stable geological history. Long periods of erosion and the rare incursion of shallow transgressive seas have produced a series of bare or mantled plains separated by retreating surface edges and the terrain is homogeneous over wide areas. Generally, this provides easy land access, though the absence of surface water poses difficulties in the provision of permanent ways. Perhaps the main feature which inhibits movement is the vastness of the country, for

To the east she’s bound by the Aurora Australis, on the west by the Day O’Judgement, and if your eyes don’t get sore with the glare you’ll see away for ever.

The surface features of the Plateau can be described conveniently in terms of the boundaries of the two remaining Pastoral Districts.

(i) The Barkly Tableland District

The Barkly Tableland District contains the whole of the Northern Territory portion of the Barkly Tableland proper. The latter is an area of open plains country that stretches 300 miles from the Queensland border in a northwesterly direction and varies from 100 to 200 miles in width. Its black soils (formed on highly calcareous or igneous rocks, or alluvia derived from these) support a vegetational cover of perennial Mitchell grass and drought-evading short grasses and forbs, of which Flinders grass is the chief. Although this provides good pasture the lack of reliable natural watering points has been a persistent problem. Fortunately, the underlying Daly Barkly Artesian Basin

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1 Anon, quoted in 'Some Impressions of the Northern Territory', by Farwell, G., in The Northern Territory, Sydney, 1949, p.22.
provided a solution, and bores opened the area to secure pastoral occupation. To the east, the plains merge with broken flood courses of the streams in the Queensland Channel Country, and access for stock on-the-hoof has traditionally been via the Georgina River. The presence of black soils makes Wet Season movement difficult and the absence of supplies of gravel adds to the cost of stabilising roads.

This surface type is separated from the dissected margin of the Plateau in the north by a band of broken country which is covered by low eucalypt woodland, with three-awned spear grass pasture associations. In the west the Tableland is bounded by a ridge that cuts it off from Lake Woods. This line is followed by the Stuart Highway and forms an important section of the main north-south communication axis. South of the plains there is a relatively small area of semi-desert that has remained unoccupied, though its surface advantages were exploited in the construction of the east-west Barkly Highway.

(ii) The Alice Springs District

The usable pasturelands of the Alice Springs District are contained, in the main, within a radius of 200 miles from the town of Alice Springs. In the east the Sandy River provides a linking corridor to the southern part of the Barkly Tableland, and to the south the pastoral country is continued across the South Australian border. Exploration, settlement and major transport lines, including the Port Augusta to Alice Springs railway, have followed the stretch of passable but poor country which skirts the Simpson Desert and the Lake Eyre Basin and links the Northern Territory to South Australia. On the remainder of the circumference, the usable land fades into soft spinifex plains, hard spinifex sand plains, and dune fields, though a narrow finger connects the area to the western Barkly Tableland to continue the north-south route (general locational information is given on Map 1.1 in the final section of this chapter).
Annual rainfall in the central core varies from 6 to 12 inches, but the presence of the linear ridges and associated flood and outwash plains of the McDonnell Ranges offers an ameliorating influence and pockets of good pastoral land occur relatively frequently. These are covered by low woodlands in which Acacia species predominate, providing edible topfeed for cattle. Short grasses flourish after summer rains and forbs follow winter storms. Despite isolated areas of rugged terrain, surface movement is comparatively easy on the intersecting open plains. Gaps eroded by antecedent streams give communication through the west-east ridge lines and rock-based roads can be provided. Movements of cattle on-the-hoof have been made more difficult by the wide spacing of permanent natural waters, but artesian supplies have relieved this problem. Alice Springs is the focal point of the District and historical factors have strengthened natural links to South Australia.

From this brief review of the surface characteristics of the Northern Territory it is apparent that it does not offer a homogeneous media for transportation. Nevertheless, roads and stockroutes can be provided over large areas at a relatively small cost and movement within the occupied pastoral country of each District is not inhibited by insuperable barriers. On-the-hoof trips between Districts are hindered by bands of poor country, but linking corridors exist in many cases. Further, distance dominates mobility considerations and generally outweighs the influence of variations in surface quality. All in all it is reasonable to consider the Territory as one transport region, within which variations in rate payments for transportation services under one mode will adequately reflect the real costs of movement. In this respect it comes near to the assumptions made in classical location theory.
2. Settlement, development, and transport policy

a. Early developments: 1824 to 1911

The first British settlement in the Northern Territory was established at Port Dundas on Melville Island in 1824 but the project was abandoned in 1829.¹ Nine years later the Port Essington settlement was founded but this venture also failed to attract an entrepôt trade or stimulate the exploration of the interior, and the garrison was withdrawn. These early attempts at settlement from the north coast proved that tropical crops could be grown successfully and led to a clear statement of the necessary conditions for the economic development of Northern Territory land: a public servant commented in 1843

It is not enough for the purposes of commerce to know that a certain plant has flourished in a garden, or has grown spontaneously in particular localities. The questions are whether over large tracts of country it can be raised for the protection of the capitalists, and by means of labour not dear in proportion to that of other places producing the same commodity, and moreover capable of being brought to sale of that quality and condition which the established markets of the world require.²

The economic history of the Territory demonstrates the persistent failure of private and public enterprise in this field because comparative disadvantages were ignored. It


²Correspondence Relative to the Establishment of a Settlement at Port Essington, House of Commons, 27 March 1847, quoted by Parsons, R.A., The Truth about the Northern Territory, Adelaide, 1907.
may be that current planning is also based on a relatively parochial appreciation of opportunities.

The first successful landward entry was made by Leichhardt who reached Port Essington from Brisbane in 1845, and in 1862 Stuart crossed the continent from Adelaide. The three early lines of penetration -- from the north coast, Queensland, and South Australia, have remained the only viable routes for trade to the present day. In 1863 South Australia secured the annexation of the Northern Territory, which it retained up to its transfer to the Commonwealth in 1911.

The completion of the Overland Telegraph Line from Adelaide to Darwin (then known as Palmerston) in 1870, and the gradual expansion of pastoral occupation in South Australia and Queensland led to a land boom and, by 1881, leases had been granted covering about ninety-five per cent of the 520,000 square miles of the Territory. The first properties to be stocked with cattle were Owen Springs (1873) and Undoolya (1876) using the route from South Australia. Although the north-south link was used for some epic droving trips, most of the effective stocking was accomplished via Queensland. By 1887 about 200,000 square miles had been occupied and official statistics showed the area held 219,000 cattle, 107,000 sheep, and 8,600 horses.¹

A major objective of the South Australian Government was the construction of a transcontinental railway from Darwin to Adelaide, and in 1889 the first section of this line from the north coast to Pine Creek was completed. This failed to reach the Main Plateau by sixty-five miles and this led to recurrent problems in droving stock to the railhead in later years. At this time the completion of the line and the rapid exhaustion of the Pine Creek and Hall's Creek gold-fields led to a decline in the population of the northern settlements and the collapse of the local markets for beef. Concurrently, the introduction of tick-

¹ Information on early stock numbers is given in the Government Resident's reports on the Northern Territory, South Australia, Adelaide (annual).
borne redwater fever resulted in quarantine restrictions on movements to Western Australia and Queensland, and the industry entered a period of depression. However, droving did provide access to southern markets and it is interesting to note that, of the 13,111 head turn-off from the Barkly Tableland in 1894, 3,425 were sent to Adelaide, 4,860 went to Queensland, and the remainder were overlanded to New South Wales. As a positive contribution to the easing of marketing problems, the South Australian Government granted an annual subsidy of $10,000 to support the export of live cattle from Darwin to Singapore and Batavia. This trade was undertaken by Goldsborough Mort & Co. and 12,684 head were shipped in 66 voyages. The subsidy and service were terminated in 1897, following disease, currency, and organisational problems, but provide an interesting case of direct government intervention in marketing.  

The early years of this century saw three further precedents which bear upon the attitudes and policies of government on the relationship between transport costs and the development of land. First, the South Australian Government decided to open the provision of the transcontinental railway to private enterprise and published a prospectus for a Land-Grant Railway which gave a highly optimistic picture of the potential of the cattle industry. Its promoters claimed that:

An approximate estimate of the carrying capacity of the country to the north of Barrow Creek - some 200,000 square miles, at 10 head of cattle per mile - gives a total of 2,000,000 head. This is an extremely low estimate, as much of the rich pasture land on the rivers flowing from the Tableland to the coast will support and fatten many more, probably double the number.

1 For further information see Bauer, F.H., 1964, pp.145-9.
However, private capital wisely avoided the venture and this meant that the responsibility for the construction of major arterial routes was placed in the hands of the Government. Second, the Resident made a strong plea in 1905 for the recognition of State responsibility in the drilling and maintenance of stockroute bores, and this appears to have been accepted.\(^1\) Third, in 1909 Bovril Australian Estates Ltd proposed to build a meatworks at the mouth of the Victoria River, but the Government put pressure on the company to locate at Darwin to provide traffic for the Pine Creek railway.\(^2\) Concessions were offered to the enterprise but the decision was taken to abandon the project. Subsequent developments in processing in the Northern Territory follow the same pattern, with the State refusing to set up a plant but retaining an interest in its siting, and in transportation to the facility. This demonstrates a widespread and important feature of public policy on transport. Permanent-way investment to reduce the cost of movements to existing processing centres is regarded as infra-structural and is recognised to be the responsibility of the state, but the provision of industrial plants, which will lower the level of total movements and promote a more efficient distribution of economic activity, is left to private enterprise. This thesis demonstrates that such a dichotomy is unreal and shows that transport economics and location theory must be used to give an integrated solution to mobility needs.

b. Commonwealth policy: 1911 to the present

When the Northern Territory was transferred to the Commonwealth in 1911, it had a non-native population of

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\(^1\) Government Resident's report on the Northern Territory, South Australia, Adelaide, 1905, p.8.

3,301, of whom 1,182 were whites. South Australia had provided 622 miles of the transcontinental railway (the Darwin-Pine Creek and Port August-Oodnadatta sections), which were being operated at a heavy annual loss irrespective of interest on capital. The cattle industry was the only viable expression of private enterprise and its exports were valued at $342,000 in 1910. About 150,000 square miles were held under pastoral leases or permits, and this area contained 513,000 cattle and 40,000 sheep. The story of the development of the industry over the following sixty years is that of a fitful growth in the occupied area to about 250,000 square miles, and the doubling of beef cattle numbers.

Viewing the situation in 1913, the first Administrator commented

One is frequently asked – Where are the markets? Surely the markets of the world are as open to products of the Northern Territory once they are produced, as to those of any other country. A Government may assist in opening up a market, in rendering facilities for transport, but the market finally depends upon the purchaser.

A graphic illustration of the importance of demand in determining the success or failure of transport investment and plant location was given by the fate of the Darwin meatworks. In 1914 the Commonwealth entered an agreement with Vestey Bros, in which it undertook to extend the railway from Pine Creek to Katherine, while the company guaranteed to spend not less than $200,000 on constructing a processing plant. The works operated between 1917 and 1920 and during this period just under 70,000 head were treated and exported as frozen beef. At this time the world meat trade was buoyant and carcases were selling for about $32 in Great Britain, but at the end of the war demand slackened and supplies from South America once more became certain.

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1 Report of the Board of Inquiry into the Land and Land Industries of the Northern Territory of Australia (the Payne-Fletcher Report), Commonwealth of Australia, Canberra, 1937, p.5.

The plant suffered high costs and closed in 1920. Some concept of the difficulties facing processors at this juncture can be gained from the pattern of payments made by the Wyndham meatworks, which was opened as an instrumentality of the Western Australian Government in 1918. Growers received an average of $14.20 per beast in 1919, but no processing was undertaken in 1921. When the plant re-opened the average price paid had fallen to $7.80 per head. It seems fairly clear that the Darwin meatworks suffered the same post-war re-adjustment problems but it never operated again. The surprising point is that after an investment of nearly $900,000 by the Commonwealth and $1,800,000 by the company, the former was unwilling to offer a subsidy to support the operation and refused to take over the plant on favourable terms.

Between 1922 and 1930, Vesteyes carried on a small and moderately successful trade in live cattle to Singapore and Manila, but the northern outlet ceased to be of importance to the industry. Though the further extension of the northern railway from Katherine to Larrimah (Birdum) in 1928-29 brought the line to within one hundred miles of the well-stocked properties on the Barkly Tableland, Darwin was a dead-end without a meatworks. Growers in the Victoria River District could turn to the Wyndham plant, but for most northern producers the distant and unreliable demand for store cattle in Queensland was the main outlet. Prices in all centres were chronically low during the Depression: in 1933 breeders were selling at $2.00 on the Tableland and fats could be bought for as little as $5.00 to $6.25. The

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3 The Payne-Fletcher Report, 1937, p.64.
average payment for fatstock at Wyndham in the same year was $5.50. By this time the cattle population of the Northern Territory had reached about 860,000 (eighty-two per cent of the 1966 figure), but it was felt that development had scarcely begun — indeed the negotiation of the Ottawa Agreement sparked an amazing optimism. The Administrator viewed the history and future of beef production in the following terms:

Established as the pioneer industry, the progress of the pastoral industry has been unduly slow, mainly through natural causes and overwhelming odds, the greatest obstacle being inaccessibility and distance from markets, and now, after a long period of general decline, fresh efforts are being made to obtain recognition of the possibilities of the Territory as an area capable of supplying the Empire's beef requirements.¹

Little thought seems to have been given to the fact that, had a real comparative advantage been evident for large scale production, British capitalists would have probably exploited the opportunities prior to this date and secured preferential tariffs.

In the south more tangible and soundly-based developments had followed the extension of the railway from Oodnadatta to Alice Springs in 1929. Though exports from Central Australia exceeded the level for 1928 in only one of the pre-war years, the line was of great importance in tapping a firm domestic market, for South Australia suffers a persistent short-fall in supplies. The extension had been undertaken as part of the Commonwealth's agreement with the State to complete the construction of the transcontinental railway and appears to have had an undoubtedly beneficial effect on the industry in the Alice Springs District, particularly since 1945. It is interesting to note, in view of the Commonwealth's refusal to support or operate a northern meatworks, that the Payne-Fletcher Report's proposal for interference in rate setting on the line was adopted.

¹ Report on the Administration of the Northern Territory, 1931, p.38.
though f.o.r. prices at Alice Springs for good quality fats in 1937 were substantially in advance of those obtaining at Wyndham.

This brief history of the development of the beef industry sets the scene for the detailed analyses of land-use in Parts 2 and 3 and raises a number of theoretical and policy issues which bear upon the efficacy of transport investment. It permits a definition of the structure of farm accessibility in terms of examples drawn from the Northern Territory and the formulation of a model of the relationship between this attribute and agricultural adjustment forms the subject of the final section of this chapter. However, at this stage it is appropriate to examine the course of government planning since 1911 to demonstrate public attitudes on the link between transportation and development.

Commonwealth policy in the Northern Territory has been marked by an intense and persistent neurosis about the slow growth of the population and the poor performance of its industries. Many of the causes of this preoccupation, such as the fear of Asian intrusion and the desire to demonstrate national vitality, lie beyond the scope of this thesis, but throughout much that is written on the development of the area runs a belief that somewhere a key exists which will open the door to closer settlement and the exploitation of resources at a profit to Australia. The provision of improved transport facilities is most frequently selected for this role and numerous recommendations have been made for investment in this sector. Inevitably, there has been a considerable gap between the advice and government action. Ten major series of inquiries have examined the problem of expanding economic activity or have looked at public responsibility in the field of transportation since 1911. A brief synopsis is given of the approaches and recommendations of each inquiry.

(i) In 1913 a Royal Commission was appointed to examine the state of the railways and ports of the Northern Territory. It reported that the construction of developmental railways
would have to be related to the needs of the pastoral industry, and expressed the view that 'without railway extension there would be no substantial progress or development of the Territory'. It recommended a survey to assess the possibility of providing a port on the Gulf of Carpentaria and favoured the continuation of the main trunk railway line from Katherine to Oodnadatta, with additional lines linking the Victoria River District, Anthony Lagoon, the Gulf, and Camooweal on the Queensland border. This was an era of high hopes and ambitions.

(ii) By 1922 the Commonwealth had begun to doubt the utility of a transcontinental north-south railway, although the agreement with South Australia contained a legal commitment to complete the line. The Parliamentary Standing Committee on Public Works in that year suggested that development would be best served by extending the northern line from Mataranka to Daly Waters, with the eventual aim of linking it to Queensland via Newcastle Waters and Camooweal.

(iii) In 1925 Sir George Buchanan presented a report on the Territory in which he stressed the need for better transport facilities for the pastoral industry, and sided against the north-south line. He recommended that railways should be built from Katherine to Wave Hill, Katherine to Camooweal, and from Anthony Lagoon to a new port on the Gulf of Carpentaria at the mouth of the McArthur River.

(iv) A Royal Commission in 1927 favoured the immediate construction of a line from Katherine to the Queensland border with the ultimate object of a connection to Bourke, New South Wales. In the following year, the North Australia

3 Report by Sir George Buchanan, Northern Territory Development and Administration, Parliament of the Commonwealth, Melbourne, 1925, p.11.
Commission was formed, and it 'concentrated its efforts on the question of transport facilities'. The Commission failed in its bid to gain control of transport planning and was relegated to an advisory role, though it did undertake research on the problems of locating road, stock, and rail routes. It endorsed the plan for the rapid completion of a Katherine to Queensland link.¹

(v) In 1937 a comprehensive inventory of the resources and potential of the Territory was issued by the Board of Inquiry into the Land and Land Industries of the Northern Territory of Australia (the Payne-Fletcher Report). It concluded that the cattle industry would be unlikely to justify the construction of new railways, and urged acceptance of the principle that

\[
\text{directly or indirectly, whether by increased production, or by the taxable capacity of the new community [a] railway [should] within a reasonable time, pay its own working costs, and interest on loan capital invested.}^2
\]

The Board recommended the construction of 150 miles of line from Wyndham to Mistake Creek, and 240 miles from Dajarra to Rankine to open up the Victoria River and Barkly Tableland Districts to the sheep industry. Further observations were made on the operations of the Oodnadatta to Alice Springs railway, the possibility of constructing a deep-water port on Vanderlin Island, and the need for the Australian Meat Board to allow a greater beef export quota to South Australia (for Territory cattle railed south).

(vi) The post-war period saw a renewed interest in national reconstruction and development. In 1945 Sir Harold Clapp made a comprehensive survey of the problems of unifying Australia's railways, and concluded that a standard gauge transcontinental line, linking Darwin and Dajarra was desirable on a total evaluation which included

¹ The Payne-Fletcher Report, 1937, p.89.
defence considerations. He also recommended a line from Winton to Bourke (via Charleville) which would have connected Darwin to Sydney. In his report, Sir Harold quoted C.L.A. Abbott (the Administrator of the Northern Territory) who estimated that the northern link would lead to a doubling of cattle numbers (from one to two million), and the development of land holding five million sheep.

(vii) The early 1950s also saw the publication of two important specialist reports on the beef industry in the north of Australia and both of these suggested that transport was the 'key to development'. In addition, a number of conferences and seminars were held on transportation and the North, and in many cases the participants backed the case for transcontinental railway lines. However, no formal evaluations were undertaken and it was frequently assumed that the possibility of obvious production adjustments was sufficient to justify enormous expenditures. The Clapp scheme for interior Queensland and the Northern Territory would have cost over $53 million in 1945, and it was probably the magnitude of the sums involved that prevented the construction of the projects. From this time road transport began to play an increasing part in the movement of cattle and gradually funds were provided to upgrade surfaces. Furthermore, the recommendations that have been made in subsequent reports have attempted to justify expenditure in greater detail, though there are suggestions that road

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1 Report to the Minister for Transport on Standardization of Australia's Railway Gauges (the Clapp Report), Commonwealth of Australia, Canberra, 1945, Appendix 9.

2 The Clapp Report, p.21.


4 See for example, Northern Australia, Task for a Nation, Sydney, 1954.
finance is sometimes provided in the belief that projects are; *sui generis*, 'good things'.

(viii) In 1959 the Forster Committee examined the prospects of agriculture in the Northern Territory, and necessarily restricted the inquiry to the high rainfall area (particularly the Top End). Although the report did not deal with road location, it concluded in a brief survey of transport facilities that

Any means by which transport costs can be reduced, including public works in the form of roads, railways, and airfields, should be accepted as one of the major contributions which the Commonwealth Government can make to the development of the Territory.¹

The Committee noted that the construction of a meatworks was essential to the development of the Top End and looked forward to the provision of a facility by private enterprise. Once again, the location of additional processing centres was regarded as being outside the responsibility of the Government, and their role in reducing transport costs was viewed separately.

(ix) By 1965 road transport had come to dominate movements in northern Australia, and the Loder Committee on transport costs concluded that 'a vigorous programme of road construction is the most important single step needed to accelerate development of the North'.² The report suggested that further State or Commonwealth expenditure on rail construction was unwarranted, and recommended subsidies on air fares and freight, the import of certain classes of foodstuffs, and air passages for school children travelling to the South for secondary education. It considered that the transport costs of a range of items should be made claimable against income,

¹ *Prospects of Agriculture in the Northern Territory* (the Forster Report), Commonwealth of Australia, Canberra, 1959, p.149.

sales and payroll taxes, and proposed subsidies on the import of 'developmental goods' from southern ports. Specific recommendations for the Northern Territory included the adoption of long-term planning in road construction, and transport subsidies for properties re-stocking after drought. Distinctive features of its approach were the avoidance of any responsibility in locating new routes, the proposals to alleviate inward transport costs while letting producers bear the weight of export charges, and its national and wide-ranging viewpoint.

(x) In the same year (1965), the Department of National Development completed its report on Beef Road development in northern Australia, which examined an exhaustive list of projects and ranked them by construction priority, using benefit-cost analysis. The report has not been released, so that many of its assumptions cannot be discussed. However, a major reason for its proscription appears to be that it recommended that Commonwealth road expenditure for the beef industry should be tied to a programme of measures to adjust farm practices so that the full developmental potential would be realised. In addition, it specified necessary conditions of property subdivision and tenure. Although it is generally accepted that the Beef Roads Programme is sound, this thesis is critical of some of the decisions that were made on the Northern Territory. Viewing the Programme from a national point of view, it is useful to consider the setting of public policy on roads and development. By 1965 the Commonwealth had allocated $13.8m. for projects in the Territory. At this time, gross private investment in structures and plant in the whole of the beef industry was about $16.5m (the figure was approximately $41.6m. if cattle are included).

2 See Table 6.2.
3 These calculations have been made by extrapolating data on capital usage on 82 properties to the whole industry on a capital per herd animal basis. The data are given in The Northern Territory Beef Cattle Industry. An Economic Survey, 1962-63 to 1964-65, BAE, Canberra, 1968.
and two Northern Territory meatworks had been constructed at a total cost of about $2.0m. Thus the level of expenditure on roads is large in comparison to the private capital which it is supporting. The question arises as to whether the $30.0m. that has been allocated for beef roads in the Territory (as at mid-1970) could have been better spent for the development of the study industry, or the expansion of beef production elsewhere in Australia.

Reviewing the history of the beef cattle industry, it is apparent that a wide variety of schemes have been proposed to assist producers. The South Australian Government tried a direct subsidy on marketing to Southeast Asia, attempted to attract investment in processing by rail concessions, failed to encourage the construction of Land-Grant railway, and accepted the responsibility of providing stock-route waters. Subsequently, the Commonwealth followed the policy of providing infra-structural transport facilities to existing markets -- a trend which has continued from the construction of the Pine Creek to Katherine railway in 1917 to the present Beef Roads Programme. Although the period from 1911 to the early 1950s was marked by irregular inventories of the potential of the industry and the publication of official reports which proposed grandiose rail schemes, relatively little was done. There was an obstinate refusal to see transport difficulties as part of the wider problem of access to stable markets where the Territory had a real comparative advantage. In addition, there was a parallel tendency to ignore the opportunities for stimulating production through means other than expenditure on permanent ways. Price support schemes, export promotion, the operation of killing centres as public utilities and direct transport subsidies on existing modes, are examples of measures that could have been adopted.

1 Minutes of Evidence relating to the proposed construction of the Top Springs to Wave Hill road, Northern Territory, Commonwealth of Australia, Canberra, 1965, p.4.
The period from the early 1950s to the present has been marked by a preoccupation with road investment, and the Beef Roads Programme for the whole of the North has overtones of the grand continental rail proposals. The Loder Report did take a wider view of transport, but reached few substantive conclusions. It seems fair to say that, though the modern reports have adopted budgeting and benefit-cost analysis techniques to assess the viability of particular proposals, there has been a general lack of appreciation of the planning issues behind the relationships between accessibility, transportation, and development. If it is true that transport is the key to the future, the past should provide evidence of the complementarity effects that follow from changes and variations in comparative locational advantages. This makes the early part of the study period particularly interesting from a theoretical viewpoint, while the marked changes that have taken place since 1960 present equal opportunity to observe the effects of improvements in transportation on output. In these aspects the beef industry in the Northern Territory provides ample scope for the examination of the study problem.

B. THE CONCEPT OF ECONOMIC ACCESSIBILITY

In the light of the description of the physiography of the Northern Territory and the review of the history of settlement, development, and planning, it is now possible to define the position of transportation in terms of a composite parameter of comparative locational advantage in production. This is termed 'accessibility'. The importance of the components of this attribute of land vary according to the scale of interest and the economic and technical conditions of the dependent industry. The following section discusses the use of this concept to categorise the mobility and demand influences on the output of the cattle stations in the Territory.

Total transfer costs on agricultural commodities are largely a function of distance from centres of final demand. At the broadest scale the quality of the location of a farm
or property is conditioned by the opportunities that are available; at the regional level, to enter world trade. Overseas demand provides the main outlet for beef from northern Australia and here the basic locational characteristics of the area are much the same as those enjoyed by other parts of the country. Prices in the international meat trade are set in London and Chicago, and there will be little difference in f.o.b. freight quotations to these centres from Darwin or Brisbane, given uniform ship loadings. Differentials do arise from economies of scale and variations in port charges which tend to favour consignments from southeast Australia, but it can be argued that these would be reduced if sufficient quantities were available for export from northern ports. The Northern Territory does possess a comparative advantage for trade with Southeast Asia if demand develops there, for the sea distance between Darwin and Djakarta is only 1,968 statute miles. In summary, the study industry is not penalised by its geographic position with respect to world markets, in the context of rivalry within Australia.

Domestic consumption provides the second major market for beef and here the Northern Territory is at a disadvantage. The local population was estimated at 37,000 (exclusive of full-blood aboriginals) in 1966, giving an outlet for only 25,000 head of cattle per year. The main centres of demand in southeast Australia are distant, and transport costs on processed meat are high. Darwin is over 2,000 road miles from Brisbane and just under this mileage from Adelaide. It would cost about 3.5 cents per lb to road-haul frozen meat from Katherine to Sydney, which is approximately equal to the cost of shipping chilled supplies from Darwin to Tokyo and just under the rate for movements to east coast United States ports (US 4.5 cents per lb).\(^1\) The

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\(^1\) Northern Territory Statistical Summary, Canberra, 1969, p.28.  
\(^2\) Data supplied by Northern Meat Exporters, field interview, June 1967.
current cost of shipping refrigerated meat to Sydney by the Darwin Trader is 2.56 cents per lb for consignments over eighteen tons, but this still makes it difficult for northern meatworks to compete on southeastern markets.\(^1\) In fact very little meat is dispatched south, but live cattle movements are important though it costs around $12.0 to rail one beast from Alice Springs to Adelaide,\(^2\) and about $13.0 for the trip from Mt Isa to Rockhampton.\(^3\)

Prior to 1963 there was no export killing capacity in the Northern Territory so that most stock were consigned to South Australia or Queensland, which meant that producers were in a marginal position in relation to the centres of price formation. This is still true with respect to the relatively high price domestic market so that it is interesting to examine the pattern of production at the regional scale. Table 1.1 presents average capital and production statistics for seven regions, which are arranged in order of proximity to Brisbane (see Map 1.1). Since Queensland has forty-four per cent of the nation's beef cattle and contributes thirty-four per cent of the gross output of beef and veal (1968),\(^4\) it dominates the export trade and supplies the short-falls in New South Wales and Victoria; the Brisbane price series is thus a good parameter of overall demand. The figures show that the application of capital in the industry and the productivity of cattle herds decrease with distance from this centre. It may be that the statistics reflect variations in natural resources which are coincidental with the location pattern, but the findings do confirm that a hypothesis based on the assumption that transport costs and net received prices may condition production scale would be reasonable at this level. This sets the scene for the empirical work which looks at the relationship at the intra-regional and local levels.

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2. Correspondence with Commonwealth Railways, March 1968.
3. Correspondence with Queensland Railways, March 1968.
4. See Table 7.9.
Table 1.1: Inter-regional variations in capital usage and turn-off in the beef industry, property average, 1962-63 to 1964-65

<table>
<thead>
<tr>
<th>Region or District</th>
<th>Total capital per square mile ($)</th>
<th>Total capital per cattle equivalent ($)</th>
<th>Turn-off as a percentage of cattle numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Queensland Coastal-South</td>
<td>6,522</td>
<td>121</td>
<td>48</td>
</tr>
<tr>
<td>Queensland Coastal-Central</td>
<td>4,367</td>
<td>105</td>
<td>27</td>
</tr>
<tr>
<td>Queensland Coastal-North</td>
<td>1,646</td>
<td>73</td>
<td>19</td>
</tr>
<tr>
<td>Queensland Barkly-Gulf</td>
<td>560</td>
<td>62</td>
<td>19</td>
</tr>
<tr>
<td>Northern Territory Barkly Tableland</td>
<td>333</td>
<td>50</td>
<td>15</td>
</tr>
<tr>
<td>Northern Territory Victoria River</td>
<td>311</td>
<td>37</td>
<td>11</td>
</tr>
<tr>
<td>Northern Territory Darwin and Gulf</td>
<td>269</td>
<td>35</td>
<td>9</td>
</tr>
</tbody>
</table>


The location of an individual farm enterprise determines its access to markets and sets the bounds to the range of net received prices that can be gained for a given commodity. So far little attention has been paid to the processes of interaction between locational attributes and supply, but it is apparent that there are two types of effect. First, the absence of markets or the lack of a viable communication between demand centres and the farm may totally prohibit the exchange of specific goods: this can be characterised as the mobility effect. In the second case, distance from markets and the quality of transport will determine the farmgate prices of the commodities that are traded. Since this leads to spatial variations in marginal returns it may be termed the elasticity effect. Looking at the history of the cattle
Map 1.1: The wider economic setting of the Northern Territory beef industry.

industry in the Territory, it is easy to find examples of their operation. A producer in the north of the study region in 1957 had a limited choice of outlets; he could dispatch fatstock to Wyndham or Darwin but deterioration losses on-the-hoof would circumscribe his opportunities in this form of production; or he could contribute store cattle to the Queensland market. The precise location of the property and his judgement of price and movement conditions would determine the enterprise structure, in the context of the spacing of markets and the poor mobility characteristics of droving as a mode of transport. Once this decision had been made, the comparative advantages of the holding would vary with its location within a given supply area so that, as an instance, a supplier of fat cattle to the Adelaide market, with a station near the Alice Springs railhead, must budget his production costs to offset the $13.0 per head margin of his South Australian rivals.

Conditions may improve for an enterprise as changes take place in six constraints on its opportunities to increase net income. First, market prices for the commodities that it is already producing may rise at existing outlets. Consignors of fat cattle to the Wyndham plant experienced this situation between 1932 and 1950 as average gross receipts for stock rose from $5.90 per head to $25.00.¹ Second, farmgate prices may improve as rate payments for transport fall; there is no obvious example of this happening in the study region, though the growth of the stock-route network may have reduced charges between some properties and destinations. Third, net receipts on the existing production of a unit may become more favourable as consignment decisions are refined. This may follow from advances in marketing which lead to the more rapid diffusion of price knowledge and the reduction of uncertainty. The spread of communications by short-wave radio in the 1930s is an instance of an innovation that linked buyers and sellers

¹ Kelly, J.H., 1952, Appendix D. This price increase is substantial, even allowing for changes in the value of money.
more effectively. Fourth, the removal of artificial barriers to trade may add greatly to the locational advantages of an enterprise. Here the removal of restrictions on movements to Queensland and Western Australia, after attempts to contain redwater fever had failed in the 1890s, can be quoted as an example. Fifth, important changes may arise from shifts in the range of opportunity for sales at existing centres or the entry of additional demand centres at new locations (the opening of the first Darwin meatworks in 1917 is a case in point). Finally, the introduction of superior transport technology may overcome mobility constraints on trade in particular commodities and reduce total transfer costs. The clearest case of the advantages that may accrue to producers from such a change is given by the expansion of the study industry in the Alice Springs District following the completion of the railway from Oodnadatta to Alice Springs in 1929.

The distinction of the effects and components of the comparative advantages of individual enterprises provides the basis for the formulation of a model of accessibility. Fig. 1.1 shows the relationship between the six components and agricultural adjustment. Broadly, the set of factors on the left side of the diagram act through the elasticity effect. Thus changes in market prices, rate payments, and marketing efficiency often exert their primary influence through receipts on existing production. On the other hand, new demands from alternative sources and the improvement of the flexibility and total cost of transport will often promote changes in the structure of output and lead to mobility gains. These are external economies that arise where changes in the economic environment act on the conditions of production other than through the effect of a rise in the price of commodities that were traded prior to the improvement. They alter the form of the production function rather than the scale of output. However, there are wide areas of overlap; for instance, a technologically superior transport mode may be important simply because it reduces rate costs while a certain rise in the price of one
Fig. 1.1: The relationship between improvements in accessibility and agricultural adjustment

- Improvements in price knowledge and marketing efficiency
- Rate payment reductions from changes in network density, route quality and adjustments in the operations of existing transport suppliers
- Increases in the market prices offered for the commodities traded at existing centres
- Shifts in received prices on existing production
- Lowering of cost of factors of production from rate reduction
- Increase in present or potential net income of the farm firm

- Removal of artificial barriers to trade
- Generation of demands for new commodities at existing centres or the entry of additional demand centres at new locations
- Introduction of technically superior transportation forms
- Additional income from new marketing opportunities
- Introduction of new production technology that is tied to mobility

Changes in the scale and form of production conditioned by shifts in the elasticity and mobility components of accessibility
good at an established centre may be enough to encourage a farmer to enter trade in this line and widen his range of output.

The complexity of the relationship between accessibility and land-use is increased by the fact that some sets of factors may act simultaneously or in combination. Thus the entry of new centres of demand may be dependent on the introduction of a new transport form (this was true in the case of the opening of the first Darwin abattoir which was linked to the extension of the northern railway from Pine Creek to Katherine), and the ability of producers to pay for improved transport will depend on the market prices they receive. Further, poor accessibility exerts additional effects on production. Thus the improvement of a transport route may lead to a reduction in the rate and non-rate costs of the delivery of store cattle, food supplies and developmental materials, so that it can promote an increase in scale through the cheapening of factors of production. In the study region, rail terminals and market centres act as distribution points so that this effect will tend to strengthen the impact of farmgate price rises. Another type of complementary effect may arise when the perishability of a commodity ties producers to a particular form of farm technology. In the beef industry, droving led to heavy deterioration losses on fatstock so that some enterprises were forced to specialise in rearing store cattle despite the fact that this did not maximise the use of their pasture resources. The entry of a processing plant in this case might allow a shift in the form of output and the employment of techniques that are more applicable to a well-organised fattening unit (for instance, stock segregation by fencing). This is an additional external economy.

It is therefore apparent that accessibility can be viewed as an entity and that variations in this attribute will be manifested in the net income of farms. The discussion suggests that economic accessibility at this scale can be defined as
the sum of the influences that affect the net income of an enterprise through spatially determined inelasticities and immobilities in the distribution of output and the deployment of resources.

The following chapter looks at the theory of farm adjustment to the elasticity characteristics of this quality. This leads naturally to an examination of von Thünen's classic treatment of the generation of location rents. Throughout the thesis the duality between accessibility and rent is stressed and this relationship points up the fact that it is impossible to dissociate the problem of improving transport from supply and demand considerations in the user-industry. The model therefore provides a frame of reference for the various empirical studies that are presented, which analyse the links between variations in accessibility and differences in land development at several levels of generality. The role of transport is complex and can only be explored fully within the context of the wider concept for, as Dupuit commented in 1844 'the ultimate aim of a means of communication must be to reduce not the costs of transport but the costs of production'.

PART 2

EXCHANGE AND PRODUCTION ADJUSTMENT TO SPATIAL VARIATIONS IN HOLDING ACCESSIBILITY
CHAPTER 2

THE NORTHERN TERRITORY AS AN 'ISOLATED STATE'

To free one factor, distance from the market, from its permanent association with all other factors, to see its working and ascertain its significance, we had to postulate a large town built, not on a navigable river, but at the centre of a plain whose soil is everywhere of the same inherent quality and at the same level of fertility. This intellectual operation is akin to the experimental methods used in physics as well as agriculture: only the factor to be determined is raised quantitatively, while all the others are held constant.

von Thünen, The Isolated State

INTRODUCTION

The previous chapter introduced the study problem by examining the relationship between transportation and pastoral land development in the Northern Territory up to 1950 and reviewing government policy on the provision of new transport facilities. This led to the formulation of a model of enterprise accessibility which demonstrated the need to set the problem in the context of the structure of demand for agricultural commodities. It also showed that improvements in transport may stimulate additional economic activity by widening the marketing opportunities of holdings and increasing marginal returns on their basic output. The former of these effects results in the generation of external economies which lead to adjustments in the range of production. These externalities will be a function of the nature of the user-industry and its mobility requirements so that it is impossible to define a general model of response. However, the theory of adjustment to elasticity effects is well developed and forms the subject of the discussion which
follows. The deductive framework for the analysis of the impact of variations in farmgate prices on production scale was set out by von Thünen in the *Isolated State* and the first section of this chapter looks briefly at the logic behind his work. The second major section then shows how the conditional assumptions of his model must be relaxed to accommodate exogenous influences on land-use intensity when it is applied in real world situations. This provides a convenient opportunity to introduce the economic characteristics of the study industry and to discuss how far a research methodology based on an analogy to von Thünen's system can be used to explore the role of transport costs in land development. In this sense the chapter gives a grounding to the empirical work presented in Chapters 3 and 4 and supplies a prologue to Part 2.

A. LOCATION AND AGRICULTURAL ADJUSTMENT: THE DEDUCTIVE FRAMEWORK

1. The foundations of theory

The term economic rent is used in economics to describe the surplus of income above the minimum supply price that is required to bring a factor into production. The concept is most frequently used to describe the income earned by land, which may arise from the quality of its inherent characteristics or their location. The theory of rent began with Adam Smith who observed

The rent of land not only varies with its fertility, whatever be its produce, but with its situation, whatever be its fertility. Land in the neighbourhood of a town gives a greater rent than land equally fertile in a distant part of the country. Though it may cost no more labour to cultivate the one than the other, it must always cost more to bring the produce of the distant to market.¹

Further, Smith recognised that rent was related to crop choice and the intensity of factor usage on farms and he saw that through this relationship transport improvements, judged 'the greatest of all improvements', would encourage the extension of cultivation and the intensification of production on existing units. From this basis Ricardo reached a refined definition of economic rent which avoided confusion with contract rent. He characterised it as 'that portion of the produce of the earth which is paid to the landlord for the use of the original and indestructible powers of the soil'.

It arose, he maintained, from the 'difference between the produce obtained by the employment of two equal quantities of capital and labour' on plots of similar area. In setting out his theory Ricardo also made some deductions on the progress of land development in a newly settled country and he formulated a stage model in which land quality determined the pattern of production. Although he saw fertility as the main determinant of the intensity of land-use in different districts through the rent theorem, he recognised that location in respect to markets was important, stating that 'the most fertile and most favourably situated land' (emphasis mine) would be cultivated first.  

Von Thünen set out to examine two aspects of agricultural location in areas of similar resource endowment; the derivation of crop patterns, and the distribution of different systems of husbandry. In his analysis of these problems, he utilised the concept of economic or 'land' rent, and pointed out that the level of the rent on an individual farm 'springs from its superiority, in soil or location, over the least favoured farm which is still producing for the market'.  

He made a major contribution to location theory by isolating the role of distance in production and setting out the

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2 Ricardo, D., 1817, p.37.
requirements for a systematic appreciation of the interaction between commodity prices, rents, and factor costs. He was first to observe that location rent theory must be grounded on two major assumptions and these are of critical relevance to the evaluation of the empirical work that follows. First, although he was only concerned with farm response to the market prices of the central Town in the Isolated State, he realised that the notion of spatial price equilibrium was essential to the argument of the model. Thus he stated

Grain cannot be as valuable in the rural areas as in the Town, because in order to fetch its market price, it must first be taken to the Town. It follows that in the country districts grain is less valuable than in the Town by the cost of its transport.  

Second, he was aware of the need to assume production equilibrium at the firm level such that the monetary marginal product (at local prices) of a production process must not exceed marginal costs (at local prices). Thus, in answer to a rhetorical question on the action of a rational farmer faced with optimising the use of a technique, he suggests that it will be applied 'so thoroughly, without doubt, that the value of the extra output is in balance with the labour cost of its production.'

These two assumptions are the basis of the concepts of spatial equilibrium in exchange and production that underlie much recent work on optimal location in agriculture. As Lefeber has demonstrated, it is possible to recast the problems of defining crop sequences and production intensities in the Isolated State in programming terms which make them soluble by mathematical processes. Thus von Thünen's model can be given credit as the progenitor of a family of spatial equilibrium formulations. One of these, the

1 von Thünen's Isolated State, p.12.  
2 von Thünen's Isolated State, p.254.  
Transportation Problem is used in this thesis to derive the total least-cost solutions to the allocation of cattle between different markets for Northern Territory stock. It can be classed as a standard equilibrium model since it utilizes demand and supply relations at the firm level. A second class of formulations are termed activity analysis models and these use production functions, factor capacities and demand relations, and require the additional assumption of factor mobility. These techniques are not used in the empirical work, but the evidence for adjustment to transport cost and farmgate price variations is presented in a manner that makes it possible to draw some inferences on their utility for prediction at the intra-regional scale. It is not feasible to use activity analysis in this study to predict production response to improved roads because the adoption of road transport involves the generation of important external economies which cannot be estimated from knowledge of the basic (pre-adoption) production function. However, the methods used in Chapters 3 and 4 do explore the possibility of using regression coefficients as indices of the elasticity of supply in the study industry with respect to variations in marginal returns. An excellent coverage of the common ground between the various extended spatial equilibrium techniques is given in a review article by Weinschenck, Henrichsmeyer and Aldinger, which also contains a fine bibliography on this subject. 1

In this thesis von Thünen's basic model has been used extensively to provide a framework for the organisation of data and to deduce normative responses to demand and transport changes. It is therefore relevant to examine the structure of the Isolated State in more detail. To assist in the solution of the two problems which are examined, he made certain assumptions in addition to price and production equilibrium and mobility of factors. He specified that soil

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fertility was homogeneous over space and constant over time; that all holdings were of the same size; and that technology was static. The relevance and reality of these constraints will be explored in the second section of this chapter with special reference to the study industry. However, it is of interest to note that they allowed him to determine the sequence of crops and the intensity of cultivation within zones running from the central Town to the no-rent margin. He was able to point out that variations in the economic rent earned by land from the production of different commodities and the use of different processes, determined their locational precedence, and, under the special assumptions of the Isolated State, rent gradients were linear with distance from the market and comparable at the industry and farm levels. Some of the inadequacies of the ring theory have been explored by Lüsch,\(^1\) Isard\(^2\) and Dunn,\(^3\) who have extended its generality, but little consideration will be given to this aspect of von Thünen's work because this thesis is restricted to the analysis of the relationship between transport costs and intensity within a single land-use zone -- extensive stock farming, which occupied the sixth ring in his model. Appositely, as in northern Australia, this ring lay on the margin beyond which 'a few hunters roam the forest ... living virtually like savages'. Since, however, the intensity theory is critical to the work that follows, it will be examined more rigorously under a separate heading.

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\(^1\) Lüsch, A., *The Economics of Location*, Yale, 1952, pp.36-63.


\(^3\) Dunn, E.S., *The Location of Agricultural Production*, Gainesville, 1954.

2. The rent adjustment process within a single industry

The operation of the process of the adjustment of land use intensity to variations in farmgate prices can be illustrated concisely by adapting some of the data presented by von Thünen, which is drawn from the accounts of his own estate. He points out that marginal returns diminish in most agricultural operations and bases much of his work on the decline in labour productivity with increasing inputs of this factor. According to his figures this took place in rye cultivation where the following relationship existed:

The 1st labourer produced 123 bushels;
The 2nd labourer produced 111 bushels;
The 3rd labourer produced 100 bushels;
The 4th labourer produced 90 bushels;
The 5th labourer produced 81 bushels;
The 6th labourer produced 73 bushels.

Consider now two farms of the same size, A and B. These units share the same production and marketing opportunities, but it costs $0.5 per bushel to transport rye from A to the central market, and $1.5 per bushel to transport it from the more distant farm B. When labourers are paid $20.0 per bushel, actual wage costs will be $110.0 per labourer for A and $50.0 for B. The optimum scale for farm A will be 505 bushels and five workers will be employed, for the annual wage of a sixth labourer would not be covered by the return on his labour of $109.5 (73 bushels x $1.5). Output on farm B will be 334 bushels and here the cost of the last input is just covered by the product. Details of the structure of factor use and profits on the two farms are given in Table 2.1.

Since the differential in output and net income is due to the respective levels of transport payments, the margin between the two enterprises can be conceptualised as a location rent. This consists of two distinct components.

\[1\] von Thünen's Isolated State, p.235. In von Thünen's example the progression runs from the 19th to the 24th labourer. The ordering has been changed to simplify the calculation of total farm returns.
Table 2.1: Locational differences in economic rents between two rye farms in the Isolated State

<table>
<thead>
<tr>
<th></th>
<th>Number of labourers</th>
<th>Product of last labourer (bushels)</th>
<th>Value of marginal product ($)</th>
<th>Wage and truck cost of one labourer ($ per year)</th>
<th>Net value of marginal labour input ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm A (net received price of one bushel = $1.5)</td>
<td>1</td>
<td>123</td>
<td>184.5</td>
<td>110.0</td>
<td>74.5</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>111</td>
<td>166.5</td>
<td>110.0</td>
<td>56.5</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>100</td>
<td>150.0</td>
<td>110.0</td>
<td>40.0</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>90</td>
<td>135.0</td>
<td>110.0</td>
<td>25.0</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>81</td>
<td>121.5</td>
<td>110.0</td>
<td>11.5</td>
</tr>
<tr>
<td>Economic Rent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>207.5</td>
</tr>
<tr>
<td>Farm B (net received price of one bushel = $0.5)</td>
<td>1</td>
<td>123</td>
<td>61.5</td>
<td>50.0</td>
<td>11.5</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>111</td>
<td>55.5</td>
<td>50.0</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>100</td>
<td>50.0</td>
<td>50.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Economic Rent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>17.0</td>
</tr>
</tbody>
</table>

Source: see text.
First, if the production of farm A equalled that of farm B (i.e. 334 bushels), it would gain $154.0 per year in net revenue, despite the fact that labour costs per man are more than double those of its rival. This is 'situation rent' mentioned by Adam Smith, and it may be defined in general terms as

the additional revenue which a farm nearer to the market (in economic distance) receives from the difference between the net value of its product and that received by the most distant producer of the same commodity, at the same scale of output, all other things being equal.

It may be noted that von Thünen's example is atypical of modern agriculture, for the money value of wages rarely varies between locations at the intra-regional level in the manner that was apparent to him from his observation of conditions in Germany in the last century. However, it gives a useful demonstration of the fact that conditions could exist which would favour the more distant enterprises. It is more probable that factor cost variations will tend to reinforce the advantages of farms with the best locations in most industries, for freight charges on transporting raw materials and machinery will vary with distance from distributing centres and in most cases these will also be markets or terminals. In the study industry this is true and relatively small amounts of materials are used in the production process so that it is possible to assume that situation rents will vary linearly with marginal returns. This parameter is used extensively in the empirical work as a surrogate for the broader attribute.

A second type of location rent arises from the difference in the scale of the two enterprises in the example. It may be termed 'intensity rent' and defined as

the sum of the net values of the additional resource inputs that are made viable by the difference between net received prices on a locationally favoured farm and those received by the most distant farm producing the same commodity, with everything except scale and location being equal.
The value of this quantity in Table 2.1 can be calculated by summing the net return on employing the fourth and fifth labourers on farm A (that is $36.5). In reality this kind of measurement is almost impossible, though production function analysis does give pointers to the role of different factors and the part played by marginal returns in determining scale. Much of the empirical work that follows is based on the assumption that gross output per unit of land resources can be used as a parameter of this variable, and reference will be made to the necessary conditions for this state in the second major section of this chapter.

Having disaggregated location rent it is useful to set out the general expression for its value per unit of land (L) under normative conditions. This can be stated as

\[ L = E(p - a) - Efk \]

where k is distance from the market, E is the yield per unit of land, p the market price per unit of commodity, a is the production cost per unit of commodity and f is the transport rate per unit of distance for a unit of the agricultural good. Thus, under the constraints of the Isolated State, the sum of the location rents on the units of land in each holding will correspond to net farm income for owner-operators. In reality this correspondence holds only when non-land inputs earn no more than the interest on their opportunity value and this is charged as a production cost (i.e. factors must not earn excess profits or 'rents').

This ideal relationship is also used as a guide to the influence of location in assessing data on the economics of the study industry. It is apparent that the limiting assumptions are important when the location rent concept is used to identify response to improved transportation in a situation where firms are making simultaneous adjustments to price and factor cost changes. Further discussion of this point is given in Chapter 6 which is concerned with the enumeration of the unambiguous benefits of road improvements.

The theoretical generation of location rents is shown diagrammatically in Fig. 2.1. Enterprise A is nearest to the market and gains a surplus on the employment of additional
Fig. 2.1: The effect of differences in location on the amount of economic rent that accrues to land

**FARM A**

- **MR** Marginal Revenue Curve
- **MC** Marginal Cost Curve
- **AC** Average Cost Curve
- **Economic rent**

**FARM B**

- **MR** Marginal Revenue Curve
- **MC** Marginal Cost Curve
- **AC** Average Cost Curve
- **Economic rent**

**FARM C**

- **MR** Marginal Revenue Curve
- **MC** Marginal Cost Curve
- **AC** Average Cost Curve

MC Marginal Cost Curve
AC Average Cost Curve
MR Marginal and Average Revenue Curve (farmgate price)
Q Equilibrium Output
factors up to the point where marginal returns equal marginal costs. The optimum enterprise scale is therefore $Q_a$ and the location rent of the farm is given by the shaded rectangle. Similar graphs for holdings of the same area on the same type of land which are located progressively further from the market (B and C) show how the rent surplus shrinks until scale at the no-rent margin is determined by factor costs (at output $Q_c$). Dunn has discussed the inconsistency of this traditional derivation of economic rents. He points out that land must be regarded as a factor of production and that its cost must be included in the determination of the firm equilibria. If land costs are taken as given it is relatively easily seen that a successive series of adjustments will occur until the optimum combination of resources is found. Consider farm B, where scale is set at $Q_b$ without reference to contract rent or capital charges on the value of land. When the additional costs are incorporated in the production function output is determined once again by reference to total factor costs and the firm equilibrium gives a new scale at $Q_b$. Further complications arise when holding size is allowed to vary and the price of land is assumed to be reached by perfect competition, and these will be discussed in the next section. At this stage it is important to note that the shape of the industry production function conditions the nature of the adjustments that can be made. It would seem that continuous and smoothly-shaped cost curves like those shown in Fig. 2.1 are seldom found in reality so that response to variations in farmgate prices may be irregular or absent, and this point is raised again in Chapter 5 in an examination of the production function of the study industry.

Three other characteristics of the model deserve consideration, before moving to the effects that follow from the relaxation of the constraints on the form of the production environment. These all involve the role of price in the actions of rational managers. First, the assumption

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1 Dunn, E.S., 1954, pp.28-34.
of perfect spatial price equilibrium requires that market prices are certain. In reality there may be considerable temporal fluctuations which cannot be predicted by farmers, and this may lead them to make a conservative assessment of scale. If knowledge becomes more widespread nearer to the market, as seems likely, this factor will tend to steepen the rent gradient. Second, the model simply assumes that supply is elastic with respect to variations in net received prices, so that the output and rent responses of a single unit to a given rise in market prices should be directly comparable to the difference that exists between two holdings with the same disparity in farmgate prices. Hence the supply response of an industry should give a good guide to the probable level of location rents. This quality of one to one correspondence over time and space between the dependent and independent variables in the process can conveniently be termed 'ergodicity'\(^1\) and is used to make inferences on the behaviour of producers in the study industry. Third, there is an inherent assumption in the model that a given reduction in transport costs will have the same effect on production as a rise in market prices with the same cash value. This is not necessarily true in reality because the changes may be associated with different degrees of uncertainty, and in most cases favourable adjustments in rate payments for transport will be more stable than market price gains. An obvious case of relatively secure change in comparative locational advantage is given by the construction of a new road, and this makes it dangerous to use evidence on the importance of spatial equilibrium, at a given point in time, based on the relationship between farmgate prices and land-use intensity, as a guide to the

\(^1\) Strictly, ergodic theory is the study of measure-preserving mathematical transformations and is applicable to phenomena which exhibit a one-to-one correspondence between variations in n-dimensional space -- see James, R.C., and James, G., Mathematics Dictionary, Princeton, 1949, pp.134-5. Used in a literary sense ergodicity is a convenient term for one-to-one variation over space and time.
generative powers of an investment in transport without qualification. The three characteristics of the model that have been discussed here are referred to again at different stages in the argument of the thesis. In summary, this section has introduced the theory of location rent response under conditions of uniformity in land quality, holding size and technology. The following section will turn to a description of the study industry and an examination of the behaviour of location rents in reality.

B. LAND-USE AND THE BEEF INDUSTRY IN THE NORTHERN TERRITORY

The Northern Territory covers an area of about 520,000 square miles. Of this, approximately 275,000 square miles are leased for pastoral occupation and the remainder has virtually no economic use, excepting mining and urban concentrations. The pastoral country contains about one million head of cattle (1,032,000 as at June 1966) and the extensive beef cattle industry dominates land-use, so much so, that for the purposes of this study, it is reasonable to assume that it has no competitors. Throughout the history of the Territory this industry has supplied the bulk of exports and has been the main employer of non-service labour. The end of the study period marks its eclipse in these fields and in 1965-66 the total value of production (about $13 million) was exceeded by that of the mining industries by a slight amount. Further, in this year tourists created business in the Territory valued at a comparable level. However, the prosperity of the beef industry remains vital to the economy and the continued occupation of this part of northern Australia. Superficially the technology used in production does not vary, and the landscape is relatively homogeneous so that it seems justifiable to hypothesise that distance from markets will be the main determinant of development.

Basic statistics on the study region are given in the Northern Territory Statistical Summaries, Commonwealth Bureau of Census and Statistics, Canberra (annual), and the Northern Territory Reports, Department of the Interior, Canberra (annual).
Map 2.1: The location of the economic units in the Northern Territory beef industry, 1966.

Sources: See Appendix 1 and text.
The industry is composed of about 180 economic units or 'stations', and Map 2.1 shows the location and boundaries of the 179 units that make up the basic population used in this study. This distribution has been determined from the examination of leasing details and some emendations and additions have been made to take account of the organisational structure of production. The names of the holdings are given in Appendix 1. The most distant of these units are over 300 miles from a market or rail terminal (marked by stars on the map), and transport costs can absorb over twenty-five per cent of market receipts for stock. In the light of this, von Thünen's model of adjustment seems particularly relevant to the study of the impact of transport investment at the firm level. However, as has been seen, it is necessary to compare its assumptions to conditions in reality before proceeding with the empirical work.

1. Economic rent and variations in land quality

Von Thünen assumed that soil quality did not vary over space in the Isolated State and that fertility was constant over time. Nevertheless, he was well aware of the inadequacy of these conditions and expressed the view that variations could be included in the model at the expense of spatial symmetry. Ricardo's exposition of the generation of economic rent was based on the comparison of returns on plots of different use-capacity, and Fig. 2.2 presents the text-book demonstration of rational adjustment to three classes of land resources. Here farms of similar size receive the same farmgate price for their product. Farm A on the best land has lower unit production costs and reaps a substantial rent which is shown by the shaded rectangle. Marginal applications of factors become successively less productive as fertility declines so that farm B shows a smaller surplus. At the no-rent margin the supply price is just sufficient to reward factor use. It is apparent that the process of rent adjustment is directly comparable to that described for location rents. Thus, though the presence of marked spatial variations in land quality may distort the intensity pattern there is no reason to suppose that it
Fig. 2.2: The effect of differences in land quality on the amount of economic rent that accrues to land.
will erase the impact of accessibility on holdings. In this situation regression techniques can be used to separate the influence of the two variables. A major requirement of success in this case is an adequate parameter of the value of different types of land and the derivation of the index used in this study must be examined.

The main aspect of land resources that affects the economic structure of holdings in the Northern Territory is the quality of native pasture. This varies over space and may fluctuate over time due to climate in the short-term and depletion in the long-run. However, it is reasonable to assume that the relative values of different pasture types remained constant over the study period. The areas covered by different pasture associations in the Territory have been mapped by the Land Research Section of the Commonwealth Scientific and Industrial Research Organization (CSIRO) and this data and the accompanying reports have been utilised in the formulation of indices of the average land quality and total grazing resources of each holding. The reports give estimates of the mean carrying capacity of each pasture type, assuming that stock have permanent access to water, and representative values have been determined from the range of publications. These are given in Table 2.2 which also shows the area occupied by the sixteen productive associations as measured on the CSIRO maps. Somewhat under half the occupied land can be classed as virtually useless to the industry and it can be seen that the estimated stocking rates on the usable country vary from forty beasts per square mile (one beast to sixteen acres) to one animal per square mile on the flooded wild rice pastures of the coastal fringe. To give economic meaning to these figures: the areas taken up by the pasture types within each lease have been determined and this allows the construction of two indices. The first is simply the sum of estimated capacities of the grassland pockets in each of the 179 blocks and has

1 The methods and sources used in these calculations are described in more detail in Appendix 1.
Table 2.2: The distribution of natural pasture types within existing pastoral leases by carrying capacity rank

<table>
<thead>
<tr>
<th>Pasture Type</th>
<th>Basic carrying capacity (beasts per square mile)</th>
<th>Area covered (square mile)</th>
<th>Theoretical total carrying capacity (beasts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Barley Mitchell Grass and other Perennials</td>
<td>40.0</td>
<td>4,724</td>
<td>188,960</td>
</tr>
<tr>
<td>(ii) Barley Mitchell Grass</td>
<td>35.0</td>
<td>22,291</td>
<td>780,185</td>
</tr>
<tr>
<td>(iii) Inferior Mitchell Grass and other Perennials</td>
<td>25.0</td>
<td>11,956</td>
<td>298,900</td>
</tr>
<tr>
<td>(iv) Short Grasses and Forbs on floodplains and outwash</td>
<td>20.0</td>
<td>6,356</td>
<td>127,120</td>
</tr>
<tr>
<td>(v) Northern Bluebush</td>
<td>20.0</td>
<td>1,244</td>
<td>24,880</td>
</tr>
<tr>
<td>(vi) Tippera Tall Grass plains</td>
<td>17.5</td>
<td>13,484</td>
<td>235,969</td>
</tr>
<tr>
<td>(vii) Short Grasses and Forbs</td>
<td>15.0</td>
<td>24,943</td>
<td>365,145</td>
</tr>
<tr>
<td>(viii) Short Grasses and Forbs on lowlands mixed with hills</td>
<td>10.0</td>
<td>17,984</td>
<td>195,400</td>
</tr>
<tr>
<td>(ix) Tippera Tall Grass on low hilly country</td>
<td>8.0</td>
<td>1,832</td>
<td>14,656</td>
</tr>
<tr>
<td>(x) Arid Short Grass plains</td>
<td>7.5</td>
<td>1,244</td>
<td>9,330</td>
</tr>
<tr>
<td>(xi) Upland Tall Grass plains</td>
<td>7.5</td>
<td>16,309</td>
<td>122,316</td>
</tr>
<tr>
<td>(xii) Bladder Saltbush and Bluebush</td>
<td>5.0</td>
<td>3,096</td>
<td>15,480</td>
</tr>
<tr>
<td>(xiii) Lowland Tall Grass plains</td>
<td>5.0</td>
<td>1,467</td>
<td>7,333</td>
</tr>
<tr>
<td>(xiv) Broken Mitchell Grass</td>
<td>4.0</td>
<td>3,067</td>
<td>20,268</td>
</tr>
<tr>
<td>(xv) Kangaroo Grass</td>
<td>4.0</td>
<td>1,705</td>
<td>6,820</td>
</tr>
<tr>
<td>(xvi) Coastal Country</td>
<td>1.0</td>
<td>1,157</td>
<td>1,157</td>
</tr>
<tr>
<td>All other vegetation associations</td>
<td>0.0</td>
<td>140,525</td>
<td>nil</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td>274,784</td>
<td>2,413,921</td>
</tr>
</tbody>
</table>

Sources: see Appendix 1.
been termed the theoretical herd size series. The second is this quantity scaled against the area of the holdings and is referred to as the index of land quality. Map 2.2 shows the distribution of land quality on this criterion. The high average value of land resources in the occupied country of the Barkly Tableland District is evident, and clusters of relatively good properties are present in the remaining Districts which cover features described in Chapter 1. These two indices have been used extensively in the empirical work as surrogates for a more comprehensive index of the value of the original and indestructible powers of the soil.

Although these parameters of pasture quality do quantify an important aspect of the resource base, it is apparent that the estimates are partially determined by the level of technology (since they are based on actual land-use) and may be subject to errors due to lack of knowledge of the behaviour of cattle on the open range. Further, some additional aspects of the physical environment may be important. The presence of permanent natural water supplies on a lease is a great advantage while ridges may reduce fencing costs. These elements cannot be included in the analysis at the industry scale and have been disregarded, though the addition of expenditure on bores and fences in one model of land-use intensity does give some measure of their importance. Finally, though constancy over the study period is a reasonable assumption, some attention has to be paid to the effect of short and long-run variations in grazing resources. Short-term climatic fluctuations have a marked effect on land-use and a series of bad years can result in total destocking. However, it is almost impossible to take systematic account of this variable because, in some instances, excess rainfall or storms at particular times in the year may be highly damaging to economic prospects. Data from the Bureau of Meteorology has been used to cast light on conditions in some seasons with the benefit of hindsight. It follows, however, that climate causes uncertainty in planning and this means that producers may be conservative in their decisions on scale. There is limited evidence that range capacity has declined in some areas since settlement
Map 2.2: The resource base.

Sources: See Appendix 1.
and this may have economic consequences in that producers may seek to offset losses by using land more intensively. These and related questions are considered in Chapters 4 and 5. In summary, although some reservations must be made on the generality of the indices, they allow the empirical work to proceed, and, as will be seen, they give valuable service.

2. Economic rent and variations in holding size

In the Isolated State all holdings were assumed to be the same size as Tellow (von Thünen's estate). This condition plays an important role in maintaining correspondence between the level of rents at the unit of area and enterprise scales and the effect of relaxing this constraint must be considered. Production costs per unit of area fall into three categories in respect to variation with farm size. They may be degressive (like fixed costs such as the provision of a homestead), proportional (like variable machinery costs), or progressive (like internal transportation costs). Thus there will be a cost minimum which is determined by the incidence of economies and diseconomies of scale in the industry. Figure 2.3 shows the shape of the industry marginal and average cost curves at a given intensity of output. The diagram represents the sum of families of curves for enterprises of different size and farm acreage increases along the horizontal axis. Marginal and average revenue are given by a single line EE, so that it is assumed that all the farms have the same location; in this case location rent can be disregarded and the diagram can be used to determine the price of land. The optimum scale is found at acreage $S_0$, where the surplus from the use of non-land factors is $B_0 - A_0$. At smaller acreages like $S_1$ the average revenue per land unit ($OE - S_1 B_1$) will be zero, while on larger farms like $S_2$, marginal revenue ($OE - S_2 B_2$) will be zero. It follows that the minimum selling

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1 The figure is taken from Weinschenck, G., Henrichsmeyer, W., and Aldinger, F., 1969, p.11.
Fig. 2.3: The determination of land prices at the industry level.
price for land will rise from nought to $A_0 B_0$ as farms of size $S_2$ reduce their acreage to the optimum, and the maximum buying price will decrease from $A_1 B_1$ to $A_0 B_0$ as farms of size $S_1$ purchase land to make the best overall use of their resources. Thus the price of land will be set at $A_0 B_0$ given no changes in commodity or factor prices. As a corollary to this derivation it is apparent that, under equilibrium conditions, all farms at a certain distance from the market will be the same size.

In reality, holding boundaries are fixed in the short-run and are likely to be far from optimal. This means that operators with farms above or below the optimum size will seek to ameliorate their position by substituting factors. On the larger farms, more land will be employed to produce a given output so that production per unit of land will fall, as will net returns. On the smaller farms, non-land inputs will be employed in greater quantities and intensity and returns per unit of land will be greater than would be predicted by the form of the optimum production function. The implications of these findings are that output and net returns provide unreliable parameters of economic rent when holding size is highly variable. However, in the long-run it would be expected that boundaries would be adjusted so that all units were of the optimum extent. In the case of boundary mobility and perfect competition in the land market, operators would also bid for rent advantages so that these would be absorbed in the production function and average returns to capital on all holdings would equal the opportunity cost of capital. Here, intensity and net farm income will vary with distance from the market, but, strictly, there will be no economic rents. These and related questions are considered in Chapter 4 in a discussion of data on the study industry. One further point may be made here. The deductions that have been made in this section are dependent on the assumption of rational decision-making under single product output in conditions of certainty. It may be that operators are willing to accept sub-marginal returns for the privilege of farming, in reality, while joint products and speculation often enter into land development. Some attempt is made to
take account of the operation of these factors in the Northern Territory in Chapter 7.

This discussion points to the need to consider the effect of holding size on intensity in the empirical work. All the land used by the beef industry is leased from the Crown. Contract rents on the leases that make up the basic station population of 179 units vary from ten cents to one dollar fifty per square mile, and, as will be seen from information on the cost structure of enterprises that is given in the following section, this item can be regarded as of minor importance. Lease boundaries are set by the Northern Territory Administration (NTA) and the sale of portions of leases is uncommon, thus in the medium term the pattern of blocks can be regarded as fixed. The stations in the basic population range from 60 to 6,292 square miles in extent, though there is a pronounced cluster at the mean (about 1,500 square miles). The relationship between lease area and land quality is not strong so that the theoretical herd size series gives weight to both variables. It gives a measure of the resources controlled by each unit and is used extensively in Chapters 3 and 4 as the basis for property output functions. Since the role of holding size in determining scale is not easily assessed, duality has been maintained in the empirical work and intensity has been examined at the enterprise and land unit levels. Inferences on the importance of variations in property resources and lease areas can be drawn by comparing the alternative sets of results. In addition this topic receives consideration in the discussion of the form of the industry production function in Chapter 5.

1 The simple correlation coefficient for holding area and the index of land quality is 0.17 (N = 179). This is significant at the 5 per cent level but not at the 1 per cent level. Thus the bigger holdings tend to control good land though the relationship is weak.
3. **Economic rent and variations in technology**

Variations in the technology used in an agricultural industry may permit different combinations of factors at particular scales, while the adoption of new techniques may cause productivity to vary over space with the progress of innovation. In these conditions economic rent responses may not be evident from the distribution of output and net income so that it is relevant to examine the structure of costs in the study industry to see whether there is broad uniformity at the District scale. Table 2.3 shows the composition of costs for a sample of seventy-two stations for 1962-63 through 1964-65. The schedules exclude any payment for management and include estimates for expenditure on rate payments for the movement of cattle to points of sale. In nearly all cases the variations in spending on different items are small. Wages, freight, repairs and fuel make up the bulk of variable costs, and depreciation is a significant element in the total structure. This illustrates that the range of inputs is limited and suggests that the production function may be both simple and relatively invariant. Some of the inter-District differences can be explained in terms of particular conditions; for instance, the greater proportion of spending on agistment (depasturing on other properties) and the lower charge for labour in the Alice Springs District can be attributed to the effects of drought. There is also some evidence of factor substitution, for the low incidence of depreciation in the Darwin and Gulf District, which marks a smaller expenditure on artificial waters, fencing and holding yards, is associated with increased inputs of labour for mustering and cattle control. However, the figures do present a general picture of uniformity. Two additional points may be noted from Table 2.3. First, the importance of fixed capital in the structure of production suggests that adjustment may be relatively slow while uncertainty from climatic variations, price movements and tenure conditions are likely to inhibit the commitment of funds to expansion. Second, the table demonstrates the heavy burden of freight and cartage costs and this confirms that the study hypothesis is reasonable.
Table 2.3: Composition of costs, station average, 1962-63 to 1965-65, by Districts

<table>
<thead>
<tr>
<th>Cost item</th>
<th>Alice Springs</th>
<th>Barkly Victoria</th>
<th>Northern Territory</th>
<th>Darwin</th>
<th>Northern Territory</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Per cent)</td>
<td>(Per cent)</td>
<td>(Per cent)</td>
<td>(Per cent)</td>
<td>(Per cent)</td>
<td>(Per cent)</td>
</tr>
<tr>
<td><strong>Materials</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel</td>
<td>5.9</td>
<td>5.9</td>
<td>5.5</td>
<td>4.9</td>
<td>5.7</td>
</tr>
<tr>
<td>Seed, fertiliser</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Pest destruction</td>
<td>0.1</td>
<td>0.0</td>
<td>0.7</td>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Livestock supplies</td>
<td>2.4</td>
<td>2.5</td>
<td>2.8</td>
<td>2.2</td>
<td>2.5</td>
</tr>
<tr>
<td>Repairs</td>
<td>10.0</td>
<td>12.1</td>
<td>9.9</td>
<td>10.4</td>
<td>10.8</td>
</tr>
<tr>
<td>Other materials</td>
<td>0.3</td>
<td>1.0</td>
<td>1.7</td>
<td>1.2</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Total materials</strong></td>
<td>18.7</td>
<td>21.5</td>
<td>20.6</td>
<td>19.0</td>
<td>20.3</td>
</tr>
<tr>
<td><strong>Services</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freight and cartage</td>
<td>13.4</td>
<td>13.6</td>
<td>13.3</td>
<td>6.1</td>
<td>12.5</td>
</tr>
<tr>
<td>Marketing charges</td>
<td>4.3</td>
<td>3.3</td>
<td>1.1</td>
<td>1.3</td>
<td>2.8</td>
</tr>
<tr>
<td>Rates and taxes</td>
<td>0.3</td>
<td>0.9</td>
<td>0.1</td>
<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td>Insurance</td>
<td>1.4</td>
<td>1.3</td>
<td>1.1</td>
<td>1.5</td>
<td>1.3</td>
</tr>
<tr>
<td>Agistment</td>
<td>2.5</td>
<td>0.0</td>
<td>0.0</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Other services</td>
<td>2.6</td>
<td>2.1</td>
<td>2.5</td>
<td>3.0</td>
<td>2.5</td>
</tr>
<tr>
<td><strong>Total services</strong></td>
<td>24.5</td>
<td>21.2</td>
<td>18.1</td>
<td>12.8</td>
<td>20.3</td>
</tr>
<tr>
<td><strong>Labour</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wages</td>
<td>15.3</td>
<td>23.4</td>
<td>24.6</td>
<td>29.2</td>
<td>22.2</td>
</tr>
<tr>
<td>Rations and keep</td>
<td>11.1</td>
<td>6.6</td>
<td>7.9</td>
<td>13.8</td>
<td>9.1</td>
</tr>
<tr>
<td>Contract</td>
<td>0.2</td>
<td>1.1</td>
<td>0.6</td>
<td>0.3</td>
<td>0.7</td>
</tr>
<tr>
<td><strong>Total labour</strong></td>
<td>26.6</td>
<td>31.1</td>
<td>33.1</td>
<td>43.3</td>
<td>32.0</td>
</tr>
<tr>
<td><strong>Depreciation</strong></td>
<td>30.2</td>
<td>26.2</td>
<td>28.2</td>
<td>24.9</td>
<td>27.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: BAE unpublished data, refers to modified sample of 72 holdings.
Although production appears to be homogeneous, differences do arise from two sources that must be noted. There is some degree of specialisation in the industry between breeding properties and fattening units though most enterprises appear to produce both store and fat cattle. Part of the explanation for the pattern of specialisation may lie in the influence of accessibility, through the displacement of different types of husbandry by the decline in farmgate prices, as suggested by von Thünen; and the incidence of deterioration losses on fatstock through poor mobility under droving. It follows that the investigation of this aspect of production is an integral part of the empirical work.

The second cause of spatial differentiation is the introduction of improved pastures in the northern part of the study region. This is the only major innovation in the industry in recent times and the development is restricted by rainfall requirements to the area north of the twenty-five inch isohyet. The use of cultivation, even on an extensive scale, changes the form of the production function, but the new techniques remained virtually unused up to 1966 so that this factor has been ignored in Part 2. However, some consideration is given to pasture improvement and the role of transport in this case in the later chapters. In summary, variations in technology must be examined in a search for location rents, but these appear to be slight in the study industry with two exceptions which will be the subject of special concern. Finally, it may be noted that inter-property differences in factor usage are largely conditioned by the quality of management. This element cannot be quantified but it is suggested that the simplicity of the input structure in the beef industry may reduce its importance as compared to other forms of agriculture.

4. Data and Distributions

Having reviewed the theoretical difficulties which arise in relating the concept of location rent adjustment to the real world situation in the Northern Territory, it is
now germane to examine the available sources on output and productivity in the study industry to prepare the way for the analytical work. The discussion considers three sets of data. First, turn-off statistics on each of the 179 holdings in the basic population can be gained from stock permit records. Since 1956 all stock movements in the Territory have been conditional on the issue of a permit by a representative of the Northern Territory Administration's Animal Industry Branch (NTAAIB). The waybills are designed to act as a clearance for disease restrictions and to assist in tracing the origins of outbreaks. The information from each permit is entered in a ledger at the head office in Alice Springs so that it is possible to extract the entries for each property and aggregate them to gain a picture of the total annual turn-off. From 1963 station totals have been prepared by the Superintendent of Stock-routes and information has become steadily more reliable and complete. Table 2.4 shows the average annual number of cattle sold by each property for the five years 1963-1967 as given by this record for the four Pastoral Districts. It will be seen that average annual sales in the Barkly Tableland District are over six times as great as sales in the Alice Springs and Darwin and Gulf Districts. Additional information on the basic population has been added to the table from data supplied by the Department of the Interior (lease areas) and the NTAAIB (herd sizes). The turn-off and herd size figures are confidential and can only be presented in aggregate or class form.

The published tabulations of a BAE survey of eighty-two stations over the three financial years 1962-63 to 1964-65 provide the second source of data. The report of the results of the survey presents over fifty tables on all aspects of the economic structure of the industry, primarily on a District basis. This information has been used in

Table 2.4: Total population and sample property characteristics by Districts

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>ALICE SPRINGS</th>
<th>BARKLY TABLELAND</th>
<th>VICTORIA RIVER</th>
<th>DARWIN AND GULF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Population</td>
<td>BAE sample 1</td>
<td>BAE sample 2</td>
<td>Total Population</td>
</tr>
<tr>
<td>Number of holdings</td>
<td>78</td>
<td>33</td>
<td>31</td>
<td>27</td>
</tr>
<tr>
<td>Average property area (square miles)</td>
<td>1.232a</td>
<td>1.559</td>
<td>1.986</td>
<td>2.652</td>
</tr>
<tr>
<td>Average property annual sales (head)</td>
<td>0.435c</td>
<td>0.463</td>
<td>0.472</td>
<td>2.929</td>
</tr>
</tbody>
</table>

Sources:

a. calculated from Details of Current Pastoral Leases, Department of the Interior (as at June 1966)
b. calculated from NTAAIB unpublished data (refers 1967)
c. calculated from NTAAIB stock permit data (refers to average annual sales 1963-67)
e. BAE unpublished data (average values for 1962-63 to 1964-65)
formulating hypotheses and offers a comprehensive background to this study. Third, special tabulations and statistical results have been derived from unpublished series from the same survey. These refer to a modified sample of seventy-two enterprises which are located on Map 2.1. The results of the second set of processed data differ from the first in that all properties having less than $2,000 gross annual returns are excluded; estimates of outward freight and marketing charges are included; and, inventory gain in cattle herds is calculated on a fixed price, rather than a variable annual price basis. Table 2.4 shows the characteristics of the two samples as compared to those of the whole population. There appears to be a general bias in both series towards the properties with bigger herds and higher annual sales, though this is not true for the Barkly Tableland District. However, it seems justifiable to ignore these differences in aggregate and accept the samples as being representative of the industry. At the District scale the small size of the classes makes them unreliable for statistical work and the figures for the stations in the three northern Districts have been pooled while the Alice Springs District is considered independently. This arrangement has validity in terms of marketing and transport conditions.

The use of statistics may be circumscribed by the distribution of values. Fig. 2.4 shows histograms for the parameters that have been introduced so far. It will be seen that only twenty-one of the properties have an average value for land quality over fifteen beasts per square mile, while in the five years from 1963-67 fourteen stations contributed forty-six per cent of the cattle sold. The distribution of costs and herd sizes in the modified BAE sample also show marked skewness and this characteristic appears to be common to nearly all the parameters that are available on the structure of the industry. To take account

1 The survey guaranteed confidentiality to respondents so that no data are available for individual holdings.
Fig. 2.4: Frequency distributions for basic holding characteristics in the study industry

- **Total Annual Costs**: Distribution of total annual costs per holding (1962-63 to 1964-65) (Basic BAE sample)

- **Herd Size**: Distribution of herd size per holding (1962-63 to 1964-65) (Basic BAE sample)

- **Land Quality**: Average land quality value per holding (Beasts per square mile) (Basic population)

- **Holding Area**: Lease area per holding (square miles) (Basic population)

- **Gross Sales**: Gross annual sales per holding (1963-1967) (Basic population)
of this situation most of the empirical work in Part 2 has been duplicated with raw and log-transformed data. The simple correlation analyses of variables are presented for the basic values in most cases but the multiple regression models widely employ the transformation. In the latter case, the concern with the influence of marginal revenue variations on marginal productivity and the desire to estimate rates of change in the dependent variable give additional rationale to this form of model. This question is considered in more detail in the text and Appendix 2 points up the similarities between the regression equations and the production function models that are frequently used in agricultural economics to estimate the role of different inputs in determining scale. Only a small part of the empirical work is described in the thesis and this has been selected for its utility in quantifying the relationship between variations in accessibility and land-use intensity. Additional results from alternative research designs are also given in Appendix 2.

This chapter has examined the theory of location rent adjustment to provide a framework for the analysis of the relationship between the elasticity aspect of accessibility and land development. The deductions made by von Thünen illustrate that factor and output intensity per unit of land and per enterprise could be expected to vary with the level of farmgate prices for the product of an agricultural process under certain conditions. The main assumptions behind the Isolated State model were then considered in turn and further inferences were drawn on the stability of location rent gradients in the real world. This also gave an opportunity to introduce some of the characteristics of the study industry and to explore some of the methodological problems that arise in organising the available data to test the hypothesis that commodity transport costs are an important determinant of land-use intensity. The following
two chapters are concerned with the evaluation of the evidence for adjustment over space, while Chapter 5, the final chapter in Part 2, takes a broader view of the marketing, transportation and production problems of station operators in the Northern Territory between 1950 and 1967. Throughout the work the concepts of spatial price and production equilibrium are employed to further the argument and results are presented in terms situation and intensity rents.
CHAPTER 3

ACCESSIBILITY AND PASTORAL LAND DEVELOPMENT, 1950-1960
-- ADJUSTMENT TO OVERLANDING

'I don't suppose there is any other country in the world', said Emmanuel, 'where men can buy a kingdom stocked with 100,000 head of cattle for £27,000'.

'There is a catch in it somewhere', answered Kidman grimly. 'But if it is only distance and transport and inaccessibility, we can overcome all that in time'.

Idriess, The Cattle King

INTRODUCTION

Chapter 1 showed that the Northern Territory could be viewed as a single transport region and described briefly the progress of the beef industry from the early days of settlement to the start of the study period. The recommendations of official investigations into the problems of the Territory repeatedly stressed that improved transportation was the key to development but few projects were implemented. Hence, by the 1950s the industry had come to terms with a relatively static and primitive marketing system. This makes it particularly interesting to examine the patterns of consignment and land-use to see whether the level of property output was heavily influenced by poor accessibility. Chapter 2 looked at the theoretical relationship between variations in the comparative locational advantages of holdings and their intensity of land development. This suggested that von Thünen's model, in which location rents are generated as a result of differences in the farmgate prices of a commodity, would provide a suitable framework for the
empirical work. However, some of the constraints of the model complicate its application in real world situations and the effects of permitting variations in land quality, holding size and technology were considered. Data on the structure of the study industry was introduced which illustrated that many of its features favour the identification of location rents, while certain methodological problems were anticipated. Thus the ground has been prepared for the analysis of the evidence for adjustment to spatial variations in accessibility in the traditional era.

So far little attention has been paid to the definition of parameters to represent the independent variable in the rent theorem. Two surrogates of accessibility are available; actual rate payments for transport from the point of production to the local market, and the net received prices for the commodity. In the Isolated State these values were identical because transportation was assumed to be unimodal, deterioration losses were ignored, and all sales were made to a single central market. The first requirement is therefore to consider the implications of relaxing these constraints and to look at the problems that arise in formulating and using series of actual values for the holdings of the beef industry. This forms the subject of the first section of this chapter. The second section is concerned with the structure of the study industry in the 1950s and attempts to relate the spatial equilibrium concept to its particular assignment and supply characteristics. Commodity profits and gross output are partially determined by fluctuations in market prices and decisions on sales that are taken in the light of short-run considerations (often occasioned by climatic variability). These factors will tend to mask production response to spatial differences in accessibility so that it is desirable to assess their relative influence before proceeding to the empirical work which necessarily demands abstraction.

The final section evaluates the evidence for adjustment to spatial exchange and production equilibrium in the study industry under the traditional marketing system, using 1957
Table 1.1: Estimated average June fatstock prices at markets receiving Northern Territory cattle, 1950-1960 (imputed value for good quality stock dressing out at 500 lb)

<table>
<thead>
<tr>
<th>Year</th>
<th>Brisbane</th>
<th>Adelaide</th>
<th>Townsville</th>
<th>f.o.r Alice Springs</th>
<th>f.o.r Mt Isa</th>
<th>Wyndham</th>
<th>f.o.b Darwin (live)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>6.90</td>
<td>7.50</td>
<td>5.90</td>
<td>5.50</td>
<td>5.06</td>
<td>5.50</td>
<td>-</td>
</tr>
<tr>
<td>1951</td>
<td>7.90</td>
<td>11.00</td>
<td>6.90</td>
<td>8.52</td>
<td>5.68</td>
<td>6.00</td>
<td>-</td>
</tr>
<tr>
<td>1952</td>
<td>12.10</td>
<td>17.60</td>
<td>10.20</td>
<td>15.12</td>
<td>8.98</td>
<td>9.60</td>
<td>-</td>
</tr>
<tr>
<td>1953</td>
<td>12.80</td>
<td>10.80</td>
<td>10.40</td>
<td>8.32</td>
<td>9.18</td>
<td>10.40</td>
<td>-</td>
</tr>
<tr>
<td>1954</td>
<td>13.00</td>
<td>17.00</td>
<td>11.00</td>
<td>14.52</td>
<td>9.47</td>
<td>11.20</td>
<td>8.00</td>
</tr>
<tr>
<td>1956</td>
<td>12.00</td>
<td>12.60</td>
<td>9.03</td>
<td>10.12</td>
<td>7.50</td>
<td>10.00</td>
<td>-</td>
</tr>
<tr>
<td>1957</td>
<td>13.00</td>
<td>13.00</td>
<td>9.23</td>
<td>10.52</td>
<td>7.51</td>
<td>9.94</td>
<td>8.20</td>
</tr>
<tr>
<td>1958</td>
<td>15.10</td>
<td>16.80</td>
<td>9.59</td>
<td>14.32</td>
<td>7.87</td>
<td>9.20</td>
<td>8.20</td>
</tr>
<tr>
<td>1959</td>
<td>20.50</td>
<td>19.90</td>
<td>15.43</td>
<td>17.42</td>
<td>13.71</td>
<td>10.40</td>
<td>8.40</td>
</tr>
<tr>
<td>1960</td>
<td>20.00</td>
<td>24.00</td>
<td>16.74</td>
<td>21.52</td>
<td>15.02</td>
<td>11.40</td>
<td>7.40</td>
</tr>
</tbody>
</table>

Sources: Brisbane and Adelaide, Annual Reports of the Australian Meat Board, (refer to 1st and 2nd export quality oxen and heifers 650-700 lb.; Townsville, June 'reports of country stock sales', Queensland Country Life; Wyndham and Darwin, NTAAIB Annual Reports (assumes animals dress at 500 lb.).
as a typical year. The analysis of the consignment pattern is based on a comparison between the actual allocation and a normative total least-cost solution generated by the Transportation Problem. This leads to certain inferences on the importance of transport payments and market prices in the consignment decisions of station operators, and the likelihood that spatial price equilibrium will arise in reality. The discussion then moves on to consider production using correlation and regression analyses. The correlation matrix relates the indices of accessibility to the intensity of output per unit of land on properties. This is therefore designed to test the hypothesis that this factor is the main determinant of the pattern of land-use. The regression models utilise the theoretical herd size series as a second independent variable to assess how far accessibility conditions property scale when some account is taken of the influence of variations in land quality and holding size. The quality of the data for 1957 is relatively low which circumscribes the conclusions that can be drawn from the work, but the results do point up some aspects of the relationship between transportation and land development while setting the scene for the more detailed analyses that follow in Chapter 4.


1. The Isolated State model and multiple markets

Von Thünen assumed that all consignments in the Isolated State were transported to a single central market which held a monopsony and was in turn supplied solely from the bounded plain that surrounded it. Within this closed system he had only to assume final crop consumption and the price of a single product to be able to derive the market prices of all other crops, their areal extent, and the optimum sequence of cultivation. Additionally the model generated the optimum intensities of production of individual crops within land-use zones. The study problem is restricted to the latter relationship in a situation where accessibility
to markets is a complex phenomena and none of von Thünen's conditional assumptions hold.

As Dunn has shown, multiple markets can be accommodated in the model without affecting the process of adjustment. Further, Lösch has demonstrated that the introduction of imports into the system does not destroy the logic of the rent succession from a central market. Neither author considers the case where final demand is exogenous and the production of the supply area is of marginal importance to total consumption. This is true of the study area where the market for beef from the Northern Territory is a small part of the market for Australian meat, which itself is one sector of the pattern of world demand. During the decade under study gross national production of beef averaged approximately 700,000 tons, of which the Northern Territory supplied about 15,000 tons from cattle that were finally turned off in South Australia and Queensland. In this case the von Thünen's central city is replaced by a series of intermediate demand centres that clear supplies from the Northern Territory and distribute them to the domestic and export markets. Here the fact that the production area occupies a marginal location with respect to final demand might be expected to make local variations in accessibility particularly important.

This aspect of the marketing system does not directly concern the arguments of this thesis, which views demand entirely in terms of the exogenously determined prices obtaining at the terminals where initial transfers may take place. Between 1950 and 1960 two major outlets were available for Territory fatstock -- the South Australian market, where there is evidence of a consistent short-fall in supplies for home consumption, and the north Queensland

1 Dunn, E.S., The Location of Agricultural Production, Gainesville, 1954, pp.57-63.
market which is primarily export orientated. All animals moving to these areas had to be railed from Alice Springs or Mt Isa, or associated railheads on the same lines. Some seventy-five per cent of cattle consigned for slaughter were dispatched to these two States and the remainder were sold to the Wyndham meatworks (Western Australia), or were shipped live from Darwin to Southeast Asia. Hence four centres represented total demand, each of which can be compared to a subsidiary town in the Isolated State. As Dunn has commented of processing plants in spatial equilibrium, 'each one will become the focal point for a new supply radius, shorter than that of the central market, but extended beyond its limit. This will give a scalloped appearance to the market boundary'.

Given the possibility of including multiple markets in the model and extending the analogy to the study region, it is possible to visualise iso-rent rings around the four centres which are consequent on producers maximising the farmgate prices of their animals. In theory the location of supply area boundaries will be conditioned by market prices given that transport costs are a function of distance alone. Table 3.1 shows the price structure that was available to producers for above average fatstock over the decade. In the empirical work that follows it has been assumed that these price series also governed the consignment of store cattle which made up sixty-eight per cent of gross production in the five years for which figures are available. This seems justifiable because store cattle values are derived from the demand for slaughter animals and, due to company linkage with fattening properties in Queensland, there was a very poorly developed store market so that price information is sparse. The main influences on beef prices

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1 Dunn, E.S., 1954, p.59.
2 These years were the financial years ending in June 1954, 1955, 1958, 1959 and 1960. The data are taken from the Annual Reports of the NTAAIB.
can be observed in the series for Brisbane. This is the major market for Queensland which supplied over one-third of national production and between sixty-five and seventy-five per cent of Australia's exports over the decade. Broadly, three trends are reflected in the series. First, between the base years, apparent per capita consumption of meat in Australia fell by thirty-six per cent resulting in the slow growth of home demand as the population rose. Second, from 1952 onwards producers were guaranteed stable prices by the operation of the Australian–United Kingdom Meat Agreement. Finally, in 1958 the export of lower quality beef to the United States commenced and this led to a considerable rise in prices particularly for boner quality animals. These trends are mirrored in the series for the centres taking Northern Territory supplies, though their individual characteristics condition the timing of response.

The location of these markets and their relationship to the properties of the study industry is shown in Map 2.1. The free on rail prices at Alice Springs and Mt Isa have been constructed by debiting the cost of railage to Adelaide and Townsville, respectively (assuming 18 cattle per wagon). In cases where it is possible estimates refer to the average for June of each year since producers must make their consignment decisions mid-year, following mustering at the end of the Wet Season (in May). The price series for Townsville has been calculated from newspaper reports of sales of bullocks and steers. It shows that there was an average shortfall of $2.87 per 100 lb under the Brisbane price which may be partially explained in terms of higher processing costs and a throughput of poorer quality cattle. With a rail cost of approximately $2.71 from Mt Isa to

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For further information on the general situation in the Australian beef industry during the decade see the relevant annual issues of the Beef Situation, BAE, Canberra, and the Annual Reports of the Australian Meat Board, Sydney.
Brisbane in 1957, as compared with $1.72 to Townsville (per eventual dressed weight), there would seem to have been a slight margin in favour of dispatch south in most years. However, this differential would have been absorbed by spelling (i.e. resting) fees and the deterioration of cattle over twice the mileage (1,439 rail miles as against 602 miles to Townsville). Comparison with the Cannon Hill series indicates an increasing disparity in prices over the decade and a marked lag in response to new demands.

The average June prices at Adelaide show a consistently firm demand for beef in South Australia. Over the ten year period the series never fell below the Brisbane price and differed by as much as $4.00 per 100 lb in 1954. From 1951 onwards freight charges per beast averaged $12.40 ($2.48 per 100 lb) from Alice Springs to Adelaide with the result that in four out of eleven years the f.o.r. price at this terminal exceeded the Brisbane average. This conclusion suggests that it is unlikely that rail charges inhibited development in the Alice Springs District during this period; for in terms of national demand the net received prices of many producers in the Alice Springs District would place their properties among the more 'accessible' in Australia.

Of the two remaining markets open to the Northern Territory, only the Wyndham meatworks can be regarded as offering a stable outlet. The price series has been constructed from the yearly average valuations of exports given in the Northern Territory: reports. It is assumed that the beasts slaughtered dressed out at 500 lb. As Table 3.1 shows, the United Kingdom market enabled the meatworks to offer attractive prices that were often above those of Townsville until the advent of the United States trade in 1958. Finally, exports through Darwin to the

---

1 Correspondence with Queensland Railways, March 1968. Adjustments have been made for rail charge increases in 1951, 1954 and 1957 in the estimated f.o.r. series for Mt Isa shown in Table 3.1.
Philippines brought returns which were low and unreliable due to the sporadic nature of demand. However, this market cannot be discounted since producers of fatstock in the Top End had limited access to alternative outlets because of the poor mobility characteristics of droving.

This introduction to the price structures affecting Northern Territory producers between 1950 and 1960 shows that this element of the comparative locational advantages of properties was relatively unstable over time. This means that farmgate price indices calculated for a particular year for the holdings within one supply area might be atypical. Further, there are grounds for supposing that production adjustment would be medium-term so that lags in response to price changes would be expected. No account has been taken of these factors in this chapter because the basic data does not justify further refinement. It is believed that the figures for 1957 (the representative year) present a valid picture of the attraction of alternative centres. Two additional points may be noted from the figures given in Table 3.1. First, since prices increased at all centres over the decade it is reasonable to infer that transport costs became relatively less important in consignment decisions. Second, the differential between the markets widened so that producers nearest the high-price centres would gain a further advantage. These inferences suggest that particular attention should be paid to the role of price in exchange and production in the empirical work.

2. The inclusion of variable rate costs

Von Thünen assumed that all commodity movements were made by the same mode and that unit transport costs were a direct function of distance from the central market. Different modes of transport have individual mobility characteristics so that it is convenient to examine farmgate prices under one form of movement to avoid the need to take account of external economies. Throughout the study decade droving was the dominant method of transport in the Territory, though between 1956-57 and 1959-60 the proportion
of the total export turn-off that was marketed by road transport rose from 3.3 to 38.5 per cent. In 1957 less than fifteen per cent of all sales were consigned to local markets by road, and nearly all the users were properties in the Alice Springs District. In the work that follows, it has been assumed that all consignments were made on-the-hoof, and this seems justifiable in the light of the local and small-scale influence of the new mode.

Although droving is possible over wide areas when feed and surface water are present, movements are constrained by the spacing of bores and dams in many years. Between 1946 and 1964 the NTA provided ninety-five waters along the gazetted stock-route network, and some reserves were fenced. It is therefore reasonable to measure the distance between properties and their favourite markets via the available net. Map 3.1 shows the distribution of facilities and the names of the declared routes. To provide a matrix of rate payments between origins and destinations the distances were measured at a scale of 1:2,000,000. These values have been retained as a subsidiary parameter of holding accessibility. Rate payments were calculated from this data by applying the charges shown in Table 3.2. The table shows that it was about fifty per cent more costly to move fat rather than store cattle. This is due to the greater care demanded of drovers. Charges also varied with mob size and the duration of the trek and these factors have been incorporated in the index by utilising knowledge of the turn-off of properties in 1957. It is interesting to note that the droving profession appeared to have some rudimentary notion of charging what the traffic would bear, for the variations between regions are difficult to explain unless reference is made to the final prices for stock at alternative centres.

1 Annual Reports of the NTAAIB.
3 A mechanical distance measurer was employed. The base map was the Northern Territory Pastoral Map, Department of the Interior, Canberra (1965).
Table 3.2: Rate costs for moving different types of consignments by droving, c. 1958

<table>
<thead>
<tr>
<th>District</th>
<th>Destination</th>
<th>Distance</th>
<th>Mob size</th>
<th>Cost per head per 100 miles ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alice Springs</td>
<td>Alice Springs (stores)</td>
<td>&lt;300</td>
<td>&lt;600</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>(fats)</td>
<td></td>
<td></td>
<td>1.50</td>
</tr>
<tr>
<td>Barkly Tableland</td>
<td>Queensland (stores)</td>
<td>&gt;150</td>
<td>&gt;1,000</td>
<td>0.50</td>
</tr>
<tr>
<td>Victoria</td>
<td>Queensland (stores)</td>
<td>&gt;700</td>
<td>&gt;1,000</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>Wyndham (fats)</td>
<td>&gt;300</td>
<td>&gt;600</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>&lt;300</td>
<td>&gt;600</td>
<td>0.83</td>
</tr>
<tr>
<td></td>
<td>all</td>
<td>&lt;600</td>
<td></td>
<td>0.90</td>
</tr>
<tr>
<td>Darwin and Gulf</td>
<td>Katherine (fats)</td>
<td>&lt;150</td>
<td>&lt;600</td>
<td>0.90</td>
</tr>
</tbody>
</table>

Source: The Economics of Road Transport of Beef Cattle, BAE, Canberra, 1959.

Fig. 3.1a shows the frequency distribution of droving payments for the 118 holdings that marketed cattle in 1957. The average payment was about $1.86 per head with an estimated maximum of $10.80 for remote properties on the Gulf coast which sent small numbers of stores to Queensland. The distribution is skewed like those presented in Chapter 2 which confirms the need to duplicate analyses for raw and log-transformed data. The rate cost values for each holding can be combined with the price information shown in Table 3.1 to give an index of farmgate prices. Here it has been found convenient to use the highest price location (the Alice Springs terminal) as a basing point and to express received price differences as negatives (the distribution of this parameter is shown in Fig. 3.1b). Thus both the rate cost and farmgate prices series would vary inversely with intensity in a normative model. Neither of these measures
Map 3.1: The location of stock-routes and transportation facilities in the Northern Territory, 1957.

Fig. 7.1. The incidence of estimated payments (in 1957) for droving services and farmgate price differentials in the 118 active holdings.

A

DROVING RATE PAYMENTS

Number of properties

Payment per holding 1957
($ per beast)
(118 active holdings)

B

NET RECEIVED PRICE DIFFERENTIAL

Number of properties

Price difference per holding, 1957
($ per beast)
(118 active stations)
give any weight to deterioration losses. Fatstock frequently lost 40 to 50 lb in dressed weight on their walk to processing plants or railheads. However, the incidence of these costs depended upon the skill of drovers and feed conditions on the stock-routes, so that they cannot be taken into account in a systematic manner at the industry level. However, the stock-route distances between origins and destinations are known and this gives some opportunity to examine the impact of mode characteristics on production, for it is reasonable to assume that deterioration costs will vary with the distance that mobs travel, over a range of consignments. In summary, indices of comparative accessibility have been calculated which allow the empirical work to proceed.

B. TEMPORAL INFLUENCES ON LOCATION RENTS, 1950-1960

1. The determinants of commodity profits

Some appreciation of the likelihood of location rent differences arising in reality can be gained from an analysis of the cost and profit structure of the dependent industry. Despite the breadth of the surveys of the Northern Territory beef industry by Kelly and Beattie during the study decade, there is little published information on the composition of property costs. Only one source is of value. In 1953 the BAE published the results of a survey undertaken in 1950 which provided base statistics for an index of cost movements required in the operation of the meat agreement with the United Kingdom. The sample was non-random and biased towards the bigger enterprises. It covered fifteen stations -- nine in the Alice Springs District, four on the Barkly Tableland, and one each in the Victoria River and Darwin and Gulf Districts.

1 Deterioration losses are examined in greater depth in Chapter 6.
Table 3.3: The level and composition of costs, station average, 1949-50 (sample of fifteen enterprises)

<table>
<thead>
<tr>
<th>Item</th>
<th>Average cost in dollars</th>
<th>Percentage of total costs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Materials</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel</td>
<td>1,441</td>
<td>7.5</td>
</tr>
<tr>
<td>Seed Fertiliser</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pest Destruction</td>
<td>103</td>
<td>0.5</td>
</tr>
<tr>
<td>Livestock Supplies</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Repairs</td>
<td>3,485</td>
<td>18.0</td>
</tr>
<tr>
<td><strong>Total materials</strong></td>
<td>5,029</td>
<td>26.0</td>
</tr>
<tr>
<td><strong>Services</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freight (inward)</td>
<td>977</td>
<td>5.1</td>
</tr>
<tr>
<td>Insurance</td>
<td>178</td>
<td>0.9</td>
</tr>
<tr>
<td>Rates and Taxes</td>
<td>142</td>
<td>0.8</td>
</tr>
<tr>
<td>Rent</td>
<td>526</td>
<td>2.7</td>
</tr>
<tr>
<td>Plant Hire</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Agistment</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>701</td>
<td>3.6</td>
</tr>
<tr>
<td><strong>Total services</strong></td>
<td>2,524</td>
<td>13.1</td>
</tr>
<tr>
<td><strong>Labour</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wages</td>
<td>7,753</td>
<td>40.7</td>
</tr>
<tr>
<td>Rations</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Contract</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Operator's Labour</td>
<td>1,490</td>
<td>7.2</td>
</tr>
<tr>
<td><strong>Total labour</strong></td>
<td>9,243</td>
<td>47.9</td>
</tr>
<tr>
<td><strong>Depreciation</strong></td>
<td>2,513</td>
<td>13.0</td>
</tr>
<tr>
<td><strong>TOTAL COSTS</strong></td>
<td>19,310</td>
<td>100.0</td>
</tr>
</tbody>
</table>

The cost structure of the sample is given in Table 3.3 in a reworked form to permit comparisons with more recent BAE data (for instance, see Table 2.3). Wage and management payments accounted for about half of total costs. This illustrates the fact that operators could adjust production scale quickly by varying inputs of labour for cattle mustering. Depreciation on investment in plant was relatively unimportant in this period so that the production function can be viewed as being both simple and flexible. This makes it possible that supply response was relatively elastic with respect to spatial and temporal variations in prices.

Table 3.4 presents data from the same source on the capital structure of the industry. The cattle on the properties have been valued at $21.00 per head (the rate quoted for breeders in the BAE index). The figures show that livestock made up the greater part of the total investment of holdings, and point to a low level of expenditure on improvements. This suggests that the industry was very dependent upon the natural resource base at this time. One further point may be noted; the magnitude of the total capital held by individual enterprises makes it likely that their operations were purely commercial. This is important when considering the utility of von Thünen's model, for family farmers who gain non-economic rewards from agriculture would probably not set their scale of production by efficiency criteria.

Following from the tabulations that have been presented, it is possible to make a rather speculative assessment of holding returns, on the assumption that the sample properties can be allocated turn-off and gross proceeds from sales in proportion to their share of the total Territory cattle population (approximately one million in 1949-50). Table 3.5 gives the results of this procedure. The figures show that the level of return to capital among the sample holdings was relatively high, though the limitations of the data must be borne in mind. However, it is interesting to use this
Table 3.4: The level and composition of capital investment, station average, 1949-50

<table>
<thead>
<tr>
<th>Capital item</th>
<th>Value ($)</th>
<th>Percentage of total investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Made waters</td>
<td>10,941</td>
<td>5.2</td>
</tr>
<tr>
<td>Fencing</td>
<td>4,345</td>
<td>2.0</td>
</tr>
<tr>
<td>Yards and buildings</td>
<td>5,771</td>
<td>2.7</td>
</tr>
<tr>
<td>Plant and machinery</td>
<td>7,591</td>
<td>3.6</td>
</tr>
<tr>
<td>Total (excl. cattle)</td>
<td>28,648</td>
<td>13.5</td>
</tr>
<tr>
<td>Cattle</td>
<td>182,867</td>
<td>86.5</td>
</tr>
<tr>
<td>TOTAL CAPITAL</td>
<td>211,515</td>
<td>100.0</td>
</tr>
</tbody>
</table>

structure to gauge the effects of spatial variations in farmgate prices. The tables show that the average property payment for transport was $5.90 per beast sold. The return to capital and management income for a holding with the same structure that was located at the market would have been about 11.4 per cent, while payments of $20.00 per beast would reduce returns to 1.1 per cent. This illustrates that rate payments and local variations in market prices could exert a critical influence on the profitability of land-use and makes it reasonable to suppose that less favoured operators would seek to minimise their disadvantage by adjusting their scale of production.

Although it would seem that transport costs were an important determinant of unit returns at the start of the decade, it is necessary to consider the relative influence of temporal variations in costs and profits to set the spatial equilibrium hypothesis in perspective. Figure 3.2 presents the cost index that was calculated on a yearly basis by the BAE as a basis for the renegotiation of prices under the Australian-United Kingdom Meat Agreement. The cumulative change is plotted with the percentage yearly movement in the average Cannon Hill price over the decade.
Table 3.5: The estimated net income structure of holdings, 1949-50

Basis of estimate:

<table>
<thead>
<tr>
<th></th>
<th>1949-50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cattle on sample properties</td>
<td>130,000</td>
</tr>
<tr>
<td>Number of cattle in the Northern Territory</td>
<td>1,019,000</td>
</tr>
<tr>
<td>Estimated value of Territory turn-off</td>
<td>$5,000,000</td>
</tr>
<tr>
<td>Estimated Territory turn-off (head)</td>
<td>125,000</td>
</tr>
<tr>
<td>Assumed turn-off of sample properties (head)</td>
<td>1,083</td>
</tr>
<tr>
<td>Assumed average market price</td>
<td>$40</td>
</tr>
</tbody>
</table>

Calculated structure:

<table>
<thead>
<tr>
<th>Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A Cash Income</td>
<td>43,333</td>
</tr>
<tr>
<td>B Cash Costs (all costs including outward freight, less operators labour allowance and depreciation)</td>
<td>21,687</td>
</tr>
<tr>
<td>C Net Cash Income (A-B)</td>
<td>21,646</td>
</tr>
<tr>
<td>D Description</td>
<td>2,513</td>
</tr>
<tr>
<td>E Net Farm Income (C-F)</td>
<td>19,133</td>
</tr>
<tr>
<td>F Operator's Labour Allowance</td>
<td>1,490</td>
</tr>
<tr>
<td>G Capital and Management Income</td>
<td>17,643</td>
</tr>
<tr>
<td>H Total capital</td>
<td>211,515</td>
</tr>
</tbody>
</table>

Percentage Return to Capital and Management Income 8.3

Sources: a, Northern Territory: report, 1949-50; and Tables 3.3 and 3.4.

On the twin assumptions that the production function remained static over the ten year period and that the price series reflects the trends on the South Australian and Queensland markets, it is possible to draw certain conclusions about movements in returns per beast sold.

Between 1950 and 1958 total costs rose by eighty-three per cent by which time prices had begun to respond dramatically to the American export market. It would appear that the early 1950s were a period of relatively stable income followed by three poorer years from 1955 to 1957. However reference to Table 3.1 indicates that properties
Fig. 3.2: Index movements of costs and prices in the Australian beef industry 1949-50 to 1959-60

in the orbits of the Wyndham and Darwin markets would have been faced with a cost-price squeeze in the late fifties. The implications of these trends are that transport costs probably became less important in the structure of returns for properties other than those tied to northern markets. However it seems that accessibility in the wider sense of access to high price markets probably became more critical as a determinant of spatial variations in returns. Though these conclusions are relevant to the hypotheses under consideration, a further point must be made on the strictly non-spatial aspect of the cost-price relationship. Spatial equilibrium demands that producers are sensitive to differences in net received prices which are locationally determined and this suggests that temporal elasticity of supply should be evident where this is true. Consider two producers in the South Australian supply area, at the nearest and most distant locations from the railhead at Alice Springs. The supplier on the market boundary will pay droving charges of approximately $2.00 per beast which would accrue to a comparable operator near the market as a profit. However during the decade prices rose by $75.00 per beast f.o.r. Alice Springs. Further, market price fluctuations between years and often between months exceeded the differentiation caused by transport costs. The reasonableness of the location rent theorem therefore depends upon the existence of a long-run adjustment to a stable pattern of comparative accessibility. Clearly the magnitude of temporal variations in market prices suggests that location may be of secondary importance amongst the constellation of decisions on factor use and scale that managers must make. This does not affect the argument that transport costs will affect situation rents but it does mean that intensity rent responses may be obscured by more general supply considerations.

2. The determinants of property output

As has been noted the immediate causes of variations in land rents are differences in the net return per unit of
output and the gross production of individual holdings. The following section considers the temporal influences which condition the level of production of properties. Ideally all firms should be in long-run equilibrium so that the statistics for their gross annual output, which are used to identify traces of adjustment to location in the third section of this chapter, would reflect a totally rational choice of intensity of land-use. In practice short-run considerations may be extremely important in maximizing the use of all available resources. The factors which may lead producers to market cattle are

(i) Supply considerations:
   (a) the need to destock following a run of good or bad seasons;
   (b) the need to sell stock to cover short-term illiquidity;
   (c) the need to dispose of stock due to an imbalance in the herd structure;
   (d) the disposal of stock on the transfer of a holding.

(ii) Demand considerations:
   (a) response to short-term specialist demands;
   (b) response to a long-run increase in market prices;
   (c) response to a change in comparative accessibility.

All the causes of cattle sales which have been enumerated may overlap so that the coincidence of a local demand for store cattle to restock a station may suit a neighbouring operator who wishes to reduce his stocking rate or service a debt. Hence it is impossible to classify movements to separate the properties that are only influenced by long-run consideration of unit returns. In addition it is easily appreciated that, even in the absence of supply considerations, the adjustment of production to a new demand structure or a change in accessibility to markets may require a considerable time period. In the case of a property responding, for instance, to an immediate increase in fat-stock prices it would take the operator at least two years to change from a specialisation in store production, and
during this period the operator would forego income. If the same property were to aim at long-term adjustment to the new price structure it would require a change in herd composition and the reorganisation of the input mix which would show results over a far longer span.

The dynamics of the production function are therefore complex and consideration will be restricted to response to two factors -- short term movements in prices and the impact of drought. The influence of temporal variations in unit commodity returns has been detailed in the first part of this section. It is immediately obvious that short-term fluctuations in market prices may tempt some operators to mine their cattle resources to gain windfall profits. These properties will therefore show an abnormally high output for a few years. Signs of elasticity of supply of this form may be observed in Fig. 3.3 which graphs the total production of the Northern Territory over the study period. Here an upswing in production in the late fifties corresponds to the general rise in prices occasioned by the opening of the United States market for boner quality beef. However, the fall in total production in the early 1960s shows that the response could not be maintained. A break-down of production between supplies to the South Australian and Queensland markets suggests the reason for the absence of a regular response to price. These two supply areas are almost discrete with the former being restricted to properties in the Alice Springs District and the latter being supplied primarily from the Barkly Tableland with some additions from the remaining two regions. It appears that the peaks of the main distribution are occasioned by abnormalities in one of the other of the sub-systems, and these seem to result from the effects of drought.\footnote{The relative effects of climatic variations and demand on supply response at the national level have been discussed by Patterson, R.A., 'The influence of Rainfall on Beef Cattle Numbers', \textit{Quarterly Review of Agricultural Economics}, 10 (1957), pp.16-21, and Bennet, A.G., 'The Effect of Recent low Slaughterings on Beef Cattle Numbers', \textit{Quarterly Review of Agricultural Economics}, 12 (1959), pp.139-145.} Thus in the first half of the
Fig. 3.3: Variations in the level of total sales in the Northern Territory, 1949-50 to 1966-67

Source: NTAAIB Annual Reports.
decade there were fluctuations within the Queensland supply area following a succession of bad years in the north of the Northern Territory from 1951 to 1954. In contrast a run of normal years in the Alice Springs District over the same period seems to have produced a relatively stable output.  

Broadly, 1956 can be counted as a good year for the whole of the Northern Territory but this was followed by a succession of bad years in the Alice Springs District which marked the start of an eight-year drought. The effect of this disturbance can be seen in the turn-off figures which show peaks caused by the sale of store stock to reduce pressure on feed. Again contrasting with this trend is the relatively stable contribution to the Queensland market under more favourable seasonal conditions. These conclusions would tend to support the view that production in the Northern Territory is in part in an ecological rather than an economic equilibrium. In so far as the empirical work that follows is affected it is reasonable to view the 1957 season as fairly normal for both supply regions. The analysis then proceeds on this assumption, but the analyses of spatial equilibrium should be set in the context of the temporal influences on production that have been described here.

C. EXCHANGE AND PRODUCTION IN 1957 -- EVIDENCE OF ADJUSTMENT TOWARDS SPATIAL EQUILIBRIUM

Spatial equilibrium in agriculture has three basic components. The first is the determination of exchange equilibrium within a bounded system given known levels of production from each supply point and known demands at processing centres. This leads to the minimisation of total transport costs and the generation of situation rents. The second problem involves the resolution of equilibrium outputs for every supply point under a given structure of net received

1 Rainfall incidence is shown on the Annual Rainfall Maps of Australia¹, Bureau of Meteorology, Melbourne, (annual).
prices. This leads to the maximisation of producers profits, and the sum of property rents. Finally there is a third problem in which the system is directed towards the minimisation of the sum of transport and processing costs by the identification of optimal locations for the commodity processing industry. Only the first two components will be considered in this section -- the final problem being delayed until Chapter 5, which is concerned with some of the dynamics of the accessibility function.

1. Spatial influences on commodity returns

   a. Exchange equilibrium and the minimisation of transport costs

   The extension of the von Thünen's model to the study industry has been based on the assumption that property net received prices, or marginal returns, result from a rational appreciation of alternative markets by producers. In the Isolated State farmers had no choice in allocation so that farmgate prices were a linear function of distance from the central market. However, it is easily appreciated that spatial price equilibrium will arise in any bounded system where producers maximise net returns. Thus, in discussing the extension of the model, von Thünen states

   ... local farmers, who have the constant choice of sending their grain to the capital or to the local town, will sell their grain locally if the small town pays for it the price it fetches at the capital less the cost of transport; i.e. its value on the farm. ¹

   The degree to which this condition is met in reality gives an important guide to the role of transport costs in consignment and production decisions. This in turn allows inferences to be drawn on the probable effects of improvements in transportation on the intensity and profitability of land-use. Before these assessments can be made for an industry it is necessary to take account of mobility constraints on consignment. Then the efficiency of the actual exchange

system may be measured by comparing its price structures with those of a normative solution.¹

Table 3.6 shows the basic structure of production in the whole of the study industry for 1957 (calendar year). The composition of turn-off appears to be fairly typical of the preceding seven years with consignments of store stock making up over half the total trade. The pattern of

Table 3.6: The Composition and allocation of turn-off in 1957

<table>
<thead>
<tr>
<th>Destination</th>
<th>Fats</th>
<th>Stores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Queensland</td>
<td>15,735</td>
<td>63,489</td>
</tr>
<tr>
<td>South Australia</td>
<td>24,844</td>
<td>13,639</td>
</tr>
<tr>
<td>Wyndham</td>
<td>4,005</td>
<td>-</td>
</tr>
<tr>
<td>Philippines (live)</td>
<td>999</td>
<td>-</td>
</tr>
<tr>
<td>Darwin town consumption</td>
<td>6,000</td>
<td>-</td>
</tr>
<tr>
<td>Alice Springs town consumption</td>
<td>1,000</td>
<td>-</td>
</tr>
<tr>
<td>Other Northern Territory consumption</td>
<td>17,775</td>
<td>-</td>
</tr>
<tr>
<td>Total apparent production</td>
<td>70,358</td>
<td>77,128</td>
</tr>
</tbody>
</table>

Other movements:

<table>
<thead>
<tr>
<th></th>
<th>Fats</th>
<th>Stores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imports from Western Australia</td>
<td>-</td>
<td>8,109</td>
</tr>
<tr>
<td>Intra-Territory transfers</td>
<td>-</td>
<td>20,378</td>
</tr>
</tbody>
</table>

a. estimated

Sources: NTAAIB stock permits, NTAAIB Annual Reports 1956-57 and 1957-58, and Quarterly returns from the NTAAIB to the Commonwealth Statistician (unpublished).

allocation shows the dominance of exports to Queensland, while sales to the Wyndham meatworks and consignments to the Philippines were of small importances. Since intra-Territory transfers between properties were highly diverse,

¹ Transportation Problem solutions for the allocations discussed in this thesis have been calculated by the MODI method, as described by Hadley, G., Linear Programming, Reading, 1962, pp.273-322, using a programme developed by IBM, on the Australian National University's IBM 360/50 computer.
it is only possible to consider movements to four markets and these can be represented by the towns of Mt Isa, Alice Springs, Wyndham and Darwin. Thus the problem is to assess the role of transport costs in the determination of the supply area boundaries of these centres. Data on the origin of supplies has been drawn from an examination of the 685 stock permits issued during the turn-off season. Although this record is unreliable in detail, it is believed that it presents a valid picture of the exchange system in the study year, for checks against published and confidential quarterly aggregations revealed no significant discrepancies. Map 3.2 shows the size and destinations of the consignments of the 118 holdings from the basic station population that contributed cattle to the four major markets. Local consumption at Darwin and Alice Springs has been added to their through-shipments.

The most obvious feature of the exchange pattern is the relatively discrete character of supply area boundaries. In the case of consignments to the South Australian market, the boundary was determined by the location of the line (the 'pleuro line' in Map 3.1) which separated the Central Australian Pleuropneumonia Protected Area (C.A.P.P.A.) from the remainder of the Northern Territory. The Area was declared in 1956 and imports of cattle from districts in which the disease was endemic were prohibited. Hence the South Australia supply area, which corresponds fairly well with the Alice Springs District, can be treated as a separate marketing system. In the three northern Districts, Queensland took about eighty-seven per cent of the total turn-off and the influence of this market extended for over 900 stockroute miles from Mt Isa (to Auvergne station in the Victoria River District). Since movement by droving is associated with deterioration losses on fatstock, distance was a major determinant of the pattern of specialisation. This point will be considered later in this section. For producers on the margins of this market, there were opportunities to sell fats to the Wyndham meatworks (in the north-west) and to the Manila trade (in the Top End).
seen on the map, Wyndham drew some supplies from Montejinni station (some 350 miles distant), while cattle travelled 550 miles from Helen Springs to Darwin. In the latter case, the consignments were transported by rail from Larrimah junction and the presence of the north-south line goes some way to explain the southern attenuation of this supply area.

Having considered some of the basic influences on the actual pattern of exchange, it is possible to compare it to a normative solution in more abstract terms. A total least-cost allocation can be calculated by solving the Transportation Problem by linear programming. The requirements are that total shipments equal gross consumption and that the costs of transporting the traded good from each origin to each potential destination are known. The rate cost payment series described in the first part of this chapter has been used to build up a matrix of transport costs under droving. It is important to note that the Problem assumes special economic conditions

Specifically, it characterises the case in which a specific crop has been harvested, storage cannot be expanded and consumer purchases are invariant for a wide range of prices. Under the assumption of competitive markets, shipments are made as long as transport costs are covered. Market prices are determined by the cost of making the marginal shipments to each market, and the distribution pattern will be such that net revenue will be a maximum for each supply point.¹

In addition, it is based on the premise that all consignments take place in response to a single set of demand

Map 3.2: The actual allocation of stock between markets, 1957.

Source: NTAAIB stock permit data.
conditions, while it is assumed that the traded good is homogeneous and does not deteriorate in transit.¹

No break-down is available between fat and store sales at the holding level for the whole industry in 1957. Consequently all stock are taken as being of uniform quality which circumscribes the conclusions that can be drawn from a comparison of the actual and normative patterns. Map 3.3 shows the total least-cost allocation. Since producers are assumed to have perfect knowledge of market prices and make rational consignment decisions, there are no zones of overlap or indifference. Three points may be noted from the comparison of the maps. First, the similarity between the extent of the South Australia supply area in both cases is striking. This suggests that the pleuro-line merely reinforced the division between the southern and northern marketing systems. Second, the depth of the overlap zones of the Wyndham and Darwin trades on the Queensland supply area becomes apparent. The explanation here lies in the fact that their demands were for a different quality of cattle, so that some properties found it profitable to turn-off both fats and stores. Third, the comparison points up the western extension of the influence of the Queensland market in the Victoria River District. A major reason for this situation appears to have been the presence of company linkages and the practice of staging store movements by spelling cattle on depot stations on the Barkly Tableland. Thus stock from Auvergne were dispatched via Avon Downs to a Queensland fattening unit in the same organisation (Brighton Downs). The structure of marketing in this period will be considered in more detail in the first section of Chapter 5.

Map 3.3: The total least-cost (Transportation Problem) allocation of stock between markets, 1957.

Source: See text.
JOSÉPH
BONAPARTE
GULF

ARAFURA SEA

GULF OF CARPENTARIA

SOUTH AUSTRALIA

QUEENSLAND
At this stage certain broad conclusions may be drawn from the analysis. Visual comparison of the patterns suggests that there is a strong correspondence between the allocations and confirms that transport costs are an important consideration in consignment decisions. The correlation coefficient between the unit transport cost series of the two patterns is highly significant \( r = 0.94 \), while adherence to the normative solution would have saved only $250 in rate payments (slightly more than one per cent of the estimated industry transport payment to drovers). However, it is apparent that the demand schedules of the markets are more important in determining supply area boundaries than rate costs. It is obvious that, if transport payments were the main consideration, the boundaries could be drawn by centering Thiessen polygons on the four markets. This suggests that it is important to examine the role of price in consignment in more detail.

b. Exchange equilibrium and the maximisation of commodity net received prices

Some further deductions on the interaction between transport costs and demand can be drawn by comparing the farmgate price structures of the actual and normative patterns. Since store stock vary widely in quality it is impossible to formulate a consistent price series, so that the discussion must take place in the context of the figures given in Table 3.1. Gross receipts in 1957 for beasts of 500 lb dressed weight would have been

- $53.10 Alice Springs
- $37.55 Mt Isa
- $50.00 Wyndham
- $41.00 Darwin.

The difference between these prices would determine the choice of markets, taking account of rate payments, in a rational and uniform system. Thus a producer would weigh the $15.55 head differential between the Queensland and South Australian offers against the cost of droving cattle.
to the alternative terminals. In this case it is apparent from Fig. 3.1 that rate payments would be unlikely to tilt the balance in favour of Queensland. This points to the need to examine the relevance of the concept of spatial price equilibrium to the real world.

In equilibrium, supply area boundaries will meet where net received prices are equal. If \( v \) represents market prices at alternative centres \( j \) and \( k \), and \( t \) represents the rate costs paid on one unit of the commodity moving from the supplier \( i \) to \( j \) and \( k \), then

\[
(i) \quad v_j - t_{ij} = v_k - t_{ik} = 0
\]

and, where \( u \) is the farmgate price, the following relationship will hold for all movements,

\[
(ii) \quad v_x - u_y \leq t_{xy}
\]

These functions can be compared for the actual and normative price structures, at supply area boundaries. The relevant information is given in Table 3.7, where the subscripts \( a \) and \( n \) denote the two sets.

Table 3.7: Actual and normative fatstock price structures at supply area intersection points, 1957.

<table>
<thead>
<tr>
<th>Property</th>
<th>Destination of cattle</th>
<th>Pattern</th>
<th>( u )</th>
<th>( v )</th>
<th>( t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banka Banka</td>
<td>Queensland</td>
<td>(n)</td>
<td>-0.70</td>
<td>1.95</td>
<td>2.65</td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td>(a)</td>
<td>-2.65</td>
<td>0.00</td>
<td>2.65</td>
</tr>
<tr>
<td>&quot;</td>
<td>South Australia</td>
<td>(n)</td>
<td>-0.70</td>
<td>1.20</td>
<td>1.90</td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td>(a)</td>
<td>13.65</td>
<td>15.55</td>
<td>1.90</td>
</tr>
<tr>
<td>Victoria River</td>
<td>Darwin</td>
<td>(n)</td>
<td>-2.12</td>
<td>1.63</td>
<td>3.75</td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td>(a)</td>
<td>-0.30</td>
<td>3.45</td>
<td>3.75</td>
</tr>
<tr>
<td>&quot;</td>
<td>Wyndham</td>
<td>(n)</td>
<td>-2.12</td>
<td>-0.90</td>
<td>1.22</td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td>(a)</td>
<td>11.23</td>
<td>12.45</td>
<td>1.22</td>
</tr>
<tr>
<td>&quot;</td>
<td>Queensland</td>
<td>(n)</td>
<td>-2.12</td>
<td>1.95</td>
<td>4.07</td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td>(a)</td>
<td>-4.07</td>
<td>0.00</td>
<td>4.07</td>
</tr>
</tbody>
</table>

Sources: See text.
Since consignments in the linear programming solution are in perfect adjustment, the price at each market is pitched so that it just covers the transport costs of its furthest supplier. In the table, the marginal market price at the Alice Springs railhead is $1.20 per beast which is just sufficient to pay droving charges from Banka Banka, when account is taken of the negative farmgate price at this supply point. The equality of the normative sets at the two properties is also specified by the constraints of the problem. The $u$ and $v$ values are also known as the marginal value products or 'shadow prices' at the origin and destinations of movements.

The discrepancies between the actual and normative structures confirm that spatial price equilibrium was absent, assuming that the series give an accurate picture of local demand conditions, and permit an assessment of the degree of deviation. For instance, Banka Banka lost $16.30 per beast on consignments to Queensland which gives an indication of the economic effects of the declaration of the C.A.P.P.A. which excluded northern producers from shipping fatstock to Adelaide. In the remaining Districts, the relative role of the Wyndham market is interesting. It appears that its significant price advantage was insufficient to capture consignments destined for Queensland. Two explanations may be given here. The first, the influence of company linkages, has already been discussed. An alternative interpretation is that the rate of deterioration on fatstock moving to Wyndham was such that it offset the apparent price gain. If receipts for fats at Victoria River Downs ($48.78) are compared to offers for store stock for the Queensland trade of about $20.00, the poor mobility characteristics of droving become apparent. However, this explanation must be qualified and this problem is examined in more detail in Chapter 5. At this stage it is sufficient to note that direct spatial price equilibrium was not apparent in 1957, and that the demand schedules of the respective markets were the major determinants of the pattern of transport costs. These findings suggest that the best
means of improving the transport cost situation in 1957 might have been the introduction of additional processing plants.

2. **Spatial influences on gross output**

   a. Shadow prices and situation rents

   Both Stevens\(^1\) and von Böventer\(^2\) have drawn attention to the fact that the shadow price structures generated by the dual of the Transportation Problem can be interpreted as location rents. More specifically, the \( u \) values should be termed a measure of location rent per unit of marginal station production capacity. This theoretical construct is seen clearly in context when reference is made to the common ground between all exchange equilibrium models that has become obvious as the Thünen model has been developed in this thesis. For both the programming and actual allocation systems it would be possible to calculate property situation rents by aggregating the marginal differences in farmgate prices and expressing this value per unit of station area. Since the net received price differences are the variations in marginal returns which should influence producer's scale decisions, there seems little value in calculating these quantities.

   b. Variations in gross outputs and intensity rents

   Although the evidence on adjustment to exchange equilibrium casts some doubt on the operation of this portion of the theory, the results do not preclude the possibility that production could be in equilibrium with the actual structure of marginal returns. Hence producers could adjust their scale of operations to the farmgate prices that are

---

determined by their perception of alternative marketing opportunities. On the assumption that these values are an adequate surrogate for the opportunity costs of marketing, including the managerial decision, it is possible to test the hypothesis that intensity of land-use is, in part, a function of accessibility. According to the von Thünen's model both the form and scale of the production function may change within an industry in response to variations in marginal returns. Von Thünen demonstrates the existence of the first response by demarcating the boundaries of different systems of rye cultivation around the central market. In the study industry the analogous case is specialisation of properties in either store or fatstock production, though here both mobility and elasticity effects may operate in the choice of the form of output. It is therefore relevant to discuss the evidence for adjustment to variations in droving rate costs and distance from market centres.

It has proved possible to reconstruct the division between consignments of store and fat cattle in 1957 for the holdings that contributed stock to Queensland. The procedure involved some assessments so that the figures are not accurate in detail. Table 3.8 shows the results of classifying the output of the twenty-eight properties by distance zones from the Mt Isa railhead.

Zones 2 to 5 show a regular fall in the contribution of slaughter stock to the total production of properties, as distance from the market terminal increases. Zone 5 contains all sales from beyond the western edge of the Barkly Tableland, and here the mobility characteristics of droving over poor country preclude the dispatch of fat

1 The logical structure of the theorem that 'for every spatial location there is some jointly optimum intensity of land use, type of land use and group of markets, the selection of which by the agricultural entrepreneur leads to spatially ordered patterns of land use', is discussed by Garrison, W.L. and Marble, D.F., 'The spatial structure of Agricultural Activities', *Annals of the Association of American Geographers*, 47 (1957), pp.137-144.
Table 3.8: The composition of turn-off in the Queensland supply area in 1957, by distance zones

<table>
<thead>
<tr>
<th>Miles by stockroute from Mt Isa</th>
<th>Number of cattle marketed</th>
<th>Number of properties</th>
<th>Average property turn-off</th>
<th>Percentage of fats in turn-off</th>
<th>Number of fats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1: 100-200</td>
<td>11,891</td>
<td>3</td>
<td>3,964</td>
<td>26</td>
<td>3,124</td>
</tr>
<tr>
<td>Zone 2: 200-300</td>
<td>18,256</td>
<td>5</td>
<td>3,651</td>
<td>34</td>
<td>6,193</td>
</tr>
<tr>
<td>Zone 3: 300-400</td>
<td>13,547</td>
<td>8</td>
<td>1,693</td>
<td>20</td>
<td>2,723</td>
</tr>
<tr>
<td>Zone 4: 400-550</td>
<td>26,330</td>
<td>8</td>
<td>3,291</td>
<td>14</td>
<td>3,639</td>
</tr>
<tr>
<td>Zone 5: over 550</td>
<td>9,200</td>
<td>4</td>
<td>2,300</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>79,224</td>
<td>28</td>
<td>2,829</td>
<td>20</td>
<td>15,679</td>
</tr>
</tbody>
</table>

a. Turn-off of nearer properties includes staging and fattening of imported stores.

Source: Unpublished Quarterly Returns supplied by the NTAAIB to the Commonwealth Statistician.
animals. The decrease over the Barkly Tableland, which is relatively homogeneous and offers good stock-route feed, suggests that the elasticity effect may have operated here. The first zone is interesting for the proportion of fats in the turn-off is low. This may be due to the influence of management variations which become particularly important in aggregations for small numbers of properties. An alternative explanation is that these stations could supply store cattle to Channel Country holdings via the Georgina stockroute because of their relative proximity. The advantage here would have been that these cattle would eventually be sold on the Brisbane market at prices superior to returns at Townsville. Hence store prices on the receiving units would be higher. This opportunity might not have been open to more distant suppliers because cattle suffer excessive loss of condition on very long treks.

According to the Isolated State model, producers distant from the market would adjust their scale of output to take account of lower receipts. As Table 3.8 shows, there was a tendency for production per property to fall between the first and fifth zones. Further insights on this point can be gained by examining the relationship between parameters of station output per square mile and the indices of accessibility at the industry scale. The production data have been derived from the stock permit aggregations (see Map 3.2). Table 3.9 presents the significant correlation coefficients for a matrix of comparisons between the dependent variable (scale per unit of land) and parameters of accessibility, land quality and holding area. Two measures of land-use intensity are available for the 118 holdings that marketed stock: total sales per square mile, and net turn-off per square mile (sales less purchases). The results show that there was a significant inverse relationship between rate payments to drovers and intensity. While this supports the view that transportation payments influence scale the relative weakness of the correlation and the possibility of bias from
Table 3.6: Significant correlations between indices of land-use intensity and basic holding characteristics, 1957

<table>
<thead>
<tr>
<th></th>
<th>Driving rate cost per beast</th>
<th>Farmgate price differential for fats</th>
<th>Stock-route distance to main market</th>
<th>Direct distance to main market</th>
<th>Theoretical herd capacity</th>
<th>Index of average land quality</th>
<th>Station area</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All contributing holdings (N=118)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales per square mile</td>
<td>-0.22</td>
<td></td>
<td></td>
<td></td>
<td>0.27</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td>Net turn-off per square mile</td>
<td>-0.23</td>
<td></td>
<td></td>
<td></td>
<td>0.24</td>
<td>0.52</td>
<td></td>
</tr>
</tbody>
</table>

| **Holdings outside the Alice Springs District (N=51)** |                             |                                     |                                    |                             |                          |                               |             |
| Sales per square mile    |                             |                                     |                                    |                             | 0.31                     | 0.62                          |             |
| Net turn-off per square mile |                             |                                     |                                    |                             | 0.29                     | 0.59                          |             |
| Value index of net turn-off per square mile |                             |                                     |                                    |                             | 0.54                     | 0.45                          | 0.48        |
| Percentage of fats in sales |                             | -0.34                               | -0.43                              | -0.32                       | -0.31                    | -                             | -0.34       |

\( a \) : \( r \) is significant at the 5 per cent level at 0.17
\( a \) : \( r \) is significant at the 1 per cent level at 0.25
\( b \) : \( r \) is significant at the 5 per cent level at 0.27
\( b \) : \( r \) is significant at the 1 per cent level at 0.35

Sources: See text
the introduction of a mob size criterion in the calculation of rates, precludes further interpretation. The link between land quality and intensity is more definite and points to the role of the resource base in production. Further inferences can be drawn from the data by considering the pattern of output in the three northern Districts (where it is possible to distinguish store and fatstock components in turn-offs). Once again, land quality appears to be a particularly important determinant of scale. The parameters of accessibility are not directly related to intensity, and this remains true for an estimate of value of output per square mile calculated on the assumption that slaughter cattle were 2.25 times more valuable than stores (i.e. comparing stores worth approximately $20.0 per head with fats worth $45.0 per beast).

However, distance from markets appears to have been directly linked to enterprise choice for there is a strong inverse correlation between this factor and the percentage of slaughter cattle in station production. This confirms the deductions that were drawn from Table 3.8. The overall results of the analysis point to the relative unimportance of elasticity effects in determining scale, so that the industry does not appear to have adjusted markedly towards spatial production equilibrium. This makes it necessary to consider the impact of variations in land quality and holding size and to adopt a multivariate approach in the search for complementarity effects. As Table 3.9 shows, the index of average land quality is related to all parameters of intensity. Station area is not a major influence on scale but has an interesting relationship to enterprise type. The bigger properties tend to specialise in producing store cattle and have higher gross returns per unit of land. The theoretical herd capacity measure, which represents the resource base of each holding, has been used to take account of both of these variables. As can be seen from the table, it is relatively highly correlated with the value index of turn-off and is inversely related to the degree of specialisation in the production of fatstock in the northern Districts. This makes it probable that the measure is a
reasonable surrogate for the comparative natural advantages of holdings.

Twenty-four regression equations have been calculated to estimate the influence of variations in accessibility on property sales, using the herd capacity measure as a constant independent variable. Four groups of properties were used; the whole population, the 118 holdings that were active in 1957, the units of the Alice Springs District, and those of the three northern Districts. The parameters of accessibility were the stock-route distance from each unit to its most patronised market, the index of actual droving rate payments and the index of farmgate prices for fatstock. The models were duplicated using raw and log-transformed data. The possibility of using the value of turn-off and the net turn-off figures as dependent variables was examined and calculations were completed for output per unit of land functions. In each case the results were less significant than for the comparable version of the basic equation. The most general results from the main analysis were given by the following two models. They refer to the whole population of stations (N = 179).

The first expresses the relationship between sales \( (X_1) \), and land resources \( (X_2) \) and actual rate payments \( (X_3) \).

(i) \[
\log X_1 = 0.85 + 0.86 \log X_2 - 0.81 \log X_3
\]

\[
\begin{align*}
\text{t-values} & = 6.66 \quad -4.19 \\
R & = 0.54 \quad R^2 = 0.30
\end{align*}
\]

The multiple-correlation coefficient for this equation is statistically significant beyond the one per cent probability level and the adjusted coefficient of multiple determination indicates that thirty per cent of the variation in holding output was explained by the two independent factors. The 't' statistics for the regression coefficients show that they

\[1\text{ Tests of significance in Part 2 use the tabulations provided by Arkin, H., and Colton, R.R., Tables for Statisticians, New York, 1950.}\]
were significantly different from zero at the one per cent level (this can be interpreted as evidence that each factor makes a distinct contribution to the function, while the coefficients give a reliable estimate of the rate of change in the dependent variable with respect to changes in each independent variable within a range determined by their standard errors). Equation (i) suggests that operators did take account of droving costs in determining holding scale in 1957, though other factors were more important. Since there is a possibility that mob size considerations introduce a systematic bias, no further interpretation will be made of this equation.

The second equation employs the farmgate price index as the second independent variable \( X_4 \)

\[
(ii) \quad \log X_1 = 0.44 + 1.00 \log X_2 - 0.80 \log X_4
\]

\[
t-values \quad -8.15 \quad -5.57
\]

\[
R = 0.58 \quad R^2 = 0.34.
\]

This function gives a slightly better guide to sales and the coefficients are more reliable than those of equation (i). The relationship between net received prices and output can be given economic meaning by considering the nature of the model.\(^1\) In logarithmic functions, the regression coefficients may be interpreted as the elasticities of the product with respect to the independent variables. Thus the regression coefficient of the logarithm of farmgate prices \( X_4 \), on the logarithm of output \( X_1 \) for the 179 holdings is -0.80, which indicates that, on average, an increase in the farmgate price differential of one per cent is associated with an increase in output of 0.80 per cent, keeping land quality constant.

The standard error of the coefficient is 0.14, which gives the range of accuracy of the prediction (that is between 0.66 and 0.94 per cent). Estimates can be provided in unit terms by quantifying the relationship at the geometric means of the variables. Thus the geometric mean of output is 1.793, which is the logarithm for 62.17 (Head), while the comparable figures for the net received price differential are 0.711 and $5.14. Hence a 5 cent per beast rise in receipts is associated with an increase in production of approximately 0.50 beasts per property. This is more meaningfully expressed by stating that, on average, holding land quality constant, a $1.00 fall in the price of fatstock for properties at increasing distances from a market centre, was associated with a decline in output of ten cattle per enterprise in 1957.

These results suggest that spatial variations in the comparative locational advantages of stations did influence the pattern of land-use in the beef industry in the early part of the study period. However, this factor is of relatively minor importance when compared to the influences that are not included in the models. These would include the effects of differential investment in plant and improvements, variations in labour usage and management skill, and short-run considerations in consignment. Lack of data precludes further investigation of the relationship between these factors and output, and of possible links to differences in accessibility. The available evidence points to the wider importance of land quality as a determinant of land-use intensity and holding output and suggests that the need to balance stock numbers against resource depletion may have circumscribed the production opportunities of operators. Natural conditions also appear to have exerted a strong influence on consignment decisions in the short-run, through the effects of drought. The validity of these observations will be checked in the subsequent empirical work which uses more extensive data sources and considers output over a five year span.
The findings of the work described in this chapter can be summarised in two sets. The first contains those that bear upon the identification and measurement of location rents. The concept of spatial equilibrium in exchange allows the von Thünen model to be extended to multi-market systems, and the Transportation Problem provides a means of measuring the apparent adherence of a commodity flow pattern to a total least-cost solution. Although consignments in the Northern Territory beef industry are influenced by a range of institutional and mobility considerations, the comparison between the actual and normative flows was instructive. It confirmed that producers did minimise transport costs within the constraints imposed by market demands. However, the examination of the structure of farmgate prices at supply area intersections showed that spatial price equilibrium was not immediately evident in reality. This confirms the need to examine the process of price formation in more detail and this topic is discussed in Chapter 5.

The structure of costs in the early 1950s showed that market price and rate payment variations were important determinants of profits at a constant scale. The relative flexibility of the production function suggested that producers could adjust their operations to take account of differences in property accessibility, and the narrow and fixed choice of markets made it possible that intensity rents could be identified from an examination of output per unit of land. Correlation analysis showed that adjustment to the actual consignment pattern in 1957 was not evident at this level. Further work incorporated the influence of land quality and holding size by formulating multiple regression models of output. The results of this procedure showed that it was reasonable to conclude that the pattern of production was partially determined by rate cost payments and market price variations. This is evidence that there was a tendency towards spatial equilibrium in production. The inadequacy of the data on the study industry in this period curtailed further work on this point.
The second series of conclusions relate more directly to the study problem. The discrete nature of the actual supply area boundaries in 1957 and obvious role of demand in setting the level of total transportation costs suggest that the introduction of additional processing centres would have been beneficial to the industry. However, operating costs and pricing policies would have conditioned their success and consideration of this aspect of marketing must be delayed. The strong link between distance from markets and the form of output of enterprises in the three northern Districts confirms this conclusion. A strategically located meatworks could have tapped supplies of fatstock that were diverted to store markets by the poor mobility characteristics of droving. Equally, an improvement in transport technology which reduced deterioration losses would have been of benefit. This leads obviously to the evaluation of the merits of road haulage of stock.

Further inferences on the elasticity effects of a reduction in rate costs can be drawn from the results of the regression analyses. The average property turn-off in 1957 was 827 head, and calculations from the rate cost index show that the average payment for drovers' services was approximately $2.70 per beast (imputing values within actual supply areas for non-producing units). Thus a reduction in payments of $1.00 per head (by thirty-nine per cent) would have had a marginal impact on gross output. This makes it unlikely that spending on route improvement for existing traffic would have a high return unless it induced modal change. However, investment in processing facilities, which would have probably resulted in more dramatic upward shifts in local prices, might have been effective in generating more intensive land development. In this light it is interesting to look again at the quotation that heads this chapter. It refers to the purchase of a one-quarter share in Victoria River Downs station by Sir Sidney Kidman in 1900. His belief that inaccessibility could be overcome was based on plans to construct a meatworks at the mouth of the Victoria River.
As documented in Chapter 1, this venture was abandoned, primarily because of government insistence that the investors should locate their plant at Darwin to make use of the northern railway. This quotation and the evidence that has been presented from the empirical work demonstrate the importance of examining accessibility as an entity and basing public policy on an integrated approach to transport needs.
CHAPTER 4

IMPROVED ACCESSIBILITY AND PASTORAL LAND DEVELOPMENT, 1960 – 1967

The main reason for a condition of virtual stagnation in the industry was the extreme difficulty of access to the then available markets, far removed from the point of production, leaving producers little incentive to spend funds on substantial improvements to cattle stations. Because of the lack of property development, production levels were critically low, being characterised by low turn-offs due to poor branding rates and heavy wastage. The returns to producers, accordingly, were not sufficient to provide adequate capital for property development. The situation, however, is now altering very rapidly . . . .

Report of the Committee of Investigation into Transportation Costs in Northern Australia [1965].

INTRODUCTION

Within the general concept of spatial equilibrium particular stress has been laid on the reactions of commodity producers to variations in accessibility to markets. The main aim of this chapter is to examine the links between recent changes in the output, profitability, and policies of the units in the Northern Territory beef industry and improvements in their marketing opportunities within the framework of location rent theory. It is still assumed that differences in marginal returns are a direct function of market price and the imputed freight cost from the property to the point of sale. Internal consistency within the system is retained by considering that all consignments were made by road haulage. This avoids the difficulties associated with the calculation of a bi-modal accessibility function, which would demand the evaluation of the relative mobility characteristics of droving and road transport.
Additionally, freight payments and net received prices have been estimated for the markets open to producers from 1963, when two permanent export abattoirs opened in the Northern Territory. The choice of 1960 to divide the study into 'traditional' and 'modern' phases can be justified by the emphasis on transportation. In the financial year 1960-61 the proportion of stock moved by road to export destinations exceeded that travelling on the hoof, and by 1965-66 the percentage transported by road had increased from fifty-five to over eighty per cent. Further, 1960 saw the displacement of the United Kingdom by the United States as the major importer of Australian beef and it was this development that led to the opening of local processing facilities. Nevertheless, the empirical work on both phases is founded on significant abstractions from reality which are necessary to maintain the comparability of the accessibility estimates for individual properties. In the dissection of a complex system some loss of correspondence is inevitable and Chapter 5 will link the two sets of assumptions by examining the excluded constraints on market choice, the diffusion of the use of road transport, and the decisions made by producers on their total factor mix.

The present chapter falls into four sections. The first details the construction of the accessibility indices used in the analysis and then examines the exchange pattern under road haulage, using 1966 as a representative year. The second and third sections deal respectively with variations in production and profitability over space. The data on property output covers the years 1963 to 1967, while the information on enterprise returns refers to the financial years 1962-63 to 1964-65. Commentaries are also given on the temporal influences on turn-off and profits to set the spatial analyses in context. The final section then reviews the theories which have been advanced on the relationship between location and land rent. This leads to conclusions from the empirical work about the hypothesis that accessibility is an important determinant of the intensity of land-use in the Northern Territory and further inferences
on the nature of the rent adjustment process. The format and methodology of the first half of the chapter are based on the structure of Chapter 3 so that little introductory material is required.

A. SPATIAL EQUILIBRIUM IN ALLOCATION, 1960-1967

1. The availability of markets

The displacement of the United Kingdom as the main importer of Australian beef in 1959-60 by the United States was accompanied by unprecedentedly high prices. In June 1960 the average price of good quality bullocks on the Brisbane market reached $20.00 per 100 lb dressed weight, and it seems clear that both the national beef and dairy herds were heavily culled in response. By 1961 the speculative aspects of the trade were apparent and an increase in normal supplies led to a decline in prices at all State capitals. However, following this setback, production and prices rose again leading to a record national output of 1,005,000 tons in 1964-65. Further loss of breeding stock and the impact of drought in New South Wales curtailed supplies in the following two years and prices continued to move upward. Table 4.1 shows the impact of these factors on the Brisbane price series. Following the procedure established in the last chapter, price series have also been constructed for the main final and intermediate markets for Northern Territory fatstock. Over the seven year span the differential between the Brisbane and Townsville series increased to approximately $20.00 per head for fatstock with a further loss of over $10.00 for receipts f.o.r. Mt Isa due to railage charges. In contrast, prices at the Alice Springs terminal maintained near parity to those of Brisbane, reflecting a continued short-fall of supplies in South Australia.

For further information see the relevant issues of the Beef Situation, BAE, Canberra (annual), and the Annual Reports of the Australian Meat Board, Sydney.
Table 4.1: Estimated average June fatstock prices at markets receiving Northern Territory cattle, 1960-1967

($ per 100 lb dressed weight)

<table>
<thead>
<tr>
<th>Year</th>
<th>Brisbane</th>
<th>Adelaide</th>
<th>Townsville</th>
<th>f.o.r. Alice Springs</th>
<th>f.o.r. Mt Isa</th>
<th>Wyndham</th>
<th>Darwin</th>
<th>Katherine</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961</td>
<td>18.30</td>
<td>20.10</td>
<td>14.83</td>
<td>17.72</td>
<td>12.72</td>
<td>11.40</td>
<td>8.33a</td>
<td>..</td>
</tr>
<tr>
<td>1962</td>
<td>14.40</td>
<td>18.40</td>
<td>12.00</td>
<td>16.02</td>
<td>10.14</td>
<td>11.00</td>
<td>8.33a</td>
<td>..</td>
</tr>
<tr>
<td>1963</td>
<td>17.15</td>
<td>19.90</td>
<td>14.12</td>
<td>17.52</td>
<td>12.06</td>
<td>11.00</td>
<td>11.00</td>
<td>10.00</td>
</tr>
<tr>
<td>1964</td>
<td>19.20</td>
<td>21.20</td>
<td>16.12</td>
<td>18.82</td>
<td>14.06</td>
<td>8.80</td>
<td>11.00</td>
<td>10.00</td>
</tr>
<tr>
<td>1965</td>
<td>20.55</td>
<td>25.60</td>
<td>17.41</td>
<td>23.22</td>
<td>15.35</td>
<td>8.52</td>
<td>12.00</td>
<td>12.00</td>
</tr>
<tr>
<td>1966</td>
<td>24.62</td>
<td>27.95</td>
<td>21.00</td>
<td>25.57</td>
<td>18.94</td>
<td>14.00</td>
<td>14.75</td>
<td>14.00</td>
</tr>
<tr>
<td>1967</td>
<td>26.00</td>
<td>26.75</td>
<td>22.00</td>
<td>24.57</td>
<td>19.74</td>
<td>16.00</td>
<td>17.00</td>
<td>16.00</td>
</tr>
</tbody>
</table>

a. f.o.b. live to Hong Kong.

Sources: Brisbane, Adelaide, Townsville, Alice Springs, Mt Isa and Wyndham, as Table 3.1; Darwin and Katherine meatworks, interviews with plant managers, June 1967.
The local outlets available in the north show more pronounced individual traits consequent upon choice of final market and increasing competition for cattle. Wyndham offered relatively high prices until 1963 for higher quality animals for export bone-in to the United Kingdom and the United States, but suffered a period of restructuring before specialising in the trade in boneless meat to the latter market. Live cattle sales to Hong Kong through Darwin absorbed roughly 7,000 head each year up to 1963 and paid about 6 cents per pound live weight. Both of these markets met heavy competition in following years from the new export abattoirs at Katherine and Darwin which resulted in an immediate rise in prices and a cessation of the trade to Hong Kong. The payments to producers by the three meatworks have continued to reflect competitive pricing, though this trend is not obvious from the series which give average values only. The inclusion of the new available markets in the models of spatial equilibrium adds to the complexity of analysis but poses no theoretical considerations other than those discussed in the last chapter.

2. The transport cost structure

Having documented temporal and spatial variations in market prices, the procedure for testing the joint hypotheses of allocation and production equilibrium demands the identification of variations in local transport costs. In the Northern Territory cattle are moved in vehicles which range in size from small body trucks (operated by individual properties) to road trains up to 145 feet long consisting of a prime-mover with semi-trailer and two 40 foot dog trailers. The larger units are operated by road haulage firms which control virtually all movements. The capacities of units are usually given in terms of the correspondence of trailers to the cattle wagons used by Queensland Railways. These are called K-wagons and hold eighteen to twenty large bullocks. The range of load can therefore vary from ten to sixty-five

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1 Annual Reports of the NTAAIB.
fat beasts (3½ K), with increased numbers for store stock. The rate cost of road transport per unit of capacity is a function of the size and regularity of lift, the length of haul and quality of the surface over which the vehicles move.\(^1\) In addition competition and contracts may reduce costs for some consignments. A survey of fifteen firms operating in the Northern Territory, during field work in 1967, showed that charges ranged from 60 cents to $1.00 per K-mile.\(^2\) Three sets of operators were distinguished with primary orientations towards Mt Isa, the northern meatworks, and the Alice Springs railhead, and there was a tendency for rates to rise in the same sequence. This variation between supply areas seems to reflect differences in the average size of haul and the nature of roads and terrain.

For the purposes of the analysis of exchange equilibrium, a simplified rate structure has been adopted which puts particular emphasis on variations in road quality since this becomes the main theme of the third part of this thesis. The assumed costs are 70 cents per K-mile on bitumen roads, 80 cents for gravel-formed stretches, and 90 cents per K-mile for movements over other dirt roads. Since the surface standards of most segments of the network changed to some degree in the early 1960s it is difficult to determine a base pattern for the rate cost index. The route hierarchy shown in Map 6.1 was used for the calculation of payments between origins and destinations because it reflects the relative standing of different roads throughout the period. In addition, certain inferences can be drawn from computations on this basis which bear upon the evaluation of the Beef Roads Programme in Part 3. Road distances between properties and markets or railheads have been measured by the nearest

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1 Detailed information on the structure of the haulage industry in the early phase of adoption is given in The Economics of Road Transport of Beef Cattle, BAE, Canberra, 1959. For recent data see Moulden, J.O., and Jenkins, E.L., 'Road Transport of Beef Cattle in Northern Australia', Quarterly Review of Agricultural Economics, 21. (1961), pp.87-100.

2 See Table 6.3.
Fig. 4.1: The incidence of estimated payments for road haulage and farmgate differentials in the basic station population and the BAE modified sample.

A

ROAD TRANSPORT RATE PAYMENTS

- Payment per holding, 1966 ($ per beast) (Basic population)
- Payment per holding, 1964 ($ per beast) (Modified BAE sample)

B

NET RECEIVED PRICE DIFFERENTIALS

- Price difference per holding, 1966 ($ per beast) (Basic population)
- Price difference per holding, 1964 ($ per beast) (Modified BAE sample)
traffic ble routes,\(^1\) checked by knowledge gained in the field. This aspect of the accessibility function has therefore been simplified by ignoring inter-modal competition and many of the minor characteristics of road haulage. The frequency distributions of the indices rate payments and farmgate prices for typical consignments from holdings for 1964 and 1966 (the main study years) are shown in Fig. 4.1 to provide a background to the empirical work. The methods of calculating the series are identical to those discussed in the first section of Chapter 3.

3. Exchange equilibrium under road transportation

Taking 1966 as a representative year, the methodology outlined in Chapter 3 has been employed to determine the degree of adjustment to exchange equilibrium following the adoption of road transport. Relatively complete and reliable origin and destination data has been gathered from the examination of the 2,083 stock permits issued by the NTAAIB during the calendar year. Table 4.2 shows the allocation of the total production of the 154 units in the primary population of properties that marketed cattle in 1966. Approximately sixty-five per cent of the gross turn-off went for immediate slaughter with Queensland taking the major share. In the store cattle category forty-two per cent of movements represented internal transfers of stock for breeding or fattening.

The actual allocation pattern of the 94,578 fats supplied by the 147 stations to the five main markets is shown on Map 4.1 (it should be noted that the local Alice Springs demand has been added to the turn-off to South Australia). A brief comparison with Map 3.1 shows that the major change over the decade was the decline in the influence of the Queensland store trade, following the entry of the Katherine and Darwin meatworks in 1963. It is also clear that the Alice Springs District remained separate and

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\(^1\) Measured at 1:2,000,000 on the 'Northern Territory Road Classification Map', Department of National Development, 1965.
Table 4.2: The composition and allocation of turn-off in 1966

<table>
<thead>
<tr>
<th>Destination</th>
<th>Fats</th>
<th>Stores</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Australia</td>
<td>15,880</td>
<td>689</td>
</tr>
<tr>
<td>Queensland</td>
<td>32,744</td>
<td>37,844</td>
</tr>
<tr>
<td>Wyndham</td>
<td>5,300</td>
<td>-</td>
</tr>
<tr>
<td>Alice Springs (local)</td>
<td>2,052</td>
<td>-</td>
</tr>
<tr>
<td>Darwin</td>
<td>17,178</td>
<td>-</td>
</tr>
<tr>
<td>Katherine</td>
<td>21,424</td>
<td>-</td>
</tr>
<tr>
<td>Intra-Territory transfers</td>
<td>-</td>
<td>27,814</td>
</tr>
<tr>
<td>Totals</td>
<td>94,578</td>
<td>66,347</td>
</tr>
</tbody>
</table>

Sources: As for Table 3.6; plus information from the managers of the Katherine and Darwin meatworks, field interviews, June 1967.

continued to control the South Australian market, though there were progressive relaxations in the requirements for stock travelling south from pleuropneumonia infected areas from 1958 onwards. The general pattern of exchange in the three northern Districts shows increased complexity with wide bands of overlap between supply area boundaries and relatively numerous split allocations. Having introduced the actual pattern it is possible to compare it with a normative solution generated by the Transportation Problem, using a matrix of imputed road transport payments. The total least-cost allocation is shown on Map 4.2.

The analysis deals solely with slaughter and virtually all movements of these stock were by road in 1966 so that

1 In 1958 duplicate yards and rail loading facilities were opened at Alice Springs to handle the through-transit of cattle from outside the C.A.P.P.A. These movements were conditional on transportation to the railhead by road haulage. The greatest number of entrants between 1958 and 1967 was 7,853 (1963). From 1964 four additional stations in the Barkly Tableland District were included in the C.A.P.P.A and the extension of protection to the Barkly, and, Darwin and Katherine Areas has allowed further modification of blood-testing and vaccination requirements.

Source: NTAAIB stock permits.
the conditions of homogeneity in consignment that are required in the constraints of the Problem are met to a large degree. However, the visual correspondence between the two patterns is less strong than was observable for 1957. Two main types of discrepancy occur. First, in reality thirty-one properties chose to send cattle to two or more centres, while the programmed solution reduced the number of split allocations to three. The Katherine meatworks shared the fats that were consigned from twenty-six properties with one or more other centres, and this illustrates its role as a competitive and active market. Of the operators that patronised three markets in the real situation, two were centrally located (Beetaloo and Ucharonidge), while the third (Waterloo) is in the Victoria River District. Under the optimal solution one of the largest producers (Eva Downs) uses its strategic position to supply Queensland, Katherine and Darwin while its large neighbour (Helen Springs) divides production between South Australia and Darwin. Within the normative and closed system these two stations exert a critical influence on prices which is entirely absent in reality.

Second, in the actual allocation eleven properties sent the whole of their turn-offs to apparently non-optimal markets. These differences result largely from the roles played by the demands of Darwin and South Australia in the two systems. In the latter case the eastward extension of the boundary between the Alice Springs and Mt Isa supply areas is greater in reality than would be warranted by the comparison of transport costs alone. This may be explained partly in terms of price advantage and the activities of agents buying for the Adelaide market. In the case of competition between Darwin and Katherine the rationale of the optimal allocation, which makes cattle travel from beyond the edge of the Katherine supply area through that centre to the coast, is difficult to appreciate. In fact, this simulates reality well because stock travel from Vestey stations such as Waterloo and Helen Springs to the Darwin meatworks as part of an integrated company operation. The question then arises as to whether this situation reflects the perception of actual opportunities.
Map 4.2: The total least-cost (Transportation Problem) allocation of fatstock between markets, 1966.

Source: See text.
The 1966 price series show that the imputed value of a bullock dressing out at 500 lb would have been $73.75 at Darwin and $70.00 at Katherine, and the differential would have been almost completely absorbed by the cost of railage between the two centres (roughly $3.00). Consequently for producers south of Katherine the two meatworks have virtually the same market characteristics. In the Transportation Problems cost matrix this is reflected in the addition of a constant to haulage costs to Katherine to cover rail charges to Darwin. This leads to mathematical indeterminancy in the solution so that any division of the joint supply area gives an optimal result. Confirmation of this fact is given by the comparison of the shadow price structures shown for Eva Downs in Table 4.3 where the equations governing net received prices at the two centres also exhibit additivity. Hence in this case an optimum cannot be identified and the similarities and differences are due to chance.

Following from this analysis of the respective patterns it is necessary to examine the degree of correspondence between the transport costs paid by producers under the actual and optimal allocations. The correlation of payments, using average per beast costs in the case of properties supplying more than one market, is 0.93, which is significant at the one per cent level. Thus, despite the dissimilarity of patterns the linear programming solution proves to be as powerful a predictor of unit costs as it did in the 1957 situation. In terms of gross payments for transportation, the programme would have saved $46,500 (about five per cent of the actual total of $938,000). Under the constraint of fixed market demands this represents the maximum increase in net received prices that could have been gained for the whole system, provided all movements were simultaneous. For individual producers a rather different situation obtains; non-adherence to the optimum could reflect either, (i) an ignorance of, or irrational reaction to, differences in transportation costs to alternative markets, or (ii) an awareness of the advantages of paying extra freight costs to gain access to a high price market. It follows that individual
divergences from the normative solution cannot be judged in terms of rationality without detailed knowledge of the producers' consignment decisions. Also, in reality, exchange takes place throughout the year so that minor monthly price fluctuations may explain some apparently non-optimal reactions. The use of road transport has probably enabled producers to maximise receipts for the components of their total turn-off by introducing a real flexibility in response. Finally, supplies are not homogeneous. For instance, many of the cattle moving from the Barkly Tableland to Katherine are female culls of a relatively poor quality that would bring very low returns in Townsville.
While it is impossible to evaluate individual decisions, the absolute correspondence of the actual pattern to the maximisation of receipts under spatial equilibrium can be judged from the comparison of net received prices at points of supply area overlap. Three examples are given in Table 4.3. Here it is again apparent that the South Australian market held a significant advantage which was not fully exploited by suppliers. Part of the explanation lies in the difficulty and cost of guaranteeing the freedom of northern stock from ticks and pleuropneumonia, but four Barkly Tableland properties did find it profitable to send stock south which suggests that the others may have been unaware of their marketing opportunities. Looking at the overlap of the Queensland and northern meatworks supply areas, similar divergences from the optimum become apparent. The f.o.r. price of a bullock at Mt Isa (dressing out at 500 lb) would have been $94.70 in 1966, according to the series in Table 4.1. The same animal would have been worth $70.00 at Katherine. The $24.70 differential would have supported transportation by road for over 600 miles. If the supply area boundaries had been determined by the equalisation of net received prices, Katherine’s supply area would have been restricted to a 150 mile radius on its eastern edge. The discontinuities in all zones of competition as shown in Table 4.3 exhibit the same trends and are significant enough to lead to the conclusion that market prices alone give a poor explanation of producer choice and the extent of supply area boundaries. A more detailed analysis of the factors governing marketing efficiency and price formation is given in Chapter 5.

At this stage the following conclusions can be drawn from the study of exchange equilibrium in 1966:

(i) the flexibility of turn-off associated with the use of road transport increased the possibility of maximising property net received prices by allowing response to short-term variations in the market prices offered at alternative centres;

(ii) as a result of (i) adherence to an overall least cost transportation pattern has become inherently more unlikely;
(iii) although producers showed an increased willingness to try alternative markets (as compared to 1957), the adjustment of supply area boundaries to long-term variations in demand was markedly non-optimal;

(iv) the fragmentation of supply area boundaries in reality indicates that distance had become less important in consignment decisions. This points to the role of new processing plants in reducing transport costs and suggests that spatial variations in marginal returns probably had less influence on scale decisions in this era.

B. SPATIAL EQUILIBRIUM IN PRODUCTION, 1960-1967

1. Theoretical and methodological issues

This section presents a series of static analyses of the relationship between land-use intensity, measured in terms of variations in output per unit of area, and accessibility. The format follows the methodology established in the previous chapter to assist the comparison of production adjustment under the two marketing and transportation systems. Though the evaluation of these two cross-sectional approaches allows deductions to be made on the determinants of change it cannot measure the relative impact of particular factors. An attempt will be made to examine some of the dynamic effects of the introduction of new markets, the adoption of road transport and technological change in the beef industry in Chapter 5, so that the following section must be viewed as a preliminary exploration of problems by complementary broad scale methods.

It is useful at this stage to look at the changes that occurred between the two study periods in the determinant variables of the extended Thünen model -- prices and transport costs, and deduce their probable effects on production under ceteris paribus conditions. This permits the identification of six hypotheses.
(i) It is possible that the adoption of road transport reduced the absolute cost of movement through the lowering of non-rate costs (such as weight losses) and its advantages in allowing flexibility in consignment. In a closed spatial equilibrium in which peripheral land remained unoccupied a general reduction in transport costs would encourage the extension of the farmed area. Hence under static demand this would lead to a reduction in the intensity of land-use on the original holdings.

(ii) It can be argued that the use of road haulage allows the transportation of stock which were unmarketable under the droving system. These beasts include culled cows, unbranded bulls, and weaner stores which were difficult to handle over long distances. In this sense road transport may be considered a yield increasing technological improvement. Within the static model this would lead to the contraction of the rent margin.

(iii) Whatever the absolute value of transportation costs it seems clear that their relative importance decreased in respect to market prices over the study period. This is a consequence of the general increase in demand for beef (for instance, the value of a first quality export bullock at Brisbane rose 189 per cent between 1957 and 1966). Since this reduces the degree of influence which location exerts on the production functions of properties it would be expected to lead to increasing adjustment in output to non-spatial factors -- particularly variations in land quality and managerial skill.

(iv) The deductive logic behind the Thünen model, which links land productivity to changes in net received prices over space, could also be expected to hold for movements in received prices over time. If supply adjustment were an ergodic phenomenon, the general rise in market prices over the study period would be expected to lead to substantial overall increases in the output of the Northern Territory, with spatial variations which corresponded to the differences in receipts between supply areas.

(v) The addition of two new outlets for production from 1963 would be expected to influence the pattern of intensity in the industry especially in the three northern regions. This localised increase in net received prices, which results from new marketing opportunities and lower transport payments, would therefore alter the spatial balance of production under static demand, or stimulate output within the new supply areas if overall demand had been augmented by their entry.

(vi) The adoption of road transport required the use of a network with topological characteristics which differ from those of the stock-route pattern. This
produces localised variations in relative transport payments under the two modes for the same journey. Under static demand in a closed system this would lead to a series of compensatory adjustments in production towards spatial equilibrium. With increased demand the same trend would be expected, though the probability is that the effects of this factor would be subsumed by the concurrent operation of the other listed changes.

The complex and frequently contradictory effects that may be deduced from the application of the Thünen method of analysis point up the difficulties associated with the examination of the dynamics of spatial equilibrium. In the study industry further confusion is added by variations in property size, land quality, and managerial skill, which may be incorporated in the extended model, and the unpredictable influence of exogenous variables, such as fluctuations in rainfall, on production. The analysis that follows can do no more therefore than offer a series of inferences from the observation of the reactions of groups of factors over time. The production data used in the empirical work presented here has been extracted from the records of stock movements held by the NTAAIB. Information is available for the five calendar years from 1963 through 1967 from the biennial summaries of stock transfers prepared from permit counterfoils by the Superintendent of Stock-routes. It has proved possible to check these statistics only for 1966, using the aggregations employed in the analysis of exchange equilibrium which were formulated from the same basic source. The comparison shows that the discrepancies are not significant and are probably negligible over the range of observations. This suggests that the figures for the remaining years are also reliable. Two parameters of production are available: gross sales (that is all movements from each property including exports, inter-Territory transfers, and a small but unknown fraction being sent on agistment in some years), and net turn-off (sales less purchases). These quantities have been converted to intensity functions by dividing them by station areas.
Comparability with the 1957 tabulations is ensured by restricting the statistical population to the 118 holdings which turned-off cattle in that year. Seven indices of accessibility are given for each unit. These are:

1. the direct distance from the property homestead to the most favoured point of sale in 1966;

2. the distance from the station to its main 1966 market by road;

3. the imputed rate cost of road transporting one fat beast over (ii);

4. the estimated net received price differential per beast for each property in 1966 (market prices are calculated from Table 4.1, road transport costs are given by (iii) above);

5. the estimated net received price differential per beast in 1964 -- in this case market prices have been calculated on a regional basis and are averaged over all types of stock (the construction of this index is explained in detail in the second half of this chapter);

6. the distance from the property to its main 1957 market by stockroute;

7. the estimated net received price differential per beast for each property in 1957.

The latter two indices have been included to account for the possibility that the production pattern could be a relic form due to a lag in the adjustment process.

This array of location parameters takes account of the changes in the determining constraints of spatial equilibrium between 1957 and 1966. The transportation cost estimates include the effects of mode and network alterations and the impact of the entry of the Katherine and Darwin markets. The net received price differentials embrace the influence of the new demand centres and the locational effects of the general rise in beef prices at the original markets and terminals. In this way the static analyses cater for all the hypothetical changes which have been detailed. In addition to the
Table 4.4: Significant correlations between indices of land-use intensity and basic holding characteristics, 1963-1967 (118 holdings)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Sales</th>
<th>Net Turn-off</th>
</tr>
</thead>
<tbody>
<tr>
<td>1963</td>
<td>0.25</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>0.24</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>0.21</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>0.20</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>0.34</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>0.28</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>0.55</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td>0.27</td>
<td>-</td>
</tr>
<tr>
<td>1964</td>
<td>0.18</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>0.17</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>0.16</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>0.19</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>0.28</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>0.23</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>0.45</td>
<td>0.19</td>
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<tr>
<td></td>
<td>0.28</td>
<td>-</td>
</tr>
<tr>
<td>1965</td>
<td>0.18</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>0.18</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>0.23</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>0.43</td>
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<td></td>
<td>0.32</td>
<td>-</td>
</tr>
<tr>
<td>1966</td>
<td>0.38</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>0.37</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>0.31</td>
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<tr>
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<td>0.29</td>
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</tr>
<tr>
<td>1967</td>
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<tr>
<td></td>
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<td>-</td>
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<tr>
<td></td>
<td>0.23</td>
<td>-</td>
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<tr>
<td></td>
<td>0.31</td>
<td>-</td>
</tr>
</tbody>
</table>

Sources: See text.
accessibility indices four other factors have been correlated with the intensity measures, namely, the area, average land quality, theoretical herd capacity, and contract rent payment per square mile of each station. These facilitate deductions on the importance of production scale and the relationship between fertility, location, and contract rents.

2. The relationship between accessibility and productivity per square mile

Table 4.4 gives the correlation coefficients between the variables enumerated and the five year series of property output parameters. Under Thunen assumptions of homogeneous land quality, intensity of land-use would be directly related to variations in net received prices. Since the accessibility values employed are negatives they would be inversely related to property sales and net turn-off per square mile under these conditions. The coefficients reveal that this situation is reversed in the study industry which indicates a general trend for land to become more productive as its remoteness from markets increases. Two factors seem to be important in explaining this departure from the theoretical gradient. First, the eccentric location of the Katherine and Darwin meatworks in relation to the distribution of better quality land confirmed the disequilibrium between the pattern of final demand and production that was partially evident in 1957. Second, the increased flexibility of allocation associated with road transport and the decreased importance of freight costs in relation to market prices probably reduced the relative influence of property location. It is notable that the degree of sophistication of the accessibility index has remarkably little effect on the result and, in most cases, the correlation coefficients are very similar for the range of parameters. It also appears that the use of lag indices and the aggregation of output statistics over a number of years does not improve the correspondence.

In contrast the results show a consistently strong relationship between productivity and the estimates of variations in land quality. In nearly all cases this is
strongest when sales alone are considered; this follows from the tendency for stations with the best quality pasture to import and fatten store cattle. It suggests that the Ricardo' concept of fertility rent is far more important in the study industry than Thünen intensity rent. Moving to station area, it seems that this factor is not highly correlated with intensity of land-use, though the signs of the coefficients suggest that the bigger properties may be generally more productive. In theory the level of contract rents should reflect the variations in productivity that result from differences in the pasture quality, size, location and level of improvement of holdings. Average lease rents per square mile for each station have been calculated from data supplied by the Department of the Interior. This parameter does not show the high level of relationship to output that would be expected. The reasons for this situation are not clear, but may reflect the nominal level of lease rents and the difficulties of revising valuations in the short-term. It is nevertheless interesting to note that this element of the land market is not highly adjusted to variations in intensity.

It is now important to consider two subsidiary relationships; the link between accessibility and enterprise specialisation, and the role of variations in accessibility in determining the extensive economic margin of land-use. From an examination of correlation coefficients for the rate cost and farmgate price indices, and the percentage of slaughter stock in the turn-off structure of the 118 holdings for 1966 and 1967, it seems clear that distance from markets continued to exert some influence on the form of output. For both years the coefficients were negative for a comparison with eleven accessibility series (simple distance, route distance, rate cost and net received price measures). In 1966 the highest inverse relationship was $r = 0.17$ for the correlation between the proportion of slaughter cattle in output and 1966 road transport rate costs. The

---

1 Significant at the five per cent level.
relationship was far stronger for 1967 when the coefficient between the straight-line distances from suppliers to their main markets (in 1966) and turn-off composition was \(-0.43\). This confirms the importance of mobility considerations in the choice of transport mode and demonstrates the marked impact of the new meatworks on production. Calculations for value of turn-off per square mile measures (assuming that fat cattle were worth, on average, $90.00 and store stock sold for $40.00 per head) did not extend the results of the analysis. However, there were indications that units with locational disadvantages were more likely to engage in local trade with other properties (the highest value of \(r\) was 0.22, for the percentage of non-market movements in turn-off and the road distance from holdings to the railheads or processing plants favoured in 1966). In summary, accessibility did continue to influence output through its mobility components in this era.

In a classical Thünen system, the improvement of the comparative locational advantages of units on the margin (from a reduction in transport costs or an increase in market prices) would encourage new operators to enter production. It is therefore of interest, to examine the characteristics of new entrants between 1957 and 1966 to see whether improved accessibility generated economic activity in this manner. Data drawn from the examination of stock permits for 1957 and 1966 shows that an additional forty-nine stations contributed cattle to final markets or sold store stock within the Northern Territory in the latter year. Using knowledge of the actual allocation of stock between different markets in 1957, the new entrants have been placed within one of the four original supply areas, and imputed values have been calculated for distances from centres and farmgate price differentials. A hypothesis of entry based upon the extension of the location rent margin

---

1 Significant at the one per cent level.

2 Some of the holdings that operated in 1957 did not produce stock in 1966.
would be supported by atypically high values for the indices in this sub-group. Here, the adoption of road transport or the opening of new markets would be particularly beneficial to intending investors.

Table 4.5 shows the means and 't' statistics for four characteristics of the forty-nine properties and the original population of 118. It appears that, on average, the new entrants produced less per square mile than the

<table>
<thead>
<tr>
<th>Table 4.5: Statistical comparison of the (1966) holding characteristics of new entrants (1957-1966) and those of enterprises operative in 1957</th>
</tr>
</thead>
<tbody>
<tr>
<td>1966 sales per square mile</td>
</tr>
<tr>
<td>Mean of new entrants 0.38</td>
</tr>
<tr>
<td>Mean of population of 118 0.59</td>
</tr>
<tr>
<td>t-values 1.40</td>
</tr>
</tbody>
</table>

Sources: See text.

older established units and were slightly further from potential markets in 1957. However, comparison of the values for net received price differences indicates that average farmgate prices on the new enterprises would have been slightly more favourable than those of the main population in 1957. To test the significance of these differences, the 't' test has been calculated for the four characteristics shown in Table 4.5. With 48 degrees of freedom, there is less than one chance in a hundred that a value higher than 2.69 could occur due to chance if the new properties had been drawn from the existing (1957)
population. Thus, the entrants may be considered similar to the original production units in terms of gross sales per square mile and comparative accessibility.

A major reason for the late entry of many of these stations appears to be the low quality of their pasture. Reference to Table 4 shows that, on average, the older properties had a considerably higher index of land quality. The application of the 't' test in this instance suggests that these two distributions are significantly different. These results confirm the validity of the observations that have already been made on the importance of the resource base as a determinant of the intensity of land-use and, hence the relevance of a Ricardian view of economic rent. Equally they add weight to the conclusion that has been reached on the relative unimportance of variations in accessibility in the creation of the pattern of production.

3. Accessibility as a determinant of property output.

None of the results given in the previous section preclude the existence of a systematic relationship between variations in accessibility and land productivity that may be obscured by the influence of pasture quality and station size. As shown in Chapter 3 it is possible to account for these variables by using multiple regression models, and the procedure outlined there has been repeated for the 1963-1967 period. With eight accessibility indices, four property groupings and five years the number of possible equations becomes large. Well over two hundred models have been examined and only a small part of the data can be presented. The results of attempts to predict 1966 sales are given because they are directly comparable to the 1957 set and are reasonably representative of the overall findings on the link between accessibility and scale. The role of rate cost payments for road haulage is particularly interesting for a consistent variation with output would permit the estimation of the complementarity effects of road improvement.
The structure of the best model relating total sales per holding \( (x_1) \) to the theoretical herd capacity of units \( (x_2) \) and their typical road transport payments in 1966 \( (x_3) \) is:

\[
(i) \quad x_1 = -458.41 + 0.08 x_2 + 0.46 x_3
\]

t-values \( 20.14 \quad 3.16 \)

\[
R = 0.84 \quad R^2 = 0.71
\]

The function refers to the 179 enterprises in the basic population. The multiple correlation coefficient for this equation is statistically significant beyond the one per cent level and the adjusted coefficient of multiple determination indicates that seventy-one per cent of the variation in output is explained by factors included in the analysis. The t-values for the coefficients show that both independent variables contribute to the correspondence.

The point that must be stressed is that the function shows that the level of sales tends to decrease on holdings nearer markets and terminals. This reversal of the classical location gradient is denoted by the positive sign for the coefficient of rate payments on output. The results confirm the inferences drawn from the correlation analyses and suggest that variations in transportation costs did not give rise to intensity rents. A further deduction is that road investment would be unlikely to generate increased output through the elasticity effect.

It is obviously necessary to qualify these conclusions until the function has been examined which relates farmgate prices to enterprise scale. The comparable equation to (i), where \( x_4 \) is the 1966 net received price differential is:

\[
(ii) \quad x_1 = -266.09 + 0.08 x_2 + 0.05 x_4
\]

t-values \( 19.52 \quad 1.54 \)

\[
R = 0.84 \quad R^2 = 0.70
\]

Here the results are almost identical but the farmgate price series makes no contribution to the model. It is
therefore justifiable to retain the conclusion that accessibility exerted a negligible influence on physical productivity in 1966. In no case among an array of equations that have been examined (some of which included value-of-output indices as the dependent variable) was there a marked reversal of this tendency, despite the use of raw and log-transformed data; lagged accessibility functions (i.e. the 1957 and 1964 indices); pooled data (i.e. average sales for 1963-67); the elimination of non-trading holdings or disaggregation to District sets. Thus it is reasonable to state that accessibility ceased to exert a measurable impact on production scale in the 1960s.

Given this finding it is relevant to examine the basis of the explanatory power of the two equations. This is obviously the theoretical herd capacity index. The relationship between this value and output suggests that pasture resources were the critical element in land utilisation. Further, comparison with the functions given in Chapter 3 shows that the relative importance of this variable increased over the decade. This is the classical response for an industry that has been released from the constraints of poor accessibility. The main reason for the statistical significance of the reversed relationship between output and accessibility is the fact that the more remote properties also tend to have superior grazing reserves. Accepting the finding that location exerted little influence on land-use intensity, it is interesting to speculate on the factors that contribute to the deviations from complete adjustment to variations in pasture quality. Cartographic analysis of the residuals from one of the equations in the array suggests three conclusions. First, some discrepancies seem to arise from possible inaccuracies in the calculation of the grassland capacities;

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1 Further discussion of these results is given in Appendix 2.
2 The simple correlation coefficient (for the 179 holdings) between the theoretical herd capacity index and sales is 0.83 (for 1966) and 0.83 (for the five year average from 1963-1967).
in particular the estimates seem to understate the productivity of the Mitchell and Flinders grass country in the Victoria River and Barkly Tableland Districts. Second, the influence of climatic variations is often apparent and this accounts for many of the negative residuals in the Alice Springs District which was affected by drought from 1963 through 1966. Finally, many minor deviations seem to be related to managerial policies and confirm some of the subjective assessments of management quality reached on fieldwork. Overall, the statistical analysis suggested that the physical determinants of supply, through spatial and temporal variations in the availability of pasture, exert a very strong influence on productivity: this topic will be pursued in the following section.

4. The effects of climatic variation over time

These regression equations may also be viewed as an attempt to relate the economic rents of holdings to actual land-use, both in terms of Ricardian theory, which emphasises the effects of variations in the 'original and indestructible powers of the soil', and its extension by von Thünen to account for differences in accessibility to markets. In theory the residuals would be explained by the operation of endogenous variables (e.g. the effects of scale and managerial judgements on the optimum input mix of the other factors of production), and exogenous variables like climate. The former will be considered in the third section of this chapter and again in the third section of Chapter 5. However the impact of climatic variations over time can be observed by comparing the correlation coefficients given in Table 4.4 for different calendar years. The degree of correlation between the index of average land quality per holding and sales per square mile ranges from 0.43 for 1965 to 0.57 for 1966. Since it is reasonable to assume that endogenous influences are invariant in the extremely short run, it may be inferred that these differences result primarily from climatic fluctuations.
The most important variable is rainfall, but it is difficult to deduce its effect on production. The ecological system which governs pasture quality, the stocking rate, and the output of beef from a given area is very complex. Slatyer concluded, when considering the problem of predicting feed value alone, that it was difficult to interpret climatic data in a way that yielded quantitative information on plant growth.¹ Even for a single season detailed rainfall statistics are required to estimate 'initial effective rainfall' and 'effective carryover rainfall' for small areas in the Alice Springs District, while the cumulative effects of a variable run of seasons are much harder to predict. The position in the three northern regions is more complicated since excess rainfall may lead to the overgrowth of grass and the destruction of its nutritive value. Finally, range response is also conditioned by long and short-run differences in the intensity of stocking.²

It is possible nevertheless, to deduce the rational reactions of operators to variations in seasonal conditions. First, in the event of short-term dry spells the tendency would be for producers to lighten their stocking rate which would temporarily raise annual output. Second, the continuation of this policy over a longer period would lead to a lowering of productivity as the breeding herd became depleted. Third, it would be expected that the most marginal enterprises would be the first to cease production if dry conditions continued. Some confirmation that the units on poorer quality land may have more variable outputs is given by the lower correlations between land productivity


and the theoretical stocking rates for 1965 in Table 4.4. This was a year of below average rainfall for the whole of the Northern Territory rangelands and the results may reflect a trend for these holdings to turn-off a greater number of stock than would be expected. Table 4.6 gives further evidence on these hypotheses and sets out the structure of property sales and purchases for all units entering production between 1963 and 1967, by region. Of particular interest is the reaction of producers in the Alice Springs District to the termination of the drought which lasted from 1958 to 1965. Up to 1965 -- the last poor year -- sales remained relatively high, purchases were small, and the number of units in production declined. In 1966 properties began to purchase store and breeding stock, especially from beyond the region, and turn-off fell though it was evenly distributed over space. The 1967 figures seem to show further adjustment to better conditions and a more stable output with imports continuing to expand. This pattern, which indicates considerable flexibility of management, is probably becoming more common. It follows from the increased opportunities for agistment and re-stocking that have resulted from the adoption of road transport and the relaxation of disease controls. These conclusions are supported by the hypothetical data presented by van Holst Pellekaan, who found that maximum flexibility in pasture use, through breeding and fattening and importing store cattle in good years, was also the most profitable form of enterprise for properties affected by periodic droughts.¹

The effects of rainfall variations on pasture growth and production policy have been discussed in detail to show the impossibility of quantifying this variable in the systematic analyses. Even the separation of the Alice Springs District from the three northern regions to account

Table 4.6: Average property purchases and sales, by District, 1961-1967 (calendar years).

<table>
<thead>
<tr>
<th>Year</th>
<th>ALICE SPRINGS</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>BARKLY TABELAND</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Average station purchases</td>
<td>Average station sales</td>
<td>Net production balance</td>
<td>Number of properties</td>
<td>Average station purchases</td>
<td>Average station sales</td>
<td>Net production balance</td>
<td>Number of properties</td>
<td></td>
</tr>
<tr>
<td>1963</td>
<td>57</td>
<td>486</td>
<td>429</td>
<td>73</td>
<td></td>
<td>933</td>
<td>3,177</td>
<td>2,244</td>
<td>25</td>
</tr>
<tr>
<td>1964</td>
<td>110</td>
<td>576</td>
<td>466</td>
<td>71</td>
<td></td>
<td>1,066</td>
<td>2,404</td>
<td>1,308</td>
<td>24</td>
</tr>
<tr>
<td>1965</td>
<td>59</td>
<td>617</td>
<td>558</td>
<td>69</td>
<td></td>
<td>969</td>
<td>2,879</td>
<td>1,910</td>
<td>25</td>
</tr>
<tr>
<td>1966</td>
<td>200</td>
<td>286</td>
<td>86</td>
<td>74</td>
<td></td>
<td>668</td>
<td>3,710</td>
<td>3,042</td>
<td>25</td>
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<tr>
<td>1967</td>
<td>238</td>
<td>405</td>
<td>167</td>
<td>74</td>
<td></td>
<td>592</td>
<td>2,992</td>
<td>2,400</td>
<td>25</td>
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<table>
<thead>
<tr>
<th>Year</th>
<th>VICTORIA RIVER</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>DARWIN AND GULF</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average station purchases</td>
<td>Average station sales</td>
<td>Net production balance</td>
<td>Number of properties</td>
<td>Average station purchases</td>
<td>Average station sales</td>
<td>Net production balance</td>
<td>Number of properties</td>
<td></td>
</tr>
<tr>
<td>1963</td>
<td>244</td>
<td>1,807</td>
<td>1,563</td>
<td>21</td>
<td></td>
<td>88</td>
<td>527</td>
<td>439</td>
<td>40</td>
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<tr>
<td>1964</td>
<td>519</td>
<td>1,884</td>
<td>1,365</td>
<td>21</td>
<td></td>
<td>79</td>
<td>738</td>
<td>659</td>
<td>35</td>
</tr>
<tr>
<td>1965</td>
<td>123</td>
<td>1,547</td>
<td>1,424</td>
<td>23</td>
<td></td>
<td>63</td>
<td>544</td>
<td>481</td>
<td>33</td>
</tr>
<tr>
<td>1966</td>
<td>71</td>
<td>1,366</td>
<td>1,205</td>
<td>24</td>
<td></td>
<td>22</td>
<td>326</td>
<td>304</td>
<td>33</td>
</tr>
<tr>
<td>1967</td>
<td>96</td>
<td>1,721</td>
<td>1,666</td>
<td>23</td>
<td></td>
<td>107</td>
<td>641</td>
<td>334</td>
<td>41</td>
</tr>
</tbody>
</table>

*Source: NTAAIB stock permit data*
for the long-term drought is not valid because similar effects would probably be observable for localised areas of the whole of the Northern Territory in some years. Notably, severe dry spells affected the southern Victoria River District between 1963 and 1965, the western Barkly Tableland in 1963 and parts of the Darwin and Gulf District in 1966. Although these variations cannot be accounted for, attention should be drawn to the systematic bias which climate can exert on the relationship between land-use intensity and accessibility. Because properties in the Alice Springs District lie within the Adelaide supply area their indices of net received prices are uniformly high. Hence, lower production in this region due to drought tends to reverse the locational relationship. This may account in part for the reversal of the sign of the accessibility function in the two regression equations for the period, and their lack of comparability with the results of the 1957 analysis.

5. Conclusion -- the basic determinants of output

The conclusions which can be drawn on the relationship between productivity (in terms of gross output) and the effects of spatial variations in land quality, climatic fluctuations, and the differences in the farmgate prices received by producers require careful appraisal. Four major inferences seem valid:

(i) Output in the study industry seems to be very dependent upon spatial and temporal variations in pasture resources. This is the result of the inextricable connection between the ecological and economic systems under open range conditions.

(ii) The influence of spatial variations in marginal returns per unit of output on land-use intensity was slight or non-existent between 1960 and 1967.

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1 Bureau of Meteorology, Annual Rainfall Maps of Australia, Melbourne.
(iii) The comparison of the functions governing holding output in 1957 and 1966 suggests that the influence of accessibility on physical productivity probably declined over the decade.

(iv) The consistently poor performance of a wide range of accessibility indices in the spatial equilibrium analysis means that coefficients cannot be obtained for the complementarity effects of local improvements in roads.

The general conclusion of the work must be that the influence of transportation costs on production scale was reduced between 1957 and 1966. This was due primarily to the general rise in beef prices and the entry of the Katherine and Darwin plants. Thus non-spatial determinants of land-use intensity became more important. This confirms Brinkman's deductive conclusion that

With the levelling out of local prices, one of the most characteristic manifestations of a progressing economic development, namely differences in intensity between the various economic locations, will be lessened accordingly so that, within a given area, the nature of the soil and climate will be more and more the determinants which explain the existing differences in intensity.¹

C. SPATIAL ADJUSTMENT IN PROFITABILITY AND FACTOR USE

The previous section examined spatial differences in land productivity and related them to the hypothesis that an explanation of the pattern can be given through the application of spatial equilibrium concepts. The following section extends the analysis to the consideration of intensity of factor use and locational differences in profits. The first part sets out the regional structure of costs, capital usage, and net income for eighty-two units for the three financial years from 1962-63 to 1964-65, and relates profitability to movements in costs and prices

between 1960 and 1967. This introduces the available data and provides a reference for the second part which is orientated to a spatial perspective. The basis of the analysis remains the Thünen model in which returns per unit of area would be dependent upon variations in accessibility under optimal and constrained conditions.

1. Temporal and regional variations in profits — an overview

The aim of this short section is to provide a context for the analysis of spatial variations in land-use profitability that follows. Figure 4.2 shows the relative national movements of the indices of prices received for beef cattle and prices paid by farmers for all goods entering production expenses.\(^1\) This confirms the importance of the recovery of cattle prices from 1963 and suggests that the industry as a whole saw an increase in returns in the succeeding years. These trends assume a static production function and may be compared with the data presented in Table 4.7, which shows fluctuations in the average percentage return to capital and management income of the stations surveyed by the BAE over the period 1962-63 to 1964-65.

In the Northern Territory there are marked regional and annual variations which seem conditioned by climatic influences (the low returns of producers in the Alice Springs District, for instance, are related to the continued drought in that region). Little evidence is available to support the hypothesis that price movements are critical and there is no consistent reaction from the properties of the Victoria River and Darwin and Gulf Districts to the extension of marketing opportunities following the opening of the two northern meatworks in 1963.

\(^1\) For further details see 'Indexes of Prices Received and Paid by Farmers in Australia', *Quarterly Review of Agricultural Economics*, 22 (1969), pp.103-13.
Fig. 4.2: Variations in the national indices of prices received and paid by beef producers, 1960-61 to 1967-68

Source: 'Indexes of Prices Received and Paid by Farmers in Australia', Quarterly Review of Agricultural Economics, 22 (1969).
Table 4.7: District and temporal variations in percentage return to capital and management income (station average).

<table>
<thead>
<tr>
<th>Sample and year</th>
<th>Alice Springs</th>
<th>Barkly Tableland</th>
<th>Victoria River and Gulf</th>
<th>Northern Territory</th>
</tr>
</thead>
<tbody>
<tr>
<td>82 enterprises:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1962-63</td>
<td>-2.2</td>
<td>8.4</td>
<td>6.3</td>
<td>3.3</td>
</tr>
<tr>
<td>1963-64</td>
<td>-0.7</td>
<td>5.8</td>
<td>-0.2</td>
<td>2.0</td>
</tr>
<tr>
<td>1964-65</td>
<td>-7.6</td>
<td>5.9</td>
<td>7.2</td>
<td>7.7</td>
</tr>
<tr>
<td>3 year average</td>
<td>-3.5</td>
<td>6.6</td>
<td>4.5</td>
<td>4.6</td>
</tr>
<tr>
<td>72 enterprises:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 year average</td>
<td>-4.5</td>
<td>3.2</td>
<td>4.5</td>
<td>-1.4</td>
</tr>
</tbody>
</table>

a. differs from the main sample in assuming a static-price inventory gain.
b. not available.

Sources: The Northern Territory Beef Cattle Industry, BAE, Canberra, 1968, and BAE unpublished data.

Table 4.8 shows the structure of net income for the eighty-two properties in the Northern Territory in the complete survey, for the three year period by District. Net cash income is the surplus that remains after cash costs have been met (these include the cost of materials, services, hired labour, and cattle purchases and exclude the operator's labour allowance and depreciation). Over ninety-four per cent of cash income in all regions came directly from cattle sales. The construction of the other indices of profitability is detailed in the table, and the same parameters are employed in all subsequent tabulations. The most marked variation between regions is one of scale with the Barkly Tableland and Victoria River District stations.
Table 4.8: The average net income structure of holdings, by District, 1962-63 to 1964-65 (BAE sample of 82)

<table>
<thead>
<tr>
<th>Item</th>
<th>Alice Springs</th>
<th>Barkly Tableland</th>
<th>Victoria River</th>
<th>Darwin and Gulf</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Cash income</td>
<td>$24,994</td>
<td>$92,096</td>
<td>$80,349</td>
<td>$42,226</td>
</tr>
<tr>
<td>B. Cash cost</td>
<td>$23,780</td>
<td>$70,959</td>
<td>$60,971</td>
<td>$40,486</td>
</tr>
<tr>
<td>C. Net cash income (A-B)</td>
<td>$1,214</td>
<td>$21,137</td>
<td>$19,378</td>
<td>$1,740</td>
</tr>
<tr>
<td>D. Interest paid</td>
<td>$2,280</td>
<td>$1,641</td>
<td>$2,480</td>
<td>$2,364</td>
</tr>
<tr>
<td>E. Cattle inventory change</td>
<td>$1,427</td>
<td>$47,794</td>
<td>$36,763</td>
<td>$27,739</td>
</tr>
<tr>
<td>F. Depreciation</td>
<td>$9,030</td>
<td>$22,228</td>
<td>$24,428</td>
<td>$12,184</td>
</tr>
<tr>
<td>G. Net farm income (C+D+E-F)</td>
<td>$4,109</td>
<td>$48,344</td>
<td>$34,193</td>
<td>$19,659</td>
</tr>
<tr>
<td>H. Operator's labour allowance</td>
<td>$1,903</td>
<td>$1,903</td>
<td>$1,903</td>
<td>$1,903</td>
</tr>
<tr>
<td>I. Capital and management income (G-H)</td>
<td>$-6,012</td>
<td>$46,441</td>
<td>$32,290</td>
<td>$17,756</td>
</tr>
<tr>
<td>J. Total capital</td>
<td>$172,646</td>
<td>$702,599</td>
<td>$717,382</td>
<td>$390,062</td>
</tr>
<tr>
<td>Percentage return to capital and management (100 I/J)</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
</tbody>
</table>


employing four times the average capital investment of those in the Alice Springs District.

The cost structure of the sample has already been described in Chapter 2 (Table 2.3) and may be compared with the 1949-50 situation as shown in Table 3.3. The most notable change between the two survey periods is the fall in the percentage of costs accounted for by labour and the rise in the importance of depreciation. This indicates a general substitution of capital, in the form of fencing,
waters, and yards, for the extensive use of manpower under open range conditions. Table 4.9 presents complementary data on the structure of capital expenditure. This confirms the presence of factor substitution since it shows that the percentage of working capital held in cattle values fell from a Northern Territory average of eight-six per cent to approximately seventy per cent between the survey dates. A further point is that although the percentage return to capital was low, the rate of annual investment over the three years from 1962-63 to 1964-65 was uniformly high, so that capital appreciated on average by 6.5 per cent per year. This reflects the confidence of operators in the industry and may also cover a tendency to plough back profits to avoid taxation.

2. Spatial variations in productivity, investment, and profits -- methodological issues

Under the assumptions of the Isolated State, spatial variations in net received prices would be expected to determine the intensity of land-use per unit of area and the overall profitability of holdings, provided they are of the same acreage, within a single industry zone. The theoretical background to these assertions has been explored in Chapter 2, where the model was related to the study industry and the effects of relaxing the constraints on land quality, property size, technical homogeneity and the influence of uncertainty. Intensity of land-use has been defined, in this study, in terms of output per square mile, but intensity in the more strict economic usage refers more often to the employment of capital and labour. Since the marginal productivity of these factors is dependent upon the level of marginal returns in von Thünen's model, their intensity of use per unit of land will vary directly with output and holding profitability along the rent gradient. However, as Hammar has pointed out, productivity and efficiency are only related to land rent under ceteris paribus conditions, since for some lands their quality may 'act as a substitute for labour and capital and this in fact
Table 4.9: The average structure of total and current capital expenditure of holdings, 1962-63 to 1964-65 (BAE sample of 82)

<table>
<thead>
<tr>
<th>Capital Item</th>
<th>Alice Springs</th>
<th>Barkly Tableland</th>
<th>Victoria River</th>
<th>Darwin and Gulf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$</td>
<td>%</td>
<td>$</td>
<td>%</td>
</tr>
<tr>
<td>Made waters</td>
<td>37,274</td>
<td>22</td>
<td>100,089</td>
<td>14</td>
</tr>
<tr>
<td>Fencing</td>
<td>23,450</td>
<td>13</td>
<td>51,511</td>
<td>7</td>
</tr>
<tr>
<td>Yards</td>
<td>9,628</td>
<td>5</td>
<td>12,962</td>
<td>2</td>
</tr>
<tr>
<td>Buildings</td>
<td>7,922</td>
<td>5</td>
<td>29,530</td>
<td>4</td>
</tr>
<tr>
<td>Plant &amp; Machinery</td>
<td>9,936</td>
<td>6</td>
<td>20,060</td>
<td>3</td>
</tr>
<tr>
<td>Total excluding cattle</td>
<td>88,210</td>
<td>51</td>
<td>214,152</td>
<td>30</td>
</tr>
<tr>
<td>Cattle</td>
<td>84,436</td>
<td>49</td>
<td>488,447</td>
<td>70</td>
</tr>
<tr>
<td>TOTAL</td>
<td>172,646</td>
<td>100</td>
<td>702,599</td>
<td>100</td>
</tr>
<tr>
<td>Gross investment per year</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total excluding cattle</td>
<td>7,908</td>
<td>64</td>
<td>31,932</td>
<td>62</td>
</tr>
<tr>
<td>Cattle</td>
<td>4,394</td>
<td>36</td>
<td>19,510</td>
<td>38</td>
</tr>
<tr>
<td>TOTAL</td>
<td>12,302</td>
<td>100</td>
<td>51,442</td>
<td>100</td>
</tr>
</tbody>
</table>

reduces the need for intensive handling of them. In this study the emphasis is placed on location rent variations within a relatively homogeneous industry and Hammar's objections to the linkage of factor use intensity to land-use intensity may be ignored.

The methodology adopted in the following two sections is based on the classification of properties by zones of accessibility to markets, defined by imputed road transport costs and net price differentials per beast from the station homestead to the centre favoured by the producer. In this sense the zones place holdings in their locational relationship to a hypothetical central market and the economic landscape is distorted to an analogy of the Isolated State. To minimise the effects of exogenous variables the zones contain quintiles of the modified sample of seventy-two stations, which results in differences in the width of rings. The data has been prepared in concert with the BAE which supplied the tabulations from their 1962-63 to 1964-65 survey. Ten properties have been omitted on grounds of their dubious character as economic units (such as where land is held for capital gain or used primarily for tourism). All parameters are represented by the mean value for the three survey years to minimise short-term temporal influences. Aggregations have been used to maintain the confidentiality of the survey data, and no information was given to the author on individual properties.

3. Accessibility zones defined by transport costs

The definition of the structure of transport costs over the survey period poses particular difficulties since it

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2 This does not imply that this factor exerts no influence on the study industry. A notable instance is the reduction in capital expenditure on properties in the north of the Northern Territory where permanent natural waters obviate the need to devote as large a proportion of investment to dams and bores.
coincides with the establishment and increasing influence of the Katherine and Darwin meatworks from 1963. In practice an attempt has been made to approximate the allocation pattern for 1964 by modifying the 1966 situation in the light of additional knowledge. This procedure assumes that production response to marketing opportunities was instantaneous. This is not justified by the analyses of adjustment to exchange equilibrium, and can be questioned further on the grounds that the modification of production scale would only occur in the longer term. However, the methodology adopted appears preferable to the subjective assessment of property accessibility variations and the estimation of lag functions for different supply areas. The internal coherence of the 1964 allocation pattern probably offsets its disadvantages.

Table 4.10 presents data on the characteristics, productivity, investment, costs, and income of the stations in each zone. In a homogeneous landscape the number of stock run per square mile could be expected to decline towards the periphery since cattle are a capital item. In the study industry this does not hold and stocking rates are fairly closely related to the estimate of the overall quality of the pasture in each ring. Under the open range system this result might be expected, but the model would suggest that the nearer producers would exploit their cattle resources more intensively. In fact, it appears that stations on the periphery have the highest average branding rates while those of the middle zone turn-off the greatest proportion of cattle for sale. According to the Thünen theory of intensity rent, the operators nearest the edge of the rent-scape are likely to use less capital per square mile than those nearer the market. The evidence does not confirm this for there is a tendency for the outer stations to spend more on fencing and waters, though investment in holding yards does follow the theoretical gradient. Symmetry is also lacking in labour usage and current costs, though these tend to match variations in land quality.
Table 8.10: Average holding profitability and factor use characteristics (1962-63 to 1964-65) by road transport rate payment access zones.

<table>
<thead>
<tr>
<th>Zonal characteristics</th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
<th>Zone 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of observations</td>
<td>15</td>
<td>14</td>
<td>14</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Average road transport payment ($ per beast)</td>
<td>2.57</td>
<td>4.55</td>
<td>0.27</td>
<td>8.30</td>
<td>11.77</td>
</tr>
<tr>
<td>Average zone land quality</td>
<td>6.78</td>
<td>13.33</td>
<td>11.71</td>
<td>9.12</td>
<td>13.05</td>
</tr>
<tr>
<td>Average property area (square miles)</td>
<td>1.60</td>
<td>2.04</td>
<td>3.97</td>
<td>2.055</td>
<td>2.110</td>
</tr>
<tr>
<td>Average stocking rate (beasts per square mile)</td>
<td>3.56</td>
<td>6.31</td>
<td>3.72</td>
<td>3.78</td>
<td>3.41</td>
</tr>
<tr>
<td>Average branding rate (calves as a percentage of cattle)</td>
<td>39.91</td>
<td>43.66</td>
<td>48.94</td>
<td>46.24</td>
<td>39.98</td>
</tr>
<tr>
<td>Average turn-off rate (sales as a percentage of cattle)</td>
<td>15.71</td>
<td>17.17</td>
<td>19.10</td>
<td>17.09</td>
<td>14.77</td>
</tr>
<tr>
<td>Average property area (square miles) (1963-65)</td>
<td>0.34</td>
<td>0.75</td>
<td>0.97</td>
<td>0.63</td>
<td>0.78</td>
</tr>
</tbody>
</table>

**Capital Investment**

| Average capital investment ($ per square mile) | 198.59 | 273.80 | 297.86 | 249.49 | 279.24 |
| Number of miles of fencing per 10 square miles | 0.83   | 1.08   | 1.11   | 1.25   | 1.52   |
| Number of water points per 100 square miles | 0.87   | 1.15   | 0.77   | 0.59   | 1.15   |
| Number of holding yards per 100 square miles | 1.15   | 1.82   | 1.22   | 1.00   | 0.96   |
| Average annual capital expenditure ($ per square mile) | 9.56   | 11.92  | 10.11  | 10.75  | 12.78  |

**Costs**

| Average 1/2 hour costs ($ per square mile) | 9.02   | 12.31  | 10.83  | 10.47  | 11.25  |
| Average total costs ($ per square mile) | 25.19  | 36.60  | 32.15  | 32.54  | 38.93  |

**Income**

| Total income ($ per square mile) | 22.62  | 39.78  | 40.76  | 25.23  | 32.57  |
| Net Farm Income ($ per square mile) | -2.57  | 3.14   | 8.63   | -10.31 | -5.30  |
| Net Cash Income ($ per square mile) | 6.36   | 15.85  | 19.32  | 7.27   | 6.14   |
| Average percentage return to capital and management | -2.96  | -2.26  | 0.36   | -3.76  | 0.15   |

**Theoretical situation rent gradient**

| Net Farm Income ($ per square mile) | 0.63   | -0.69  | -1.84  | -3.33  | -5.51  |
| Average percentage return to capital and management | -0.19  | -0.76  | -1.24  | -1.87  | -2.80  |

* Calculated from the Northern Territory average (zone 3).

**Sources:** Special tabulations prepared by the BAE from unpublished data (sample of 72 stations) and NTAAIB stock permit information.
Four indicators of variations in income are tabulated which correspond to those used modified BAE survey results. In all cases the middle zones appear to contain the most profitable properties, with the fourteen stations in zone 3 being the only group to realise a positive average percentage return to capital and management income. The gradients are not regular and it is difficult to draw any conclusions which support the hypothesis that transport costs are a critical determinant of profits. The trends may be compared to the theoretical effect of variations in situation rents on a hypothetical property, representing the industry mean, at the base of the table. Here it is assumed that zone 3 contains the actual Northern Territory average and transformations have been made by calculating the effect of higher and lower transportation costs using the modal zone values.

Several complicating factors may be responsible for poor performance of the model, including the effects of variations in pasture quality and holding size. In addition the methodology assumes that operators react to differences in transport costs rather than net received prices. However, considering that the more remote properties pay an average of four times the freight charges of those in the nearest zone the results bring into question the operation of this aspect of rent theory in practice. Certainly, compared with the regional and temporal analyses of profitability the locational classification tends to obscure rather than illuminate the critical factors. The only conclusions that can be drawn from the gradients are that the more distant stations may be prone to over-investment, while those nearer the market do not seem to make the best use of their resources. These inferences will be pursued in the following section which repeats the procedure using variations in received prices.

The percentage return figures are directly comparable with those shown for the 72 enterprise set in Table 4.7.
4. **Accessibility zones defined by net received price differentials**

The short-term effects of the introduction of two new markets over the survey period make the estimation of differences in farmgate prices particularly difficult. Two contrasting positions may be held. On the one hand it could be argued that the immediate rise in prices affecting northern producers would result in a rapid increase in marginal returns and profits, due to the shift in their situation rents. On the other, it could be that these properties had insufficient time to adjust their factor mix to their new opportunities, so that their intensity rents would be relic forms. To account for these two views the price differentials adopted are based on regional variations in receipts for all classes of cattle, rather than the prices available for fatstock at alternative markets. The BAE survey found that average net receipts per beast sold over the three year period varied between regions as follows:

<table>
<thead>
<tr>
<th>Region</th>
<th>Receipts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alice Springs</td>
<td>$49</td>
</tr>
<tr>
<td>Barkly Tableland</td>
<td>$44</td>
</tr>
<tr>
<td>Victoria River</td>
<td>$37</td>
</tr>
<tr>
<td>Darwin and Gulf</td>
<td>$40</td>
</tr>
</tbody>
</table>

Thus producers in the Barkly Tableland region have been debited $5.00; and those of the two northern regions $10.00 per beast marketed, since their opportunities were virtually the same. These weightings have been added to the imputed transport cost estimates. The effect of this procedure is to restrict the first two zones to properties in the Alice Springs District and broaden the groupings in the remaining rings. 1 Table 4.11 gives a duplicate set of zone characteristics and economic parameters on this basis.

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1 The pattern of comparative accessibility produced by this procedure corresponds closely to the author's subjective assessment. Fig. 4.1 shows the frequency distribution of the series. Here it will be observed that the class intervals show a continuous spectrum, unlike those based on actual market price reports which appear to give a disproportionate weight to price.
Table 4.1: Average holding profitability and factor use characteristics (1962-65) by net received price zones

<table>
<thead>
<tr>
<th>Zonal characteristics</th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
<th>Zone 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of observations</td>
<td>15</td>
<td>12</td>
<td>18</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>Average net received price differential ($) per fat</td>
<td>3.15</td>
<td>3.52</td>
<td>16.92</td>
<td>16.00</td>
<td>16.07</td>
</tr>
<tr>
<td>Average zone land quality</td>
<td>6.37</td>
<td>4.55</td>
<td>13.73</td>
<td>10.06</td>
<td>18.40</td>
</tr>
<tr>
<td>Average property area (square miles)</td>
<td>1,267</td>
<td>1,408</td>
<td>2,186</td>
<td>1,729</td>
<td>2,337</td>
</tr>
<tr>
<td>Average stocking rate (beasts per square mile)</td>
<td>1.80</td>
<td>1.43</td>
<td>6.78</td>
<td>0.85</td>
<td>7.98</td>
</tr>
<tr>
<td>Average branding rate (calves as a percentage of cows)</td>
<td>43.56</td>
<td>52.64</td>
<td>46.61</td>
<td>41.44</td>
<td>44.54</td>
</tr>
<tr>
<td>Average turn-off rate (sales as a percentage of cattle)</td>
<td>18.72</td>
<td>23.53</td>
<td>14.58</td>
<td>13.10</td>
<td>13.78</td>
</tr>
<tr>
<td>Average sales per square mile (1963-65)</td>
<td>0.42</td>
<td>0.39</td>
<td>0.77</td>
<td>0.86</td>
<td>0.95</td>
</tr>
<tr>
<td>Capital Investment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average capital investment ($) per square mile</td>
<td>138.60</td>
<td>115.94</td>
<td>273.10</td>
<td>271.85</td>
<td>353.03</td>
</tr>
<tr>
<td>Number of miles of fencing per 10 square miles</td>
<td>0.84</td>
<td>0.87</td>
<td>1.20</td>
<td>1.16</td>
<td>1.89</td>
</tr>
<tr>
<td>Number of male voters per 100 square miles</td>
<td>1.54</td>
<td>1.55</td>
<td>0.63</td>
<td>0.67</td>
<td>0.94</td>
</tr>
<tr>
<td>Number of holding yards per 100 square miles</td>
<td>1.29</td>
<td>1.07</td>
<td>1.08</td>
<td>1.04</td>
<td>1.03</td>
</tr>
<tr>
<td>Average annual capital expenditure ($) per square mile</td>
<td>5.57</td>
<td>6.22</td>
<td>12.05</td>
<td>13.05</td>
<td>17.96</td>
</tr>
<tr>
<td>Costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average labour costs ($) per square mile</td>
<td>5.66</td>
<td>5.57</td>
<td>12.31</td>
<td>12.00</td>
<td>14.18</td>
</tr>
<tr>
<td>Average total costs ($) per square mile</td>
<td>23.14</td>
<td>29.75</td>
<td>32.42</td>
<td>30.34</td>
<td>45.91</td>
</tr>
<tr>
<td>Income</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total income ($) per square mile</td>
<td>19.39</td>
<td>14.54</td>
<td>43.03</td>
<td>35.10</td>
<td>33.83</td>
</tr>
<tr>
<td>Net Farm Income ($) per square mile</td>
<td>-3.85</td>
<td>-6.26</td>
<td>10.61</td>
<td>8.02</td>
<td>-12.08</td>
</tr>
<tr>
<td>Net Cash Income ($) per square mile</td>
<td>6.05</td>
<td>4.95</td>
<td>15.19</td>
<td>20.09</td>
<td>4.67</td>
</tr>
<tr>
<td>Average percentage return to capital and managemen</td>
<td>-3.06</td>
<td>-3.20</td>
<td>-1.96</td>
<td>-0.29</td>
<td>-2.38</td>
</tr>
<tr>
<td>Theoretical situation rent gradient</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Farm Income ($) per square mile</td>
<td>3.35</td>
<td>0.97</td>
<td>-1.84</td>
<td>-5.23</td>
<td>-6.61</td>
</tr>
<tr>
<td>Average percentage return to capital and management</td>
<td>0.95</td>
<td>-0.16</td>
<td>-1.24</td>
<td>-2.68</td>
<td>-3.26</td>
</tr>
</tbody>
</table>

Sources: As Table 4.10.
Because of the effect of drought on the core of the Alice Springs District it is useful to evaluate the table in two parts and separate the first and second rings from the remainder. Here the holdings to the south of the region near the railway to Adelaide show lower branding and turn-off rates than those in the second zone. However their capital investment and factor usage is higher and all the parameters of profitability give them superiority. The main reason for the differences appears to be the inter-zonal variation in land quality, though it is tempting to speculate that producers with adverse fertility and location rents are forced to work their cattle resources harder, as witnessed by their average branding rate.

For the properties of the other three zones the parameters can be divided broadly into two types. First, there are those that seem to vary in concert with land quality such as the turn-off rate, and capital investment and average labour costs per square mile. Second, there are those that increase towards the periphery. These are the actual stocking rate per square mile, the actual turn-off per square mile, investment in bores, capital expenditure, and total costs per unit of area. Thus there is a tendency for land quality to govern factor usage (cattle, capital, and labour), while an increase in the locational disadvantage of a property is associated particularly with an increase in the intensity of land-use. This may reflect a general substitution of land for the other factors of production towards the periphery that is masked by variations in land quality. If this is true it points to the need to consider the production function as an entity. This means that it may be unrealistic to isolate the effects of location on land-use and brings into question simple models of rent adjustment. Part of the explanation may lie in the tendency for the remote stations to breed store cattle while the nearer units specialise in fattening. Thus the rent gradient may be split at the intersection of two industry types with continuity in value of production per unit of area and a reversed gradient in total sales.
Confirmation of this inference is given by the consistent decrease in three of the indices of profitability towards the edge of the rent-scape. This occurs regardless of the effects of land quality and land-use intensity variations. It offers important evidence that location may condition returns through the elasticity effect and this gives some measure of the possible impact of improving transportation. However, the net received price differentials are wide and this suggests once again that the provision of additional processing facilities might be a more effective way of raising local prices and stimulating output. Since the form of the apparent rent gradient does not correspond with that of the theoretical situation rent slope, it is necessary to examine the process of adjustment in more detail. The preceding sections related the evidence linking accessibility and land-use intensity to comparable trends in temporal series and also considered the influence of exogenous variables. The following section abandons this approach and boldly links the empirical findings to rent theory. This leads to a number of more general deductions on the role of accessibility in land development.

D. ECONOMIC RENT AND LOCATION -- REVIEW AND CONCLUSION

1. Rent theory reviewed

The assumptions and deductions of a series of hypothetical models which have been put forward to explain spatial variations in returns to land and capital in primary production must now be examined more closely. This leads to the reinterpretation of the empirically derived rent gradients which have been considered solely in terms of their comparability to the Thünen model. In evaluating further elaborations of the Ricardian concept of economic rent, it is useful, first, to clarify the definition of this parameter. As Barlowe states:
The difference between an operator's total production costs and the value of his total product is referred to as "net return". Depending upon one's point of view and one's assumptions regarding the nature of the items covered by production costs, this difference might also be described as an economic surplus, as economic rent, or as the operator's profit.1

The fundamental determinant of the choice of phrase is the emphasis afforded to each of the four basic factors of production. 'Net return' suggests that capital is the main concern of the analyst; 'economic surplus' states a pre-occupation with labour and 'profit' with managerial skill. Finally, the word 'rent' emphasises the land aspect that forms the core of this study.

Ricardo demonstrated the source of rent by comparing the relative returns to labour on the cultivation of four dimensionless parcels of land of differing quality. He concluded that 'rent is always the difference between the produce obtained by the employment of two equal quantities of capital and labour', and that 'it invariably proceeds from the employment of an additional quantity of labour with a proportionally less return'.2 In this simple theorem economic rent is a direct function of variations in fertility but it is important to note that two underlying assumptions are made. First, the cost of land does not enter the calculation of the marginal productivity of capital and, second, scale of enterprise is totally ignored, which means that the economic rent on a marginal input of land is the same at the farm and industry levels within an area of homogeneous land quality.

The extension of this theory by von Thünen to embrace the effects of spatial differences in the marginal returns of producers from sales of a particular crop was based on the explicit assumption that all holdings were of the same

size. With uniform land fertility the industry rent function was therefore a direct function of variations in net received prices. In the original model this would lead to a linear rent gradient for the industry which would be composed of an infinite series of steps between farm boundaries. Dunn has made two major theoretical contributions to these deductions which may be extended to general rent theory. He has shown that differences in farm size may be a critical determinant of economic rent regardless of location, and that there is no reason to suppose that these two variables are interrelated, as long as there is no constraint on the amount of capital that may be employed by a single operator. He has also drawn attention to the fact that the cost of land will influence its intensity of use through compensatory adjustments in the total factor mix. This leads to the general conclusion that the rent gradient is unlikely to be linear, and a further inference seems valid for most cases. Since the cost of non-land inputs is likely to increase away from a central market, 'the probability is high that the distance-rent function will be concave upward' (i.e. that location rents will fall at a decreasing rate as distance from the market is increased; provided all holdings are of the same size).

While variations in land quality are important as determinants of the optimum intensity of factor usage within a farm, they may have little relevance to the actual scale of output or the overall profitability of a given enterprise. The failure of classical rent theory to take account of the dynamics of farm organisation has led Schultz to question its relevance as a guide to the profitability of land-use. He argues that the operation of the capital market will eventually lead to the equalisation of returns to capital and management since, in the long-run, farmers on sub-marginal land will rationalise, mechanise, or quit. As he states:

Dunn, E.S., The Location of Agricultural Production, Gainesville, 1967.
In short, the basic difficulties of acquiring the assets necessary to obtain the combination of inputs essential in organising an efficient farm arise from the way in which the capital market functions. It does not arise from the natural and original differences in the physical properties of land used for farming. As a special case, particular differences in land may result in a windfall gain; and when this occurs, to that extent the realised gain will lessen the adverse effects of capital rationing.1

It follows that under Schultz's hypothesis, intensity of land-use will be only partially determined by fertility and location, while farm rents will tend to disappear as all returns come to approximate the opportunity cost of capital.

Further complexities are introduced into the arguments which have been presented when the constraint on variations in the quality of management is relaxed. Two special cases will be discussed that lead to the reversal of the traditional Thünen gradient. The first has been postulated by Webber and involves the windfall profits which accrue to pioneers on the rent margin.2 He assumes that there will be a time lag before economic rents are absorbed by the land market in a newly settled area, so that the most distant operators will gain returns/rents for management and initiative that will vary inversely with the distance from the central market. Since under classical rent theory it is of no importance whether land rents are allocated to owner-operators or a rentier class it is clear that this model will only hold under specialised assumptions. The second case can be formulated from the work of Norman and Castle.3 Their 'range of choice' hypothesis suggests that

where the environment threatens the success of an agricultural enterprise it culls the least efficient operators and demands a high standard from the remaining managers. Thus farmers on marginal land will have a circumscribed range of choice of operations and the penalties for failing to adopt new techniques will be proportionally greater. Applied to the Thünen system, this would mean that, faced with lower net received prices and greater uncertainty in the event of a change of price at the market, the more distant producers would be forced to optimise the use of their resources to a greater extent than operators in more fortunate locations. For, as Norman and Castle conclude, 'the possibility [is] that penalties, as well as rewards, may act as incentives'. The validity of this model depends upon its behavioural assumptions and, while it could operate in some instances, there is no reason to believe that it has general application.

In summary, it can be seen that the traditional theory of economic rent may offer only a partial guide to spatial variations in returns. In general it will give a reasonable explanation of differences in the intensity of land-use provided the effects of factor substitution and managerial skill are not overwhelming. However, the relationship between profits and economic rent per holding is not direct and will be affected by the actual value of land and the ease of adjustment of holding boundaries towards the optimum scale.

2. Economic rent and returns in the study industry

The nearest approximation to the actual value of economic rents in the study industry can be reached by subtracting from net farm income, the annual cost of servicing total capital investment at the current rate of interest, and a charge for managerial services. This presumes that no account need be taken of the value of the property leases and that the quality of management is invariant. Table 4.12 sets out the results of this calculation for the properties in the net received price zones given in Table 4.11.
Table 4.12: Imputed economic holding and land rents, by net received price zones, 
(1962-63 to 1964-65)

<table>
<thead>
<tr>
<th>Item</th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
<th>Zone 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average holding net farm income ($)</td>
<td>-4,627</td>
<td>-8,737</td>
<td>23,195</td>
<td>1,418</td>
<td>-28,230</td>
</tr>
<tr>
<td>Average holding gross capital investment ($)</td>
<td>175,613</td>
<td>163,200</td>
<td>597,000</td>
<td>468,674</td>
<td>825,039</td>
</tr>
<tr>
<td>Annual charge on capital at 5 per cent ($)</td>
<td>8,781</td>
<td>8,160</td>
<td>29,850</td>
<td>23,434</td>
<td>41,252</td>
</tr>
<tr>
<td>Operators labour allowance per holding ($)</td>
<td>1,903</td>
<td>1,903</td>
<td>1,903</td>
<td>1,903</td>
<td>1,903</td>
</tr>
<tr>
<td>Average property economic rent ($)</td>
<td>-15,311</td>
<td>-18,800</td>
<td>-8,558</td>
<td>-23,919</td>
<td>-71,385</td>
</tr>
<tr>
<td>Average station area (Square miles)</td>
<td>1,267</td>
<td>1,408</td>
<td>2,186</td>
<td>1,724</td>
<td>2,337</td>
</tr>
<tr>
<td>Economic rent per square mile ($)</td>
<td>-12.08</td>
<td>-13.35</td>
<td>-3.91</td>
<td>-13.87</td>
<td>-30.54</td>
</tr>
</tbody>
</table>

Source: Calculations from Table 4.11.
Interest has been charged at five per cent which is well below the current overdraft rate of six and a half per cent. The operator's allowance has been estimated at $1,903 per year -- the figure used by the BAE in their survey tabulations. The adjustments made in this calculation do not alter the ranking of zones which was apparent from the comparison of spatial variations in net farm income per square mile and percentage return to capital and management income per holding. Since these trends hold for the three parameters, the inference is that the land determinants of economic rent have not been offset by the long-run adjustment of property scale and profits as hypothesised by Schultz.

Given the relevance of classical rent theory to the study industry, it is desirable to identify the relative effects of land fertility and location on the rent gradient. To further this end the seventy-two properties in the modified BAE sample were divided into three groups according to the ranking of the estimates of their average pasture quality. Thus for holdings in the first group the imputed theoretical stocking rate ranges from ten to thirty beasts per square mile. In the central class this varies between five and a half and ten, while for the group containing the stations with the worst land it ranges from one to five and a half animals per square mile. The procedure applied to the whole population was then applied to these groups, so that average values for economic characteristics are available for sets of observations delimited simultaneously by land quality group and net received price zone. For example, there are nine properties that lie in the upper land quality class and the fifth accessibility zone, while the average number of stations in each sub-class is four. In the case of the second zone in the upper class only one holding satisfied the joint conditions and this has been added to make a combined zone with the three observations in the inner zone. The gradients of net farm income per square mile and percentage return to capital and management income per enterprise given by this method are plotted by net received price zones in Fig. 4.3.
**Fig. 4.3**: Actual and theoretical holding and land rent gradients in the study industry, 1962-63 to 1964-65

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Dashed lines are the theoretical situation rent gradients

**Sources**: See text.
Although the number of stations in each sub-class is small the results of this procedure are of great interest. Comparison of the gradients for the two parameters of returns indicates a markedly regular and linked variation over space. In each case the importance of differences in land quality is immediately apparent and the effect of accessibility is notable and consistent. A series of inferences on the relative effects of the various determinants of economic rent may now be made with some confidence. First, the shallow profiles of returns for the properties in the worst land class would seem to indicate that producers on marginal land are cautious in avoiding variability in profits. This would support the deductions of the Norman and Castle model. Second, the gradients for the remaining land classes show a marked tendency to dip towards the rent margin and it seems reasonable to attribute this primarily to the effect of variations in situation rents. Comparison of the slopes of these profiles with those of the imputed theoretical gradients shown in Fig. 4.3, and described previously, shows, however, that the fall off in income towards the periphery is faster than would be expected.\(^1\) For this to be due to variations in intensity rent it would be necessary to prove that the level of capitalisation of the outer properties was lower than those of the inner zones. Reference to Table 4.10 shows that this is not true since the stations in zone 5 have the highest average capital investment. Indeed, this factor seems to explain why their returns are relatively lower, so that it may be that operators in the most remote locations tend to judge their input mix on the basis of the industry production function and suffer accordingly.

One further point remains. It is tempting to formulate a composite model of spatial variations in returns to explain the poor performance of the two inner zones. This could involve a 'market shadow' effect resulting from the tendency for the fortunate to ignore some opportunities and settle

\(^1\) The slope of these gradients is convex, indicating that Dunn's inference does not hold in the study industry.
for what they deem a reasonable return. Unfortunately
this inference is not warranted by the data. The inner zones
consist of properties in the Alice Springs District and it
seems probable that spatial and temporal variations in land
quality are the cause of their lower profits. In general
the stations in these zones tend to be in the lower part
of the range in each quality class, while all remained
drought afflicted throughout the survey years.

In conclusion, all the analyses given in this chapter
point in the same direction. So far as the land component
of the rent equation is concerned, variations in land
quality are far more important than differences in
accessibility. The evidence that is available on the
linkage between location and intensity of land-use suggests
that this factor is relatively unimportant and is
decreasing in influence. The relationship between the
intensity of factor usage and accessibility of holdings
conforms to this conclusion. Where location may still be
of some relevance is in the determination of profits through
situation rent differences, but the causal linkage between
this factor and intensity of resource use that is suggested
by the opening quotation from the Loder Report seems entirely
absent, and would be only expected in theory in the presence
of severe capital rationing.¹

¹ Commonwealth of Australia, Report of the Committee of
Investigation into Transportation Costs in Northern
Australia (the Loder Report), Canberra, 1965, p.93.
CHAPTER 5

ADJUSTMENT IN MARKETING, TRANSPORTATION AND PRODUCTION, 1950-1967 -- THE FACTORS INHIBITING ADHERENCE TO SPATIAL EQUILIBRIUM

It would indeed be miraculous if in reality, where everything is still in the process of development, where every change is but a transition to a higher state, if here the rational were already manifest in all its ultimate finality. But even had this miracle occurred, we would still have to prove that the existing state of things is rational, and show why this is so.

To obtain a full solution to our problem, we must subject to scrutiny and criticism everything taken from reality; we must discover the underlying laws, and where we have succeeded, transfer to the Isolated State these laws, and not the phenomena appearing in the real world. This, however, raises the prospect of innumerable problems....

von Thünen, The Isolated State

INTRODUCTION

The search for evidence of an ordered link between accessibility and productivity in the study industry has been inhibited by the complexity of the real world. Ideally, the model framework would incorporate each factor and specify its simultaneous relationship to individual variables, interactive sets, and the whole system. Since this is not possible, the concept of spatial equilibrium has been employed as a unifying structure for a series of analyses which select manageable groups of factors and examine their interrelationship at a particular period of time. The unsatisfactory aspects of this approach have been recognised by Lösch who states
If a system is regarded as an order of preference, the emphasis lies heavily on the word order. We order our facts according to viewpoints that are important to us. Hence the same thing appears again and again but is seen differently, whereas in a proper sequence, in an ideal system, it would have a unique place.

Nevertheless, this form of methodology permits some appreciation of the whole through the examination of different segments and facets. The framework for the empirical work described in Chapters 3 and 4 was derived from von Thünen's isolated State, and was based on the concepts of spatial equilibrium in exchange and production. The aim of this, the concluding chapter in Part 2, is to consider some of the specific problems which have been set on one side to simplify the approach.

The first of these problems concerns the assumption that the pattern of demand for beef cattle is independent of the location of supplies. Von Thünen was aware that the optimal size and spacing of towns and processing plants could be determined from the actual distribution of production in a complementary manner to the identification of rational land-use under the constraint of fixed demands. In reality the relationship is mutual. In the long-run both producers and consumers will move towards a spatial equilibrium in which excess profits are minimised and all returns come to approximate the opportunity cost of capital. One of the conclusions which has been drawn from the analysis of exchange in 1957 and 1966 is that the capacity and location of demand centres bear little relation to the local availability of cattle, for monopsony, lacuna, and excessive overlapping of supply areas are all evident. These are considered in the first section of this chapter, which also looks at the reasons for the apparently non-optimal response of producers to variations in marketing opportunities. In contrast to the first question, the need here is to prove the adequacy of the assumptions which have been made on the components of accessibility, rather than to broaden the scope of the model.

The second section extends the discussion of exchange equilibrium by detailing the factors which contributed to the adoption of the use of road transport over the study period. This performs two tasks. It provides a link between the 1957 and 1966 benchmarks which use uni-modal transport functions and, in addition, it allows further conclusions to be drawn on the importance of accessibility to producers in a decision matrix which includes non-rate costs and uncertainty. Again this is a modification of the basic model. The extension of the concept of complete adjustment to transportation services involves the consideration of the form of external economies but examination of this topic will be delayed to Part 3, which shifts the emphasis of the work to the costs and benefits of rural road investment.

Finally, section C explores some of the reasons for the discrepancies between the actual pattern of factor usage in the beef industry and the deductions which von Thünen reached on the adjustment of production scale to locationally determined variations in marginal returns. In reality, the decisions of operators on the form of their production function are conditioned by an array of influences which were ignored in the Isolated State model. Among these are land quality, farm size, and uncertainty. In addition, certain special characteristics of extensive cattle raising must be considered, such as the simple technological base and the relatively high level of capitalisation on holdings. These factors could be incorporated in a modified location theory, but in a wider sense they represent a need to link the study to a more general economic approach. This point is examined at the end of this chapter, where the emphasis is placed on the response of the industry to temporal variations in market prices and where spatial adjustment is compared to the wider problem of elasticity in supply. Thus each of the three sections looks at a distinct set of residual problems from the empirical work and emphasises the overall findings of this part of the study on the links between accessibility, transportation and land development.
A ADJUSTMENT IN MARKETING

1. The concept of exchange efficiency

To evaluate the relative efficiency of marketing in the Northern Territory it is necessary to formulate a series of standards which may be applied to the general problem of commodity exchange. Fortunately, Sosnick has provided such a framework which defines the efficiency of a marketing system in terms of the following seven propositions:

(i) transportation costs should not persistently be needlessly large;

(ii) economic facilities should exist at all assembly points;

(iii) price formation and the pairing of buyers and sellers should not be unreasonably costly;

(iv) price flexibility should not generate costly search for information, needless livelihoods for speculators or inefficient accommodation to uncertainty;

(v) prices should be high enough to avoid excess demand and low enough to avoid undesirable inventory accumulation;

(vi) for a set of prospective buyers and sellers at an assembly point, the ratio of actual to potential gains from trade should be maximised;

(vii) for a set of geographically scattered prospective buyers and sellers, the ratio of actual to potential gains from trade should be maximised.

Although the application of these criteria demands subjective assessments, this schema does provide a useful guide to the kinds of factors that have to be considered. In the context of this study the first and last points are of particular importance. On transport costs Sosnick comments:

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...sometimes excessive transportation is readily ascertainable and even quantifiable. This will be true when a "central market" sits outside the location polygon. It will be true when firms continually ship perfect substitutes into each other's "natural" market areas. It will be true when route duplication occurs.¹

The following sections are therefore concerned with two major problems, namely, the inefficient location of buyers and the non-optimal response of sellers.

2. Equilibrium considerations in the processing industry

a. The processing industry, 1950-1963

Prior to 1963 there were no export killing facilities in the Northern Territory despite the fact that the region contained upward of one million head of stock. Further, of the transhipment points offering export possibilities -- Darwin, Mt Isa, and Alice Springs -- only the latter is well located in relation to a major cattle producing area. The basic reason for the latter situation appears to be the historical development of settlement and route networks -- a point which has been made elegantly in the Payne-Fletcher report

Viewing the railway position as it exists today, it can readily be seen that the development of the Territory was commenced at the wrong points. It would almost seem as if an unkind fate presided over its destinies and compelled mistake after mistake to be made. Darwin, surrounded by inferior unproductive lands, was a poor jumping-off place in the first instance, while the Central Australia line, which runs through the low rainfall belt of South Australia, traverses land of very limited productive value. It seems almost incredible that it should have been built.

If development had been attempted from the east and west, instead of from the north and south, and railways had been constructed from Cloncurry in Queensland on the one side and from Derby or Wyndham in Western Australia on the other, the development and

¹ Sosnick, S.H., 1964, p.112.
Financial history of the Northern Territory would have been vastly different, as the best lands of the Territory would have been traversed. However, the present position must be accepted, and whatever can be done to alleviate it must be done.\textsuperscript{1}

The implication that the pattern of land-use would have been vastly different with an alternative rail net can be questioned, but this statement presents a valid picture of the poor layout of transportation facilities in this era.

The eccentric distribution of towns, ports and railheads in relation to the best cattlelands would seem to offer a partial explanation for the absence of private investment in processing. Apart from stock the industry requires power, high quality water, labour, and easy access to internal and export centres of demand. The manager of the present Katherine meatworks reports that an annual kill of 30,000 head demands the use of 1,800,000 k.w. hours of electricity, 7,000,000 gallons of water, a staff of 180, and the reservation of refrigerated storage for 1,000 tons of meat close to the Darwin wharf.\textsuperscript{2} Since power, water, and housing for employees are only available in existing centres of population the choice of location is narrowed to Alice Springs, Tennant Creek, Mt Isa, Katherine, Darwin, and Wyndham. All these towns are peripheral to the rangelands of the Barkly Tableland and the Victoria River Districts which contain nearly two-thirds of the cattle resources of the Northern Territory. Further, the low overall quality of fatstock commits most of the turn-off of the northern regions to the export trade and this gives a significant advantage to works with a seaboard location where a single refrigeration plant can be used to freeze and store meat prior to shipment.

In the study period the locational choice for an abattoir would appear to have been limited to Katherine,

\textsuperscript{1} Report of the Board of Inquiry into the Land and Land Industries of the Northern Territory of Australia (the Fairbairn Fletcher Report), Commonwealth of Australia, Canberra, 1957, p.27.

\textsuperscript{2} Personal communication, 14 March 1968.
Darwin, and Mt Isa, with the latter two being favoured because of the possibility of monopolising significant local markets for fresh beef. Processing plants at these centres would have significantly reduced transport costs in spite of their distance from the main producing areas. For instance, in 1957 the Victoria River District turned-off approximately 23,500 cattle, of which only about 4,000 were sold for immediate slaughter. From origin and destination data it is possible to estimate that these stock travelled a total of 12,000,000 beast-miles on the hoof. The reallocation of half of these animals to the Katherine railhead would have reduced movements to roughly 8,500,000 beast-miles and saved $25,000 in droving charges alone.

Similarly, if 30,000 head of the Northern Territory cattle entering Queensland had been slaughtered at Mt Isa, producers would have saved about $50,000 in railage costs to Townsville. Other things being equal, these reductions would have increased returns substantially: this, then, suggests there may have been a disequilibrium in spacing of processing centres.

Part of the explanation seems to lie in the failure of two meatworks ventures which were ill-founded and badly timed. In 1914 the Vestey Bros. began constructing a large facility at Darwin with a daily slaughtering capacity of 500 head. This works operated for three years until 1919 and processed a total of about 70,000 cattle. According to Kelly, the main reason for its lack of success was its poor location in relation to the fattening country of the Northern Territory. \(^1\) Other sources lay blame upon labour troubles and the lack of government support. \(^2\) Whatever the true cause it is probable that the failure of this project acted as a deterrent to subsequent investment for, as the Payne-Fletcher Report comments,

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Intending investors shudder when they hear of Vestey's experience and proceed to find avenues for their energy and capital elsewhere.¹

The second plant was located at Katherine and designed to produce meat extract from inferior quality cattle. The owners, Bovril Pty Ltd, ceased construction in 1951 and the works was never opened. Here the reasons for failure are obscure but, as in the case of the Vestey facility, the decision to cease work on the project may have been taken as a result of changes in the structure of international trade in meat. It may be that these Australian plants were begun to fulfill contracts in uncertain post-war conditions when alternative supplies, particularly from Argentina, could not be guaranteed.

While these ventures suggest that the construction of a meatworks in the north is a high risk undertaking, they also confirm the existence of opportunities for investment. In the study period the national price of beef rose markedly from 1952 following the implementation of the Australian-United Kingdom Meat Agreement making conditions more favourable to both producers and processors.² This, however failed to attract private enterprise to the region. One reason can be given by examining the cost structure of the Wyndham meatworks, which was operated by the Western Australian Government from 1919 to 1966. Its locational characteristics are very similar to those of Darwin though it lacks an inland rail link. Approximately one-fifth of its annual kill was drawn from the western Victoria River District and these animals made up about five per cent of the total turn-off of the Territory -- the only beasts processed for export in the North.

Table 5.1 sets out the average annual cost of treating one beast for the financial years 1949-50 to 1965-66. The

² See Tables 3.1 and 4.1 for annual shifts in the price of fatstock at Brisbane (the best indicator of national trends).
Table 5.1: Annual costs, payments to producers and throughput at the Wyndham meatworks 1949-1965

<table>
<thead>
<tr>
<th>Year</th>
<th>Variable processing costs per beast ($, financial year)</th>
<th>Average payment to producers per 100lb ($, financial year)</th>
<th>Annual throughput (head, calendar year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1949</td>
<td>17.72</td>
<td>3.78</td>
<td>31,734</td>
</tr>
<tr>
<td>1950</td>
<td>17.62</td>
<td>4.67</td>
<td>33,410</td>
</tr>
<tr>
<td>1951</td>
<td>22.98</td>
<td>5.60</td>
<td>30,437</td>
</tr>
<tr>
<td>1952</td>
<td>34.18</td>
<td>7.64</td>
<td>19,449</td>
</tr>
<tr>
<td>1953</td>
<td>27.92</td>
<td>7.84</td>
<td>26,066</td>
</tr>
<tr>
<td>1954</td>
<td>28.11</td>
<td>8.30</td>
<td>26,756</td>
</tr>
<tr>
<td>1955</td>
<td>40.87</td>
<td>9.53</td>
<td>29,142</td>
</tr>
<tr>
<td>1956</td>
<td>27.24</td>
<td>8.02</td>
<td>30,640</td>
</tr>
<tr>
<td>1957</td>
<td>29.51</td>
<td>6.87</td>
<td>28,985</td>
</tr>
<tr>
<td>1958</td>
<td>28.09</td>
<td>9.48</td>
<td>34,669</td>
</tr>
<tr>
<td>1959</td>
<td>Not known</td>
<td>Not known</td>
<td>37,522</td>
</tr>
<tr>
<td>1960</td>
<td>37.15</td>
<td>10.46</td>
<td>33,708</td>
</tr>
<tr>
<td>1961</td>
<td>42.27</td>
<td>8.90</td>
<td>30,139</td>
</tr>
<tr>
<td>1962</td>
<td>39.03</td>
<td>9.23</td>
<td>31,860</td>
</tr>
<tr>
<td>1963</td>
<td>29.89</td>
<td>9.39</td>
<td>34,650</td>
</tr>
<tr>
<td>1964</td>
<td>62.35</td>
<td>11.03</td>
<td>30,905</td>
</tr>
<tr>
<td>1965</td>
<td>86.65</td>
<td>12.73</td>
<td>23,523</td>
</tr>
</tbody>
</table>

Sources: Personal communication, Department of Agriculture, Western Australia, 17 December 1969 and BAE unpublished data.
figures include the cost of wages, salaries, travelling, charges on products and materials, and general expenses. They exclude payments to growers, savings for renewals, and any allowance for profit. The extraordinarily wide variation between years is the main feature of the series, and this appears to bear little relation to fluctuations in the size of the annual kill. Second, the general level of costs for a plant with a capacity of 300 head per day is abnormally high. Comparison with calculations made by Cassidy to estimate the short-run average cost curves of meatworks operating in Queensland are instructive. For a plant of the same capacity the average slaughtering costs per head were $17.00 in Central Queensland and $14.00 in the southern part of the State in 1964-65. Among the major reasons for the poor performance of the Wyndham works are the short and unreliable killing season (May to August), and a mandatory contract which stipulated that all workers would be paid for a minimum of sixteen weeks regardless of irregularities in throughput.  

Though these figures do reflect some of the difficulties of operating in the North, it is not possible to conclude that facilities elsewhere run under private enterprise would have been uneconomic. All that can be said is that uncertainty provided a significant deterrent. Taking a different view, it might be argued that the very existence of the Wyndham plant raises the issue of the passive role of the Commonwealth in the economic development of the Northern Territory. Although the Payne-Fletcher Report recommended against the purchase of the Darwin works by the government in 1937, it concluded

A meatworks would be a great boon to the district, and enable the cattle industry to awaken from its

2 Personal communication, Department of Agriculture, Western Australia, 17 December 1969.
present lethargic state. From a national viewpoint it is unwise that the pastoral industry in this district should be allowed to stagnate because Vestey’s big venture failed when conducted under most unfavourable conditions. 1

Twenty-two years later, the Forster Committee stated unequivocally that ‘the only way to get a permanent increase in the cattle raising potential of the Top End is to have an export killing works’. 2 These observations are particularly interesting when compared to the action taken by the Commonwealth in the field of road investment. The States Grant (Encouragement of Meat Production) Act 1949 was the first of a series of plans to reduce transportation costs to existing processing centres. Little or no thought seems to have been given to the possibility of providing one or more export abattoirs as public utilities.

In summary, it is not possible to prove that private enterprise ignored economic opportunities in the processing industry in the early part of the study period. Both the locations available and the nature of operations in the North would have tended to discourage entrepreneurs. However, the growing demand for poorer quality beef from 1958 onwards for the American trade makes it likely that the margin in favour of local processing was widening rapidly in the late fifties. The developments that eventually followed form the subject of the next section.

1 The Payne-Fletcher Report, 1937, p.64.

2 Prospects of Agriculture in the Northern Territory (the Forster Report), Commonwealth of Australia, Canberra, 1960, p.35.
II. The processing industry from 1963

After such a long period of inaction from private enterprise it is remarkable that three export treatment plants were opened in 1963. The suggestion has already been advanced that this timing corresponded with a realisation in the industry that the United States market for boneless beef had long-term potential. A large part of this demand had been met previously from the exploitation of the more accessible sections of the national herd (including culls from the dairy industry), but by the early sixties attention had turned to more marginal supplies. In this context Northern Territory cattle represented a reservoir of cheap beef of ideal quality. The locations chosen were Darwin (by W. Angliss (Aust.) Pty Ltd -- a member of the Vestey group), Katherine (by Northern Meat Exporters Pty Ltd), and Montejinni (a private venture by the station operator).

The latter case is particularly interesting to the location analyst. Montejinni is situated 180 miles south of Katherine on the eastern edge of the better cattle country of the Victoria River District. The plant was restricted to a kill of fourteen per day and its supplies were drawn entirely from the property which runs a herd of 12,000 head. According to the operator, killing costs averaged three cents per pound of beef over a total throughout of 1,500 in 1963. Most of the meat was taken to Daly Waters in refrigerated vans and flown from there to Adelaide at a total cost of four cents per pound. Apparently, returns were in the order of $50.00 per beast for the whole operation. Although the plant closed after one year due to competition from Katherine, it presents an unusual case of location, being raw material orientated rather than tied to the provision of services. Further, the relative success of a venture based on a small scale facility and the use of the most costly form of outward freight transport suggests that

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1 Field interview, May 1968.
the opportunities for local processing had become extremely good by 1963.  

The locational characteristics of Katherine and Darwin have already been discussed, and the observation has been made that they have virtually the same allocation advantages for producers south of the Katherine railhead. Although Darwin is a further 220 miles north of the major concentrations of cattle, this is offset by the lower costs associated with an integrated operation on the seaboard. Some concept of the general level of processing costs in the North can be gained from figures supplied by Northern Meat Exporters. For an annual kill of 27,500 head the operators budgeted that the total cost per beast for treatment and storage would have been $31.00 in 1967. According to the same source a plant located in northern Australia carries an $11.00 per beast disadvantage over a comparable works in east-central Queensland resulting from freight charges on materials, the shorter killing season, and the need to pay a premium for skilled labour. These additional costs can be allocated on the following basis:

| Charges on inputs       | $2.00 |
| """ outputs             | $3.00 |
| """ construction         | $2.00 |
| """ services             | $1.00 |
| Extra labour costs      | $3.00 |

These costs appear to be moderate when compared to the variable costs of processing at Wyndham given in Table 5.1. How far this reflects the technical superiority of the modern Katherine plant or the relative competence of management is difficult to judge.

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1. With variable costs of about $15.00 per beast processed the plant seems to have been an attractive financial proposition. At this scale services cease to be a critical determinant of location. The Montajinni plant used bore water, generated its own electricity and employed semi-skilled butchers. The main factors which limit the construction of similar works are (i) heavy capital and transportation costs per beast marketed, and (ii) the difficulty of complying with hygiene regulations, particularly for the US trade.

2. Personal communication, General Manager, Northern Meat Exporters Pty Ltd, 14 March 1968.
The location of three operational works in relative
proximity (Katherine, Darwin, and Wyndham) poses the problem
that the northern part of the Territory may now exhibit
disequilibrium through excess capacity. Table 5.2 shows
the allocation of fatstock to northern demand centres since
the opening of the new plants. In the five financial years
from 1963-64 to 1967-68 the supply of slaughter stock to the
three plants from the Northern Territory averaged about
93,000 head. On the assumption that the optimum capacity is
a daily kill of 300 beasts over a six day week, each
meatworks could handle an annual throughput of 36,000,
working at design capacity for twelve weeks and at two-thirds
of this level for six weeks at each end of the season. On
this basis the supply of stock is clearly inadequate.1
Table 5.2 shows the competition between the rivals and
indicates a general trend towards compensatory adjustments
which are determined by the buying policies of the companies.

It is not possible to confirm definitely that the
present distribution of processing plants in the North is
uneconomic since it may be that the presence of the new
works will stimulate the development of the cattle industry,
particularly in the areas with potential for fattening on
improved pastures. However, it seems probable that periods
of deficit and excess may be a feature of the processing
industry as a whole. Cassidy draws attention to the
duplication of facilities in southern and central Queensland
and suggests that conditions exemplify the operation of
Bressier's 'law of mediocrity' which states that

where spatial monopolies receive relatively high
profits, and this temporary feature is allied
with low barriers to entry, an influx of
competitors results in the halving and quartering
of market areas. This process further repeats
itself until resulting bankruptcies and collapses
enable a dominant firm to add market areas.

1 Allowing an annual average of 7,000 head for the Wyndham
works, the calculation suggests that one of the remaining
plants is redundant.
Table 5.2: The allocation of Territory fatstock to northern markets, 1962-63 to 1967-68

<table>
<thead>
<tr>
<th>Years (financial)</th>
<th>Wyndham meatworks</th>
<th>Katherine meatworks</th>
<th>Darwin meatworks</th>
<th>Darwin town consumption</th>
<th>Export live ex Darwin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1962-63</td>
<td>4,796</td>
<td>884&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2,114</td>
<td>4,933</td>
<td>7,670</td>
</tr>
<tr>
<td>1963-64</td>
<td>4,395</td>
<td>18,316&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8,739</td>
<td>4,383</td>
<td>3,271</td>
</tr>
<tr>
<td>1964-65</td>
<td>7,761</td>
<td>21,381</td>
<td>6,502</td>
<td>4,726&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-</td>
</tr>
<tr>
<td>1965-66</td>
<td>3,361</td>
<td>26,799</td>
<td>13,220</td>
<td>4,544</td>
<td>-</td>
</tr>
<tr>
<td>1966-67</td>
<td>4,493</td>
<td>19,221&lt;sup&gt;b&lt;/sup&gt;</td>
<td>16,743</td>
<td>-&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-</td>
</tr>
<tr>
<td>1967-68</td>
<td>2,531</td>
<td>30,730</td>
<td>19,444</td>
<td>-&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-</td>
</tr>
</tbody>
</table>

<sup>a</sup> Includes the kill of Montejinni

<sup>b</sup> Includes 3,850 head from Western Australia

<sup>c</sup> Included in the Katherine and Darwin kills

Source: NTAAIB Annual Reports.
making higher profits, and then the process repeats again.\(^1\)

In the study region the small number of plants and possible sites precludes the application of a standard equilibrium formulation to determine an optimal processing pattern. Nevertheless, it is reasonable to conclude that disequilibrium in the location of buyers is the rule in the Northern Territory, though the entry of additional works in 1963 certainly led to the reduction of total transport payments and the widening of exchange and production opportunities.

3. Price Formation

The process of price formation and the choice of market by producers have received only passing attention in the foregoing chapters. Of necessity von Thünen assumed that the price of agricultural commodities at the central town was determined by perfect competition within a closed system. In reality, the prices received by producers in the Northern Territory reflect its marginal position in relation to domestic and world centres of demand, and the imperfect knowledge and reactions of sellers to alternative marketing opportunities. The use of a normative spatial equilibrium model of exchange as a guide to efficiency in allocation involved the adoption of a number of unreal assumptions, such as homogeneity in output, inelastic market demands, perfect price knowledge, rational behaviour, and the absence of uncertainty. In the following two sections market and farmgate prices will be discussed in a wider context to incorporate some of these variables and, in turn, to permit some general conclusions on the efficiency of marketing in the various supply areas within the study region.

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Reference has already been made to one of the special characteristics of marketing in the Alice Springs District. Its separation from the remainder of the Northern Territory by the regulations demarcating the Central Australian Pleuropneumonia Protected Area ties it to the Adelaide market as an extension of the beef producing regions of northern South Australia. The main centre of demand for its store stock lies in the southeast of the state near Kingston and Millicent, while the bulk of the fatstock imports are consumed in metropolitan Adelaide. The markets for both forms of cattle are limited and, although the quoted price series indicates a persistent short-fall in supplies, payments are reputed to vary widely according to the size of yardings. Second, the predominance of domestic demand in the trade for finished beasts means that a premium is paid for younger bullocks of a high quality. Both these points must be borne in mind when considering the apparent failure of properties on the Barkly Tableland to capitalise on the opportunities of this market, given the possibilities of complying with the disease control regulations. One grower remarked that the returns on a three year old beast dressing at from 600 to 640 lb would be approximately equal at Rockhampton and Adelaide. Finally, the Alice Springs District is distinct in possessing representatives of the major stock and station agents who handle sales on a commission basis and arrange transport to the final buyer. Part of the explanation for their success lies in the greater number of small independent station operators in the district, but it seems probable that their location in Alice Springs also reflects the long historical connection between the region and South Australia. Because of the centralised nature of marketing, opportunities are maximised and it seems clear that this contributes to the stability of the enterprises in this supply area.

In comparison to this relatively sophisticated marketing system conditions in the remaining regions are primitive. Prior to 1963 most of the properties of the Barkly Tableland and the Victoria River District depended
upon the Queensland store trade for the bulk of their income. Due to variations in climatic conditions in the receiving regions (particularly the Channel Country), prices fluctuated widely from year to year. Table 5.3 shows the allocation of the store cattle crossing from the Northern Territory to Queensland in 1957, and points up two significant facts. First, nearly sixty per cent of these stock were railed to properties and saleyards beyond Dajarra, which suggests that the importance of company linkage to the Channel Country has been overstressed. Second, twenty-five per cent of the total crossed the border in the control of drovers who had no idea of their final destination.

Table 5.3: The apparent destinations of Northern Territory store stock crossing to Queensland, 1957

<table>
<thead>
<tr>
<th>Destination</th>
<th>Number of stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dajarra railhead</td>
<td>20,342</td>
</tr>
<tr>
<td>Queensland Channel Country</td>
<td>15,044</td>
</tr>
<tr>
<td>Queensland Barkly-Gulf Region</td>
<td>10,987</td>
</tr>
<tr>
<td>Unknown</td>
<td>15,679</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>62,052</strong></td>
</tr>
</tbody>
</table>

Source: NTAAIB Quarterly Returns to the Commonwealth Statistician (unpublished).

The chronic uncertainty of the trade was confirmed by interviews in the field with pastoralists in the Victoria River District. In 1957 one operator turned-off 2,730 head in two mobs and was forced to spell them at the border for ten weeks due to an outbreak of pleuropneumonia. A subsequent muster yielded only 1,400 animals and these were sold for $18.00 per beast. According to the owner he incurred a direct loss of $12,000 in droving and agistment charges. In the following year, for want of buyers, he
restricted sales to 55 head and refused offers of $16.00 and $24.00 per beast, finally disposing of them at $36.00 each. In another case, his neighbour complained of having sold 1,500 head at $28.00 per beast to a dealer in 1960, who was able to dispose of them immediately as a travelling mob at $34.00 each. These instances suggest that price formation was unreasonably costly, and it may well be that the insecurity of the exchange system was a greater deterrent to property improvement than the nature of average prices.¹

One response to this situation was the formation of chains of properties by integrated companies. Cattle could then be held on depot stations and moved east when stockroute conditions were good and demand was assured. Examples of linkages of this type are the units of the Australian Agricultural Company (Auvergne - Avon Downs - Brighton Downs), and those of the Australian Investment Agency [Vesteys], (Wave Hill - Helen Springs - Morestone). A more comprehensive solution would have been the operation of a guaranteed price scheme based on forecasts of the needs of Queensland fatteners but, to the author's knowledge, this was never seriously considered.

In the light of the inadequacies of the Queensland market, it is surprising that the supply area of the Wyndham meatworks was so small. In 1958 this market was offering $46.00 per bullock,² which would appear to have been an attractive price for producers in the Victoria River District. An explanation in terms of the poor quality of the local stockroutes is unconvincing when related to the persistent flow of fatstock from the Barkly Tableland over the equally poor routes to Dajarra and Mt Isa. Similarly, since many of the producers of the District have responded to the opening of the Katherine works by changing from a specialisation in stores to the turnoff of slaughter cattle it is not possible to claim that the pastures of the region are unsuited to

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¹ Field interviews, May and June 1968.
² The Economics of Road Transport of Beef Cattle, BAE, Canberra, 1959, p.14.
fattening. Two more probable reasons may be the nature of marketing and the presence of a lagged response to new opportunities. During the period of operation of the works by the Western Australian Government, cattle were bought from producers in a series of instalments. Often the first payment was not substantial and a final price could not be guaranteed until the meat was graded. Also the final payments were not made until late in the season so that it was probably more attractive to send cattle to Queensland where a more uncertain but immediate price was received. In addition, Table 5.1 shows that average returns at Wyndham only began to move upwards from 1952 following a long period of low prices. To capitalise on the market for fatstock the operators in the region would have been forced to develop their properties to ensure mustering a reasonable proportion of the cattle left to fatten from their third to fifth year. It may be that the period of higher payments was too short to call forth this response and divert supplies from the traditional Queensland outlets.

The entry of competitors in 1963 broke a long period of monopsony for Wyndham during which prices were set by a formula that guaranteed the covering of variable costs. Reference to Table 4.1 shows that the Katherine and Darwin meatworks were content at first to follow the price lead of their established rival. Both entrants were vertically integrated, with the former depending on the allegiance of major shareholders, particularly the Australian Agricultural Company and the Hooker pastoral interests, which together held seven of the properties in the Ord-Victoria area. More obviously, the Darwin works restricted its initial operations to stock drawn from the eleven stations in the Vestey organisation. Following this establishment period, competition for the cattle of uncommitted pastoralists became intense, amounting at times to a price war. By 1965 Katherine was drawing cattle from properties situated fifty miles from Wyndham, and this action precipitated the sale of the works to private enterprise. In 1967, the first year of operation by the new owners, Wyndham was paying $19.00 per
hundred lb dressed weight for cattle from Camfield, normally within the orbit of Katherine, as a retaliatory measure. Since then there appears to have a recognition that some degree of price trade-off is necessary to ensure stability in the industry and this has led recently to charges of collusion amongst processors by some pastoralists.¹

Although competition for cattle amongst the three abattoirs has been a notable feature of marketing in the northern regions since 1963, their price structures reflect a more basic need to capture cattle from the Queensland trade without losing a sufficient margin to cover the extra cost of operating in the North. Table 5.4 shows the aggregate turn-off from the three northern regions to final markets, and the proportion of these cattle going for immediate slaughter between 1953-54 and 1966-67.

Table 5.4: The proportion of fatstock in total sales to all centres of final demand except Alice Springs and South Australia, 1953-54 to 1966-67

<table>
<thead>
<tr>
<th>Year</th>
<th>Sales of fats (head)</th>
<th>Total sales (head)</th>
<th>Fats as a percentage of total sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>1953-54</td>
<td>9,076</td>
<td>79,174</td>
<td>11</td>
</tr>
<tr>
<td>1954-55</td>
<td>10,370</td>
<td>33,666</td>
<td>31</td>
</tr>
<tr>
<td>1957-58</td>
<td>26,777</td>
<td>93,191</td>
<td>29</td>
</tr>
<tr>
<td>1958-59</td>
<td>31,565</td>
<td>82,856</td>
<td>38</td>
</tr>
<tr>
<td>1959-60</td>
<td>37,777</td>
<td>92,120</td>
<td>41</td>
</tr>
<tr>
<td>1960-61</td>
<td>29,656</td>
<td>103,329</td>
<td>29</td>
</tr>
<tr>
<td>1961-62</td>
<td>42,203</td>
<td>100,415</td>
<td>42</td>
</tr>
<tr>
<td>1962-63</td>
<td>31,186</td>
<td>98,383</td>
<td>32</td>
</tr>
<tr>
<td>1963-64</td>
<td>68,169</td>
<td>100,226</td>
<td>68</td>
</tr>
<tr>
<td>1964-65</td>
<td>53,431</td>
<td>74,232</td>
<td>72</td>
</tr>
<tr>
<td>1965-66</td>
<td>86,132</td>
<td>115,888</td>
<td>74</td>
</tr>
<tr>
<td>1966-67</td>
<td>65,611</td>
<td>85,884</td>
<td>76</td>
</tr>
</tbody>
</table>

a. Figures are not available for 1955-56 and 1956-57.

Source: NTAAIB Annual Reports.

Unfortunately the series is not complete but it does suggest that about thirty-five per cent of the total sales were made to fatstock buyers in normal years up to 1962-63 (i.e. the meatworks of east coast Queensland, Wyndham, and the live cattle trade to Southeast Asia). Since then the proportion of so-called 'fats' has moved steadily upward, but total production has remained relatively static. The implication is that the kills of the Katherine and Darwin works are largely made up of cattle that would previously have been classified as stores. This is confirmed by the manager of the Katherine plant, who states

We are tied to the U.S. export market. Its buying price East Coast (Australia) is about $18 to $20 per 100 lbs, (mostly clouded by an overflow of the local market up to $24 per 100 lbs). We have to operate about $3 to $4 per 100 lbs under the actual export East Coast cow market, which points to about $15 to $16 per 100 lbs. To pay over is to court disaster and this situation will continue.¹

In conclusion, the complexity of the factors governing price formation in the study industry may be contrasted to the simplicity of the assumptions of the Thünenian model and other extensions of the concept of spatial equilibrium. It is implicit in the widened structure of the Isolated State that processing costs do not vary between small towns and the capital whereas, in reality, spatial competition between neighbouring plants is conditioned by the need to cover costs, and relate prices to local, national, and international demand. Hence, though there is a tendency towards the equalisation of local market prices, their absolute level is determined exogenously. Extending the comparison to widely-spaced markets such as the demand centres of South Australia and Queensland, it is apparent that the size of the supply area is only partially conditioned by transport costs and the net receipts of consumers. The institutional structure of marketing provides at least part of the explanation for non-adherence to a spatial equilibrium. In the following

¹ Personal communication, 14 March 1968.
section the emphasis will move from the actions of buyers to the response of sellers.

4. Seller response and marketing efficiency

The use of the Transportation Problem model as a guide to the presence or absence of rational behaviour in the marketing policies of properties can be questioned. It yields an optimal solution which would only hold if the total system was closed and all movements were simultaneous with transport costs as the only minimand. However the comparison of the normative and actual patterns points up discrepancies which may then be investigated by other means. In this study the Victoria River District provides an interesting case since the stations of the region contribute to all the major markets available for cattle. In a field survey in 1968 the author interviewed the owners and managers of fourteen properties to discover the reasons for their consignment decisions. Four interwoven non-transport factors appear to be important, namely, the structure of the enterprise (i.e. specialisation), the structure of the firm, the knowledge of the operator, and his attitude to innovation and risk.

The interaction of these factors can be observed in the decisions of three owner-operators located in the southeast of the District. All three turned-off two and a half year old store cattle to Queensland until the Katherine meatworks opened in 1963; then they started to produce bullocks and culled cows for slaughter, although retaining some interest in the store trade. By 1968 their judgements of opportunities for the future differed markedly, although the size and quality of their holdings is very similar. One of the owners had purchased a property in the Alice Springs District and was committed to supplying it with weaner stores to be fattened for the Adelaide market. These stock have to travel 750 miles by road transport, following a spell of thirty-five days in which they are blood-tested and dipped clear of ticks. In this case the enterprise type and the marketing decision are conditioned by the structure
of the firm and the willingness of the operator to accept a high degree of risk. Known locally as the 'independent grazier', the owner is also acutely aware of the variations in the prices offered at Wyndham, Katherine, and Darwin.

In contrast his northern neighbour has decided to specialise in the production of high quality fatstock and has begun a Brahman cattle stud. In his opinion the main opportunities lie in linking production to the Top End where there is potential for development with improved pastures. He views the Katherine works as the 'cattleman's friend' and is a loyal supplier. Further south, the last of the group plays the market with the three meatworks and has begun to sell young fats to an Alice Springs' butcher, receiving $18.20 per hundred pounds dressed weight on the property. All three cases present rational but different reactions to the same set of possibilities. However these decisions are made in the context of relative transport costs. The growth of the connection with the Adelaide market is particularly interesting because a sensitivity analysis of the 1957 Transportation Problem solution, using a re-run with straight-line distances between stations and markets, indicated that the southern part of the Victoria River District would have been linked to the Alice Springs railhead in a normative situation.

The opportunities for maximising the use of cattle and pasture resources held by the big integrated companies are of a different scale. In 1968 the Vestey organisation laid plans to transport 27,378 head from their eleven properties.¹ Lifts included the transfer of store stock to the fattening stations of Helen Springs and Manbulloo, and contributions to the Darwin and Wyndham meatworks. Their turn-off schedule exhibits some interesting features which bear upon the allocation problem. In one case cattle are back-hauled 230 miles from Nutwood Downs to Helen Springs for fattening, prior to being sent north again for slaughter at Darwin. The justification for the extra transport costs

¹ Field interview, June 1968.
lies in the fact that this saves one year in their growth to mature animals which will dress out at 560 lb. According to the company this is worth $25.00 per head. The overall plan is made in Sydney at the beginning of the season specifying the number and destination of mobs from each unit. These are based on the analysis of branding rates, managers' reports, and the demands of the meatworks. The aim is to maximise total company profits rather than the net received prices of individual consignments.

In summary it is difficult to arrive at a realistic assessment of the efficiency of marketing in the Northern Territory. Certainly, the absence of saleyard exchange points to the immaturity of the system, but the communication of information, even of a confidential nature, is often extremely rapid on the two-way radio network. Further, the widespread use of air transport permits meatworks' buyers to make speculative trips to inspect cattle. Hence imperfect knowledge is ceasing to be important as a cause of misallocation. The analysis of some of the institutional features of marketing and its relationship to firm and enterprise structure also suggests that in many cases irrational behaviour may be more apparent than real.

Ideally spatial equilibrium models would take into account the influence of the factors listed by Sosnick, but this has rarely been the case. Wallace lists nine studies of the inter-regional exchange of single agricultural commodities in which the correlation coefficient between the actual and predicted price levels is less than 0.50.1 He concludes from this that the choice then lies between explaining the residuals in terms of marketing 'inefficiency', or imputing them to the inadequacy of the models.

The present study is unique in two respects. First, the equilibrium formulation deals with individual firms rather than regional aggregates. Second, the analysis of

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spatial adjustment in marketing has been linked to a detailed evaluation of the factors which are excluded from the model. The main conclusion that may be drawn from this procedure is that marginal differences in prices are not a reliable guide to the reactions of producers. This applies to both spatial equilibrium studies and many works in microeconomics. As Farris states, reviewing his study of the alternative prices offered by wheat elevators in Iowa,

We commonly assume that the pricing process in most agricultural markets tends to yield results not greatly different from results under our theoretical ideal of perfect competition. This means, for one thing, that price can be relied upon to allocate resources. But if the empirical existence of a high or low price fails to indicate that more or less of a commodity of particular quality is demanded, the price signal to producers is not likely to call forth the quantities and qualities of products that consumers and the trade really want.¹

This finding has particular relevance to the empirical work presented in Chapters 3 and 4, which consider the more complex problem of spatial adjustment in production to variations in net received prices, and to the hypothesis that the elasticity effects of improved transportation generate economic activity.

B. ACCESSIBILITY AND MODAL CHOICE IN TRANSPORT

Most of the analytical work up to this point has been based on the assumption that the rate cost of transportation to the market determines farmgate receipts. In the study industry the relationship between transport costs and returns is more complex since the commodity moved is perishable. Hence weight and condition losses on cattle may influence the choice of market, route, and mode, and will represent costs which must be borne over and above those incurred in freight charges. Further, the relative

The importance of these costs is a function of the market price of the saleable beef lost in transit. This situation makes it desirable to consider accessibility in terms of a composite parameter, and points to the need to consider the effects that this may exert on the operation of the Thünen model in reality.

The following sections discuss this characteristic of the study industry with particular reference to the adoption of road transport by station operators. Its aims are to explore the dynamic aspects of the transport component of accessibility between 1950 and 1967, and from this to draw inferences on the attitudes of property owners to adjustment to variations in comparative locational advantage. The first section gives a brief summary of a wide selection of deductive approaches to the determination of the optimal choice of mode. These were largely written while the change was in progress. The second section looks at the actual rate and pattern of the diffusion of road transport and relates the evidence to the hypotheses advanced by other commentators. This provides insights on the determinants of change which complement the discussion of the costs and benefits of road construction in Part 3.

1. The factors involved in modal choice -- the deductive approach

It seems fair to suggest that the subject of modal choice and its influence on the economic development of the beef industry in northern Australia has claimed a disproportionate share of the research resources of government agencies. Major reports were made by Allen in 1959 and Moulden in 1965, and articles have been

1 The Economics of Road Transport of Beef Cattle, Canberra, 1959.
contributed by Kelly, Allen, Patterson, and Moulden and Jenkins. These works share a preoccupation with theoretical cost models, supported by the evidence of specific movements and general regional trends. The two major reports provide valuable data on the cost structures of road haulage firms from field surveys, and give a more detailed appreciation of the factors influencing the adoption of road transport by producers.

The possible advantages or road transport over droving can be summarised as follows:

(i) it avoids the weight losses, deaths, and strayings which are associated with on-the hoof movements;

(ii) it permits the turn-off of small numbers of fats at their peak condition at any time during the Dry Season;

(iii) it allows the extension of the turn-off period and the adjustment of production to variations in the price situation during the year;

(iv) it releases station plants for additional work;

(v) it allows the sale of culled cattle which could not be walked to market and thus avoids a total loss of income from this source;

(vi) it permits the marketing of weaner type stores and young fats -- qualities of stock that it would be impossible to drive;

1 For example, Kelly, J.H., and White, L., 'Northern Territory Beef -- Improved Roads and Management can increase output', Quarterly Review of Agricultural Economics, 2 (1949), pp.142-3.


(vii) it avoids the waste of fattening time and pasture resources at receiving stations, which were associated with the droving of store cattle;

(viii) it enables pastoralists to agist or market stock during drought conditions;

(ix) it makes possible the more regular use of railway and processing plant capacity.

All these factors influence received prices and existing cattle stocks directly and, therefore, can be said to promote an increase in the situation rents of properties. In addition to these primary effects there are two other consequences which may be important:

(i) the ability to market cull cattle and younger stores and fats enables station operators to increase their stocking rates, since it leaves the maximum amount of pasture available for breeders and growing cattle;

(ii) the flexibility of turn-off age permits stations to specialise in the form of production that is best suited to the quality of their pasture, and the nature of the markets available.

Since these changes demand an increase in capital and management inputs they can be equated to shifts in the intensity rents of properties.

To summarise, from the economic viewpoint, the rate of adoption of road transport will depend upon the following five factors:

(i) the relative unit rate costs of the two modes;

(ii) the relative level of deterioration losses under the two modes for specific movements;

(iii) the current level of market prices, which will determine the absolute level of deterioration costs, and the proportion of gross returns that can be spent on direct rate payments;

(iv) the importance of speed of movement, economies and diseconomies of scale in consignment, and the
minimisation of uncertainty; and the influence they exert on station operating costs;

(v) the appreciation by operators of the longer term advantages of road transport which would accrue through the adjustment of scale and resource use.

This framework provides a basis for the evaluation of the evidence which will be presented on the diffusion of the use of road transport over time and space. In addition an alternative set of hypotheses will be considered which link the findings to the literature on the diffusion of innovations in agriculture as a whole.

2. The factors involved in model choice -- empirical findings

a. Diffusion over time

Fig. 5.1 shows the rate of adoption of the use of road transport by the cattle industry in the Northern Territory from 1948-49 to 1966-67. The innermost scale on the vertical axis gives the percentage of cattle moved from stations to meatworks, railheads or extra-Territory destinations by road for financial years. The residuals represent the share of these movements which were made on the hoof under contract drovers or station plants. Five major periods may be distinguished: a period of speculative innovation from 1947 to 1950; a quiescent stage from 1950 to 1956; a primary growth phase from 1956 to 1960; a marked retrenchment from 1960 to 1963; and, finally, an upswing to total adoption from that date.

Before discussing these stages it is relevant to note briefly two theoretical concepts which explain the adoption process in economic terms. First, if rate costs were the only consideration, the relative prices of both services would determine the rate of substitution between modes within the overall demand for transport services. This approach, which involves the determination of the price elasticities of the two forms, has been employed by Perle to evaluate national, regional, and industry demands for the
services of motor carriers and railways in the United States.\textsuperscript{1} In the study industry non-rate costs make this method redundant. Reference to the details given in Chapters 4 and 5 of the level of charges of drovers and road hauliers show that rates of the two modes bear no direct relation to each other. On average road transport costs about 4.0 cents per beast mile, which can be compared to 0.5 cents per beast mile under droving. Although the availability of the latter form has decreased, and hauliers' charges have dropped slightly since 1960, this order of relationship holds for the whole of the study period.

The second and more complex concept involves the influence of income variations on demand. Since non-rate costs are primarily a function of market price, this approach offers the best model for the problem. Here Perle has drawn attention to the applicability of the Slutsky equation which characterises the relative demand for a particular service in two terms, which represent the rate of change that is conditioned by the relative prices of substitutable service forms, and the rate of change that is attributable to movements in the value of the serviced commodity.\textsuperscript{2} In the case under consideration the overall demand for transport is inelastic, but the marginal utility of the two forms is determined by the market price of cattle. To explore the relevance of this formulation temporal changes in the imputed value of beef at the Mt Isa terminal have been plotted against the outer axis of Fig. 5.1 (the values are given in dollars per hundred pounds dressed weight and are drawn from Tables 3.1 and 4.1).

The sociological approach to the rate of the diffusion of innovations in agriculture offers an alternative model. This tends to stress non-economic factors such as the

\textsuperscript{1} Perle, E.D., \textit{The Demand for Transportation}, University of Chicago (Department of Geography Research Paper, No. 95), Chicago, 1964.

Fig. 5.1. The proportion of total Northern Territory sales transported by road, 1948-50 to 1966-67

Sources: NTAAIB Annual Reports and Tables 3.1 and 4.1.
experience and knowledge of individual adopters. The work of many rural sociologists is based on a model in which the diffusion process is represented by an 'S' shaped curve. The slow initial adoption phase develops as 'innovators' begin to use the new technique, while the trend towards total usage slows as the process nears completion due to the ignorance and prejudices of 'laggards'. As Lionberger states:

Ordinarily adoptions are very slow at first. After an initial slow start, they increase at an increasing rate until approximately half the potential adopters have accepted the change; after this acceptance continues, but at a decreasing rate.2

Clearly these behavioural aspects may be superimposed upon the more fundamental economic constraints, and the two approaches may be combined to provide a detailed explanation of the reactions of users.

The five stages previously mentioned can now be examined with these general explanatory concepts in mind. The period of speculative innovation in the study problem has been documented by Kelly.3 In 1946 one road transport operator began to carry cattle in the Alice Springs District with units which he designed and built from war disposal materials. Due to inadequate provision in the rate structure for repairs and depreciation, the business faltered and the owner was forced to raise charges from twenty-six cents per beast-mile in 1949 to fifty cents in 1951. This deterred users and the operation failed. Many of these early movements were orientated to the Alice Springs railhead and the high price Adelaide market. The largest series of lifts

consisted of 239 fats which were moved 528 miles from Anthony Lagoon to Alice Springs in 1948.

Although the price of fatstock rose in the early fifties, the new mode made a negligible contribution to total movements until 1956. This quiescent stage seems to be attributable to the deterrence of both suppliers and users by the premature introduction of the new technique. However, in that year five operators entered the haulage industry and all chose to base themselves at Alice Springs. Total lifts involved 2,925 cattle and the average trip distance was 150 miles. The Alice Springs District has several characteristics which encouraged experimentation -- the most important being the high net receipts from cattle sales. In addition, the small size of properties in the region made it difficult to aggregate economic droving mobs. The average road transport lift was 209 head which falls far below the optimum mob size of 600 bullocks. It may also be that the experience of producers in the first phase contributed to their readiness to try again.

Although Queensland stock prices fell slightly from 1956 to 1958, the primary growth phase also saw the adoption of road transport by the largest cattle company in the Northern Territory. In 1957 the Vestey organisation set up an integrated haulage business to move stores from Helen Springs to Queensland, under centralised management. In contrast to the lifts in the Alice Springs District, hauls were generally over 500 miles and 1,555 head were carried in fifteen lifts in the first year of operation. It seems reasonable to assume that the use of large capacity vehicles, with economies of scale under programmed management, made the enterprise viable in an unfavourable price situation. Nevertheless, the company was given credit as an innovator in the 1956-57 NTAAIB Annual Report, which comments:

Vestey interests are to be congratulated on showing a lead in the North. If other stations follow suit ... progress and development in production will at last be possible.
From 1958 the diffusion of the use of road transport was rapid and the annual growth in the proportion of cattle moved by road up to 1962 shows a marked correspondence to shifts in the price of fatstock. This suggests that the income effect was particularly important as a determinant of the rate of adoption at this stage. In this context droving represents an inferior good, since consumption is inversely related to commodity receipts. To explore this finding in more detail, the components of the trend shown in Fig. 5.1 have been disaggregated to show the rate of adoption for the two main types of stock. Figs. 5.2a and 5.2b give respectively the proportions of fat and store stock moved by road transport in the South Australian and Queensland supply areas. Support for the income hypothesis would be provided both by a lagged response in the Queensland supply region, since market prices are substantially behind those of the Adelaide market and by a lower level of usage for store movements, which would follow from the smaller per beast return from marketing this type of stock. The trends shown in the graphs confirm these deductions.

A number of other conclusions may be drawn from these graphs. First, the variability of usage also seems to be a function of the level of received prices for cattle. Second, certain non-price effects can be observed. One instance is the rapid adoption of road haulage for store cattle in the Alice Springs District from 1958: this would appear to be the direct result of the effects of the 1958-65 drought which led to the need to dispose of weakened stock that would have travelled badly on-the-hoof particularly on the deteriorating stock-routes in the region. In contrast, the generally favourable droving routes of the Barkly Tableland restricted road transport to under twenty-five per cent of demand in this sector until 1964-65.

All three show that there was a retrenchment phase between 1961 and 1963. Again this seems to be related to the fall in cattle prices at that time, and was probably common to the whole of the beef industry of northern
Fig. 5.2: The proportion of different types of stock transported by road in the South Australian and Queensland supply areas, 1955-56 to 1964-65.

Source: NTAAIB Annual Reports.
Australia, for a similar trend was identified by Moulden from data referring to movements in the Queensland Channel Country. The last stage (the upswing phase) seems less conditioned by income considerations than was the case in the primary growth phase for adoption outpaced the rise in beef prices. In part this may reflect the influence of behavioural variables on the diffusion process, but even here purely economic factors seem the most likely explanation. The opening of the Katherine and Darwin meatworks in 1963 was followed by a general rise in offers for stock in the northern Districts and this appears to have stimulated almost immediate adoption. Interviews with the haulage contractors now located at Wyndham and Katherine confirm that they were well aware of the potential demand. The major operator began trucking to Wyndham and Darwin in 1960, though his main base was at Alice Springs. In 1961 he moved to Wyndham for the whole of the cattle season and by 1962 over half the total kill was road-hauled (all cattle walked to the works prior to 1960). In 1963 the same operator moved to Katherine to support the new meatworks which from its inception received all its supplies by road.

In conclusion it is reasonable to attribute the rate of adoption of road transport over time to the combined effects of income variations in receipts from cattle sales, and the lesser influence of a range of historical and behavioural factors. This inference has three important consequences. First it suggests that the on-property organisational benefits of using the new mode did not appear to be particularly important to producers. Second, it leads to

2 Field interviews, August 1967.
the further deduction that local variations in route quality and rate costs had very little influence on the adoption process. (These conclusions are of particular importance to the arguments advanced in Part 3 of this thesis on the merits of the government's Beef Roads Programme.) Finally the main finding suggests two points which bear upon the use of the Thünen model to identify spatial adjustments to comparative locational advantages. The first of these involves the fact that producers seem acutely conscious of the relationship between the level of market prices and the optimum choice of mode. Second, since the adoption curve appears to have an interrupted 'J' shape, it may be inferred that station operators are very willing to innovate.¹ Both these points suggest that the absence of spatial equilibrium in production is not the result of a failure to perceive the effects that location may exert.

b. Diffusion over space

Knowledge of the spatial distribution of road transport usage is particularly important as a guide to the rationality of producers' consignment decisions. Since this forms the purpose of the analysis, it is useful to consider now the pattern of usage within supply areas and pass over the more general problem of the diffusion of the use of road transport over the whole of the Northern Territory. Two contrasting case studies are presented: the first looks at modal choice in the Alice Springs District in 1957 (at the start of the main adoption phase) while the second provides comparative data for properties which supplied the Queensland market in 1963 (at the beginning of the upswing phase).

Fig. 5.3 plots the percentage of the stock that were turned off by road from individual stations north of the

Fig. 5.3: The proportion of total sales transported by road in the Alice Springs District, 1957, by rate payment zones

Source: NTAAIB stock permit data.
Table 5.5: Zonal road transport usage -- Alice Springs District, 1957

<table>
<thead>
<tr>
<th>ZONE</th>
<th>Number of properties</th>
<th>Average road transport rate payment ($ per head)</th>
<th>Total sales (head)</th>
<th>Average station sales (head)</th>
<th>Total stock transported by road (head)</th>
<th>Percentage of stock transported by road</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>1.02</td>
<td>4396</td>
<td>1099</td>
<td>162</td>
<td>3.7</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>2.90</td>
<td>4024</td>
<td>805</td>
<td>529</td>
<td>13.1</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>4.99</td>
<td>7353</td>
<td>613</td>
<td>3456</td>
<td>47.0</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>6.75</td>
<td>3014</td>
<td>335</td>
<td>1761</td>
<td>58.4</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>8.83</td>
<td>2015</td>
<td>288</td>
<td>1270</td>
<td>63.0</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>11.30</td>
<td>3506</td>
<td>584</td>
<td>464</td>
<td>13.2</td>
</tr>
</tbody>
</table>

Source: NTAAIB stock permits.
Alice Springs railhead in 1957. The residuals again represent the proportion of the production of these properties that travelled on the hoof. The horizontal axis gives the imputed cost of road transporting one beast from the homestead to the terminal, on the assumption that movements on dirt and bitumen roads cost 90 and 70 cents per K-mile, respectively. There are forty-three observations and the data is drawn from the examination of stock permits. No information is available on the type of stock transported. The general scatter of points suggests at first that no spatial regularities are apparent and the correlation coefficient for the two variables is 0.03. To extend the analysis the observations were aggregated into six groups defined by transport cost zones, each of which is $2.50 (equivalent to about 60 miles) wide. The zone characteristics defined by this procedure are given in Table 5.5.

Over the six zones property turn-off is inversely related to the percentage of cattle moved by road transport. Maximum usage occurs in zone 5 where rate charges average $8.83 per property. These findings are of great interest when compared to a cost model put forward to determine the optimum choice of mode in the District by Allen in 1959.\(^1\) He considered the relative cost of moving bullocks 200 miles by making estimates for mortality and loss of weight and blood on the hoof and valuing the wasted beef at $15.00 per 100 lb. According to his calculations the comparative overall costs per beast would have been $11.93 for droving and $9.00 for road haulage. For a store mob of the same size the estimates were $3.04 and $6.80, respectively, which reverses the balance in favour of droving. Thus the spatial pattern seems to be influenced by an underlying economic rationale. When the zone means are entered on Fig. 5.3 they describe a truncated 'S' curve which suggests a fairly regular increase in the proportion of stock moved by road up to 250 miles from the railhead, which is probably the result of the judgement of the gross costs of the two

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\(^1\) The Economics of Road Transport of Beef Cattle, 1959, p.65.
modes by producers. Beyond this limit additional costs were incurred at that time in using road haulage which stemmed from the need to spell cattle or risk injuries on over-night trips. For the stations near Alice Springs the new mode offered few advantages because property owners could employ their own mustering plants to deliver cattle. An additional factor which would have increased the advantages of road haulage in the central zones is the small average size of turn-off which is far below the optimum number for a droving mob.

Using the same methodology, the production of the twenty-five stations in the Victoria River District and the Barkly Tableland that supplied Queensland markets in 1963 has been aggregated by accessibility zones (Table 5.6). Several significant points arise: first, zonal variations in usage for store and fat cattle are consistent; second, total road transport use within zones is not directly related to average property turn-off or the proportion of production going for immediate slaughter; and finally, there are two peaks in the zone means, at the $89.18 (250 mile), and $17.21 (425 mile) limits. The second peak is shared by both types of stock movements and supports Moulden's finding that the advantage lay with road haulage for the movement of fats over distances around 500 miles in the Channel Country in 1963.¹ He calculated a cost model to evaluate the merits of both modes for the transportation of 700 fats over variable distances, assuming charges of 0.86 cents per beast-mile for droving and 3.5 cents per head per beast by road. He included the cost of bruising, mortalities, and weight losses and valued the saleable meat at $16.00 per 100 lb. Once again the assumed mob size probably understates the overall attraction of the use of road transport.

Although numerous provisos must be made on the validity of both the empirical and deductive findings both seem to represent a true picture of the basic reasons for substitution over space. It is tempting, furthermore, to compare the

Table 5.6: Zonal road transport usage -- Queensland supply area, 1963

<table>
<thead>
<tr>
<th>ZONE</th>
<th>Number of properties</th>
<th>Average road transport rate payment ($ per head)</th>
<th>Total sales (head)</th>
<th>Percentage of fats in total sales</th>
<th>Percentage of fats transported by road</th>
<th>Percentage of stores transported by road</th>
<th>Average station sales (head)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>6.07</td>
<td>11,529</td>
<td>43.1</td>
<td>25.3</td>
<td>0.0</td>
<td>3,843</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>9.18</td>
<td>5,466</td>
<td>63.5</td>
<td>100.0</td>
<td>24.5</td>
<td>2,733</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>11.74</td>
<td>17,219</td>
<td>59.1</td>
<td>38.1</td>
<td>3.1</td>
<td>3,444</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>13.85</td>
<td>6,599</td>
<td>58.1</td>
<td>16.6</td>
<td>0.0</td>
<td>1,650</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>17.21</td>
<td>21,733</td>
<td>37.8</td>
<td>100.0</td>
<td>93.5</td>
<td>5,433</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>28.09</td>
<td>7,055</td>
<td>18.8</td>
<td>20.2</td>
<td>1.0</td>
<td>1,008</td>
</tr>
</tbody>
</table>

a It is assumed that all stock travel to Mt Isa.

Source: NTAAIB Quarterly Returns to the Commonwealth Statistician (unpublished).
occurrence of the innermost peak to the situation that has been described for the Alice Springs District in 1957. Here the differentiation between fat and store stock becomes important, which suggests that producers may be willing to forego only a certain proportion of gross receipts to gain the convenience associated with road haulage. If this is so it points to the operation of a complementary aspect of the income effect. These conclusions may belie the subtlety of producers' consignment decisions and alternative explanations of the pattern of adoption could be given in terms of stochastic and behavioural influences. Hence the reactions of the four stations in zone 5 may be conditioned by the innovation lead of the Vestey organisation since it contains their depot property. However it is difficult to support this argument because the logical form of diffusion, if knowledge was the main determinant, would be annular waves from the railhead at Mt Isa where the major haulage companies are located. Similarly, it would seem that random influences are an unconvincing explanation for the marked patterns which have been found in the empirical work.

The main conclusion of the spatial analysis is that economic aspects of the choice of mode by producers in different locations are complex. This points up the difficulty of arriving at a composite parameter of transport costs to replace the uni-modal functions used in the search for adjustment in exchange and production. Some spatial regularities seem to be apparent which may add weight to the conclusion that producers are conscious of the interaction between commodity prices and modal choice. Returning again to the Isolated State analogy, it is apparent that modal substitution complicates the testing of von Thünen's exchange and production hypotheses. However, since the overall costs of both forms of transport appear to be very similar, it is justifiable to cast the accessibility function in terms of rate payments alone: for in each case the level of actual transport costs can be presumed to vary linearly with distance.
The general findings of the work on modal choice confirm the need to view accessibility as an entity. Although trip distance and rate payment variations did exert some influence on the pattern of diffusion, the main determinant of the rate of spread appears to have been the upward movement in the market prices of stock. Modal choice was conditioned by the direct value of deterioration losses on different types of consignments, while it appears that producers were only willing to forego a certain proportion of immediate returns for relatively uncertain external economies. The data therefore suggests that station operators did attempt to minimise rate payments and maximise farmgate receipts within the constraints of their knowledge of mode advantages and the behavioural aspects of innovation.

C. ADJUSTMENT IN PRODUCTION -- THE CONSTRAINTS ON OPTIMUM SCALE IN THE BEEF INDUSTRY

The major aim of the following four sections is to explain why variations in land-use intensity and production scale in the study industry do not follow the patterns that can be deduced from the extension of von Thünen's logic.

1. Assumptions and peculiarities

At this stage it is appropriate to refer again to the constraint structure which is shared by most spatial equilibrium models. Three classes of assumptions are made -- those conditioning exchange, production, and land-use. Since location and land-use form the main areas of interest in this thesis, the data presented in Chapters 3 and 4 have been ordered to search for regularities in the industry that are determined by differences in the accessibility and fertility of holdings. This assumes that the form of the production function for individual properties and the whole industry is constant over space and time, and that the optimum scale of output is totally dependent upon the quality and situation of land. In reality disturbances result from variations in the availability of the factors of production that are
applied to the basic resources of a holding. Thus to explain the process of adjustment to an optimum scale it is necessary to consider differences in investment, technology, labour usage and the quality of management. It has been noted already that properties may be distinguished by their degree of specialisation in supplying the markets for store and fat cattle. Moreover, comparison of the average cost structures of units in 1950 and the early sixties suggested that there is an increasing tendency for operators to substitute capital, in the form of improvements, for inputs of labour. The latter conclusion points up the need to take a dynamic view of the scale decision, and, by extension, it is readily seen that comparable firms may reach the same level of output at a given period of time by using a different combination of resources. Such decisions may be entirely rational and will depend upon the fixity and availability of particular factors and their substitutability. In addition the choice of the factor mix will reflect the knowledge and judgement of producers in an uncertain and changing economic environment.

These general problems would be met in any attempt to match the Thünen model to the production patterns of a whole range of agricultural commodities, but some of the characteristics or peculiarities of extensive cattle raising merit special attention since they condition the probability of adjustment to location. So far this thesis has tended to stress the following points that are favourable to the analytical procedure:

(i) Spatial variations in market prices and transportation costs are of such a wide range that it appears intuitively obvious that location will influence scale (for instance, the Loder Report found that transport costs absorbed between 6.9 and 47.6 per cent of the gross proceeds of sales from Northern Territory properties in 1965).

(ii) The importance of fixed costs in the industry production function is so great that it is reasonable to assume that long-term capital investment will be carefully tied to variations in the level of receipts. (The BAE found that depreciation and repairs accounted for forty-three per cent of the average total annual costs of their sample of eighty-two properties in the early 1960s).
(iii) The choice of variable inputs is so narrow that it increases the probability that operators will be able to visualise the importance of adjustment to location. (In the BAE survey a further thirty-nine per cent of total costs were absorbed by payments for labour).

(iv) The technology employed by the industry is invariant over space and almost static, which reduces the influence of differences in the attitudes of producers to innovation, that might otherwise disrupt space-ordered patterns.

(v) The lack of an alternative land use for the area occupied by the cattle industry simplifies the identification of an optimum production scale.

(vi) The threshold of entry into the industry is so high that it makes it likely that it will attract operators of a high managerial calibre, and exclude those who gain non-economic rewards from pastoralism. (The average capital investment of the BAE sample was $442,661.)

However, these factors must be set against a series of effects that would tend to inhibit adjustment to variations in accessibility:

(i) The uncertainty in production caused by fluctuations in natural conditions is so great that it tends to preclude or disrupt long-term planning.

(ii) Price uncertainty at the market is often high, so that temporal shifts in prices may exceed or outweigh differences that result from the range of transportation costs paid by producers within one supply area.

(iii) Output tends to lag due to the breeding cycle of cattle and is difficult to relate to fixed and variable costs in the short-term.

(iv) Land tenure is relatively insecure and this imposes additional constraints on the relationship between investment and production since operators will tend to relate all decisions to the length of their lease.

(v) The low level of technology employed in the industry tends to impose uniformity by default because producers have relatively little control over their pasture and cattle resources, which are in an ecological rather than an economic balance.¹

¹ The industry appears to share many of these features with ranching in the United States; see Upchurch, M.J., 'Economic Factors in Western Range Improvement', *Journal of Farm Economics*, 35 (1953), pp.728-41.
Granted that the assumptions made in the empirical work on the exchange constraints of the model were tolerably accurate and that property size is not a critical variable, the apparent failure of the study industry to reach, or even move towards, spatial equilibrium in intensity in the 1960s can be ascribed to the immobility of factors of production, or variations in the quality of management, or the character of the decision matrix. The following sections explore these possibilities by examining the interrelation between inputs and attempting to formulate a basic production function. This leads to a number of conclusions on the need to set locational adjustment in the wider context of the theory of elasticity of supply as it applies to agricultural firms.

2. The input structure

In an industry study it is important to draw a distinction between the physical constraints on further development and the optimum use of factors of production at various scales of output. Thus in the beef industry it is not sufficient to diagnose that additional investment in transport services or on-property improvements would remedy technical inefficiency in the use of pasture and cattle resources. All additional inputs must be evaluated by considering the marginal revenue which they contribute to the whole economy. The extensive nature of open-range cattle raising and the low level of technology employed in the industry encourage the tendency to assume that primitive methods must be uneconomic and that development awaits a key that will open the way to closer settlement and the more intensive use of land. As von Thünen states

An ancient myth pervades our agricultural writings: that whatever the stage of social development, there is one valid farming system only - as though every system that is more simple, every enterprise that adopts extensive methods to economise on labour, were proof of the practising farmers ignorance.¹

¹ von Thünen's Isolated State, p.258.
This points to the need to take a systematic view of production and the interdependence of basic and applied resources at the firm level.

To trace the relationship between the intensity of land-use and variations in the application of capital and variable inputs correlation coefficients have been calculated for a matrix of thirteen factors. All data on costs and returns have been supplied by the BAE and refers to their modified sample of seventy-two stations. Average values for the three financial years of the survey (1962-63 to 1964-65) have been employed to minimise the effects of short-term variations. In addition three indices have been added to represent differences in land quality and accessibility. Since scale of output per unit of land is the dependent variable, the first factor is designed to quantify the effects of productivity and specialisation. The parameter chosen is cash income per property per hundred square miles and includes the actual value of sales of all types of stock net of transport costs. Because store and fat cattle are valued at their farmgate prices the index incorporates both situation and intensity rent influences. Necessarily its use assumes that the overall size of an enterprise is not a critical variable.

Table 5.7 sets out the correlation coefficients for logarithmic transformations of the thirteen variables. Comparison with a less extensive matrix which uses untransformed values indicates no substantive differences in the results. The independent factors are:

\( X_2 \) -- the index of land quality;
\( X_3 \) -- the number of made waters (bores, dams, earth tanks and wells provided for stock) per hundred square miles;
\( X_4 \) -- the number of miles of fencing (boundary and internal) per hundred square miles;
\( X_5 \) -- the number of yards (drafting, bronco and other types) per hundred square miles;
Table 4.7: Matrix of significant co-relationships between holding characteristics, 1962-63 to 1964-65

<table>
<thead>
<tr>
<th>Cash income per square mile</th>
<th>Index of land quality</th>
<th>Vaters</th>
<th>Fencing</th>
<th>Yards</th>
<th>Herd size</th>
<th>Stocking rate</th>
<th>Area</th>
<th>Operating costs</th>
<th>Labour costs</th>
<th>Road rate costs 1954</th>
<th>Farmgate prices 1964</th>
<th>Inward Freight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash income per square mile</td>
<td>0.67</td>
<td>0.61</td>
<td>0.77</td>
<td>0.85</td>
<td>0.86</td>
<td>0.48</td>
<td>0.32</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Index of land quality</td>
<td>0.68</td>
<td>0.67</td>
<td>0.61</td>
<td>0.31</td>
<td>0.53</td>
<td>0.37</td>
<td>0.31</td>
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<td></td>
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</tr>
<tr>
<td>Vaters</td>
<td>0.54</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Fencing</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yards</td>
<td></td>
<td>0.90</td>
<td>0.64</td>
<td>0.65</td>
<td>0.83</td>
<td>0.53</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Herd size</td>
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<td>0.64</td>
<td>0.65</td>
<td>0.83</td>
<td>0.53</td>
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<tr>
<td>Stocking rate</td>
<td></td>
<td>0.85</td>
<td>0.55</td>
<td>0.54</td>
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<tr>
<td>Area</td>
<td></td>
<td>0.79</td>
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<td>Operating Costs</td>
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<td>Labour costs</td>
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<td></td>
<td></td>
<td></td>
<td>0.76</td>
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<tr>
<td>Farmgate prices 1964</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Inward Freight</td>
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</tr>
</tbody>
</table>

$r$ is significant at the 5 per cent level at 0.03
$r$ is significant at the 1 per cent level at 0.20

Source: BAf unpublished data [refers to modified sample of 72 stations]; for the definitions of the parameters see text.
\(X_6\) -- the actual size of the heard carried by each property;

\(X_7\) -- the actual stocking rate of each holding;

\(X_8\) -- the actual property area (in square miles);

\(X_9\) -- the total annual operating costs of each unit per hundred square miles (i.e. the cost of materials, services, labour and depreciation);

\(X_{10}\) -- the annual cost of labour inputs per square mile (i.e. wages, rations contract labour payments and an allowance for the operator's labour);

\(X_{11}\) -- the imputed cost of transporting one fat beast to the most favoured market by road in 1964;

\(X_{12}\) -- the imputed net received price differential for one fat beast in 1964;

\(X_{13}\) -- the actual total cost of inward freight charges per property.

Parameters \(X_3\) to \(X_5\) represent inputs of fixed capital and have been preferred to the survey figures for the gross capital investment of holdings since the inclusion of depreciation understates the utility of long-established improvements; \(X_5\) and \(X_7\) cover stock inputs, viewing cattle as either a land resource or an item of capital, \(X_9\) and \(X_{10}\) represent the variable cost category, and here labour costs are particularly important; and \(X_{11}\) and \(X_{12}\) are the accessibility indices that have already been described in the work on zonal variations in returns to land in Chapter 4. The final parameter has been added to see whether location exerts a pronounced effect on scale through variations in the cost of materials.

The results shown in Table 5.7 suggest that there is a high degree of interrelation between the components of the production function. Of the forty-five correlation coefficients for the matrix \(X_1\) to \(X_{10}\), twenty-two are significant at the one per cent level so that it is difficult to avoid circularity in the search for the causative elements of differences in scale. As an example it is apparent that
the basic quality of land will condition the unimproved stocking rate; this in turn will influence the marginal productivity of investment in improvements and permit an increase in the carrying capacity of a given area of land. Depending upon one's point of view the productivity of the land parcel is determined by pasture quality, the capital value of cattle or the expenditure on improvements. While cumulative causation presents many problems it is fairly obvious that grass is the basic resource that operators have to market and that variations in fertility are a prime cause. Unfortunately the index used \((X_2)\) is not immune from the same endemic fault, since the optimum rates are derived from the evidence of differences in the actual stocking rates of holdings over the Northern Territory. This means that the index of land quality is itself conditioned by the level of technology employed.

However, Fig. 5.4 offers some clarification of the structure of interrelationships between variables. The factors have been divided into three classes -- those representing land inputs (pasture quality and station area); stock inputs (herd size and the actual stocking rate); and variable and fixed costs. The lines represent significant correlations between pairs of factors, and the asterisks show that individual parameters are related to cash income per hundred square miles. All the factors that bear upon the intensity of output are also linked directly to the index of land quality, which seems to confirm the dominance of this factor. If this is so it means that the opportunities for manipulating the input mix to gain an optimal scale of output are narrowly circumscribed by the resource base.

If pasture is the primary resource of the industry, the most critical item of capital is the provision of livestock. One of the main features of all types of stock farming is the ambiguous economic status of this input. As Hildreth and Jarret have pointed out in their study of livestock production and marketing in the United States a given animal may be regarded as a finished good, a good in process or a piece of
Fig. 5.4: Correlation linkages between land, investment and cattle population factors (1962-63 to 1964-65)

* indicates that the factor is also correlated with cash income per square mile.

Source: Table 5.7.
fixed capital. In the study industry further complications arise since the cattle on many properties are semi-feral. The most underdeveloped stations have so little control over the breeding cycle of their stock that their operators tend to view cattle as a land resource rather than an item of capital. This may explain to some degree why producers seem content to accept a universally low return to capital and management income. If the book value of herds was extracted from the sum of capital inputs the average return to fixed capital investment would rise markedly, for example, the BAE found that the average percentage return to all capital in the Victoria River District was 4.5, but this represents a return of 18.4 per cent when stock are excluded from the calculation.

The extent to which cattle are regarded as capital is reflected in the accuracy of three basic statistics on the herd. These are (i) the total number of stock on the run; (ii) the branding rate, which gives a guide to cow fertility, calf mortality, and mustering efficiency; and (iii) the turn-off rate, which gives a measure of the productive capacity of the population. Many commentators, despairing of being able to quantify the quality of different pastures and properties, have been led to consider production in demographic terms and have constructed herd models to permit deductions to be made on the effects of changes in structure on output. Two objections may be raised to this approach. First, in emphasising stock rather than pasture, the studies are observing secondary and not primary causation. Second, the quality of the statistics available is so low that sophisticated calculations often bear little relation to reality. As an example, the author was told by the head stockman of a fairly well-developed property on the Barkly Tableland that cattle numbers were about 22,500. The owner, who also lives on the station, insisted that 27,000 head would be a more accurate estimate. In this case both men


Field interviews, May 1968.
make frequent flights to observe the locale of cattle groups and yet the range in the basic figures would lead to a difference of two per cent for the turn-off rate, since sales average three thousand head per year.

One example of the herd structure approach to productivity is a study by Treloar of the turn-off patterns of five stations in the Kimberleys over a thirty-seven year period. He found that production in any one year depended largely on the number of calves branded six years before, and the incidence of rainfall during the life cycle of the cattle sold. Using regression analysis he was able to estimate that these factors explained eighty-two per cent of the variation in turn-off. The addition of cattle prices and the value of improvements on the holdings had no effect on the results. This study confirmed that climate is an important determinant of temporal variations in output, but did not explain why turn-off varies between properties. The final conclusion was that the industry was in the grip of 'the overwhelming influences of the irrevocable past and the unpredictable seasonal conditions'. To reach this inference is to admit defeat in formulating a production function for the industry. The relevance of these findings to the present study is that it seems justifiable to regard the stocking rate as a dependent variable of pasture quality and expenditure on improvements, rather than as an index of the intensity of capital usage.

Moving to the application of fixed capital it is useful to consider the relationship between various items and the advances in husbandry that they permit. Table 5.8 sets out the progressive sequence of improvements described by Beattie, which led him to suggest a five stage model of development. In reality operators tend to adopt all or most of the recommended practices simultaneously, where fencing is adequate. Thus the completely open range system may co-exist with a well-developed sector within one holding boundary.

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<table>
<thead>
<tr>
<th>Improvement</th>
<th>Main husbandry advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Construction of a bullock paddock and drafting yard.</td>
<td>Allows cattle to adjust to control prior to marketing.</td>
</tr>
<tr>
<td>4. Provision of yards for speying.</td>
<td>Assists in controlling the stocking rate.</td>
</tr>
<tr>
<td>5. Construction of a paddock for maiden heifers.</td>
<td>Permits controlled mating and the improvement of the stock strain.</td>
</tr>
<tr>
<td>7. Internal subdivision and secure boundary fencing.</td>
<td>Assists in total branding and selection of the best mates. Also allows the introduction of new blood strains.</td>
</tr>
</tbody>
</table>

The general tendency appears to be for development to extend in a cellular fashion from homesteads and out-stations as bores, yards, and paddocks are provided. Since, as Waring has noted, the cost of operations such as fencing tends to increase approximately as the square root of the area required to support one beast, the best pastures are the first to be used more intensively. This means that there is a long-term trend towards decreasing marginal productivity in fixed capital investments. A further point that must be made here concerns economies and diseconomies of scale. As von Thünen and Chisholm have observed, distance from the farm homestead may influence the intensity of usage of the component fields and paddocks of a unit. This would suggest that the biggest properties would tend to neglect the development of peripheral pastures. One reason for the absence of evidence of this reaction from producers is that large holdings may be easily run as a group of semi-independent stations. One example is provided by Victoria River Downs which is divided into four units -- Victoria River homestead, Moolooloo, Pigeon Hole, and Mt Sandford. The overall herd is about 70,000 head and the lease covers 4,772 square miles, but the internal organisation is such that the resources controlled from one out-station are very similar in scale to those held by neighbouring independent operators.

If individual improvement indices are examined as a guide to efficiency several difficulties are encountered. Chief of these is the fact that additional labour inputs may be a perfect substitute for capital. Comparison of the cost structures of holdings as tabulated in the 1950 and 1962-63 to 1964-65 BAE surveys shows a general trend to an increase

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2 von Thünen's Isolated State, p.244.
in investment, which may reflect the rise in labour costs over
the period rather than an overall growth in the use of all
factors of production. Confirmation that this form of
substitution also occurs at the regional scale is given by
comparing figures abstracted from the later survey results
for the Barkly Tableland and the Victoria River District.
Output, investment, and labour usage have the following
relationship in the two regions:

<table>
<thead>
<tr>
<th>District</th>
<th>Cattle sales per property</th>
<th>Average capital per 100 square miles (excluding cattle)</th>
<th>Number of labour weeks worked per 100 square miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barkly Tableland</td>
<td>2,049</td>
<td>$10,376</td>
<td>38</td>
</tr>
<tr>
<td>Victoria River</td>
<td>2,029</td>
<td>$7,832</td>
<td>56</td>
</tr>
</tbody>
</table>

Although the average size of properties in the Victoria River
District is slightly greater than the figure for stations on
the Barkly Tableland it seems clear that scale adjustments
are made by altering the input structure. In this case there
is no evidence that the real cost of the two factors varies
between the two Districts. One explanation for regional
variations in the production function is that certain
qualities of land demand investments of a particular type.
The main example of this is the need to provide water on the Barkly Tableland where the physiography of the Mitchell
and Flinders grass plains precludes dependence on natural
supplies. Since these are the most productive natural
pastures, the land quality index tends to be correlated with
the number of waters per hundred square miles (see Table 5.7).
In this instance the natural qualities of land (over and
above the pasture component) act as a substitute for capital
on other types of terrain. Further complexity is added by
the fact that some forms of investment are also partial
substitutes. Thus bores hold stock on some pastures as
effectively as fencing and the trap yards employed in the two
northern regions cut down the need for fences and labour.

Viewed in the long-term it may be that the increases in
productivity from improvements that result from the more
effective use of pasture and cattle resources are only
offsetting a general trend towards a decline in production
caused by the deterioration of range quality. Treloar
observed that producers in the Kimberleys were not surprised
that investment had no impact on turn-off. As he states

...the consensus of opinion among pastoralists
seems to be that overstocking has led to a
decline in the carrying capacity of the native
pastures. That output has been maintained in
the face of this decline indicates the
possibility that investment has had at least
a compensatory effect.1

In a similar study, under the BAE, of thirty Kimberley
stations, Westerman found that their stocking rates were
highly correlated with the value of improvements per square
mile \((r = 0.82)\). From this he deduced that 'at least at
current low levels, producers are achieving something more
with their investment than simple compensation for the
deterioration of pastures due to overstocking in the past'.2

A more valid explanation for the relationship might be that
the marginal productivity of investment is often directly
related to the unimproved carrying capacity of land.

The main conclusion which can be drawn from this
discussion of the input mix is that the general features of
extensive cattle raising account for most of the variations
in scale that are apparent in the industry. The local
availability of applied factors of production (particularly
capital and labour) does not appear to influence scale, and
the opportunities in management are narrowly circumscribed
by the resource base. This affirms the validity of
examining production primarily in terms of intensity of
output per unit of land. The wider implications of these
findings will be pursued in the following two sections.

2 Westerman, P.A., 'The Kimberley Beef Cattle Industry',
Having considered some of the characteristics of production, it is now possible to use the BAE data to explore the study problem in greater detail. The combined influence of non-land inputs on intensity will be examined and then the role of accessibility will be discussed in the light of a more complex model of production. The deductions reached in the empirical work suggest that the most logical form of intensity function would stress land quality, while fencing and labour inputs have been chosen as additional independent variables for two reasons: their obvious role in station operations and, their relative freedom from statistical multicollinearity (see Fig. 5.4). The following equation relates cash income per square mile \(X_1\), the index of land quality \(X_2\), the number of miles of fencing per hundred square miles \(X_4\) and annual labour costs per square mile \(X_{10}\) for the seventy-two stations in the modified BAE sample

\[
(i) \log X_1 = -0.76 + 0.28 \log X_2 + 0.63 \log X_4 + 0.31 \log X_{10}
\]

\[t\text{-values} \quad 3.56 \quad 5.85 \quad 4.84\]

\[R = 0.82 \quad R^2 = 0.67\]

The multiple correlation coefficient for this equation is statistically significant beyond the one per cent probability level, and the adjusted coefficient of multiple determination indicates that sixty-seven per cent of the variation in cash income per square mile in the sample was explained by the three independent factors. The 't' statistics for the regression coefficients show that they were significantly different from zero at the one per cent level, which suggests that each factor contributed to the model.

The equation could be termed a 'revenue intensity function' and represents an attempt to characterise scale at the unit of land level. Under certain conditions, as discussed in Chapter 2, the dependent variable would approximate economic rent. The analysis shows that differences in fencing and labour inputs do condition the value of output, since they control the exploitation of pasture and cattle resources. Extending the interpretation,
it is possible to give an estimate of the economic importance of each variable; thus, on average, a one per cent increase in the amount of fencing per hundred square miles would lead to an increase in revenue of 0.63 per cent, holding other inputs constant at their geometric means. The function has many basic similarities with the standard Cobb-Douglas formulation, though the mixture of physical and cash measures and the stress on intensity preclude interpretation in this manner. However, it is interesting to note that, if the regression coefficients are taken as the elasticities of the product with respect to variations in factor usage, the model indicates increasing returns to scale (since the sum of the coefficients exceeds 1.00). This would appear to be due to the strong influence of land quality -- a resource which cannot be varied in the production functions of units -- at least in the short-run.

Of the non-land factors, fencing seems to be most important and this factor has been selected as a 'key' to development. As the Forster Committee commented

The best owners...interviewed, when...asked what they needed most on their properties, almost always replied more fences.¹

One reason for the failure of many operators to exploit the advantages of this form of investment is that it is discontinuous. For example, a paddock roughly seven miles square, enclosing fifty square miles of country, would cost about $12,600 and would be useless until completed.² This is a large sum for an improvement that will only have a long-term effect on output. Since this category of decision is likely to be taken in the light of the stability of market prices over time, it is not surprising that there is little evidence of adjustment to relatively minor variations in net received prices over space. Labour inputs can be varied relatively easily, but current wage trends and the apparent

² Assuming that suspension fencing, costing $450 per mile, is used.
shortage of pastoral workers suggest that economic opportunities for expansion through the more intensive exploitation of cattle resources may be limited. Thus there are also rigidities in this aspect of the production function. These inferences will be considered in a more abstract light in the last section of this chapter, while more detailed information on the constraints on long-run supply response is given in Chapter 7.

As a final test of the hypothesis that accessibility may have exerted a strong influence on the intensity of land-use in the early 1960s, the indices of road transport rate payments \((X_{11})\) and farmgate price differences for fatstock \((X_{12})\) were added to the equation. Both were included simultaneously to see whether the analysis could be extended by differentiating their effects. The resulting equation took the form

\[
\log X_i = -0.78 + 0.27 \log X_2 + 0.62 \log X_4 + 0.24 \log X_{10} - 0.15 \log X_{11} + 0.26 \log X_{12}
\]

\[
R = 0.84 \quad R^2 = 0.70
\]

The t-values for the coefficients were 3.52; 5.90; 3.42; -1.19; and 2.23 respectively.

The addition of the two variables appears to make little difference to the function and examination of their 't' statistics shows that the coefficients may be due to chance, though the negative sign for rate payments is interesting since this indicates a possible output response to accessibility. In this case the causative element may be the mobility effects of the use of road transport. One additional theoretical point must be considered. In the model put forward by Dunn, the cost of inward freight to farms steepens the rent gradient. Market terminals and station supply centres coincide in the Northern Territory and freight

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1 For further results and a discussion of certain of the methodological issues raised in this section see Appendix 2.
Haulage charges vary from six to eleven cents per ton-mile according to the distance travelled. This means that the delivered cost of items such as cement may vary by as much as $40.00 per ton. The main reason why this factor does not affect the level of station operations is that livestock supplies and fuel make up less than ten per cent of total costs. These are the principal variable costs that could be influenced by distance. Similarly, where decisions have to be made on fixed capital investments freight is likely to be a minor consideration when related to the overall cost.

Finally it is necessary to examine briefly the reasons for the rather low value of $R^2$ in equation (i). It would be tempting simply to attribute the unexplained part of the variance in cash income per hundred square miles to the factors of production that have been ignored in the analysis. Of these management must be the chief, but differences in the efficiency of this factor are difficult to measure. From another viewpoint it is possible to argue that the production function suggested by equation (i) understates the actual influence of its components, since forty-one of the seventy-two observations refer to stations in the Alice Springs District which were affected by drought during the survey years. Whatever the true causes it appears that the regularities that result from varying applications of the basic production factors -- land, capital, and labour, as they are represented in the function, are the major determinants of differences in the scale of output per unit of land.

4. Output response in the Northern Territory beef industry

Production adjustment to spatial equilibrium can be viewed as one of a set of problems that involve the elasticity of supply in agriculture with respect to variations in commodity prices. By ordering their analytical procedures to the identification of locational regularities economic geographers are in constant danger of forgetting the basic economic causation of the phenomena that they seek to explain. As an economist von Thünen was well aware that his deductive system was grounded on a particular emphasis of the
relationship between firm scale and aggregate demand. The implication of this line of reasoning is clear — agricultural adjustment to variations in price must be seen as an ergodic function. Brinkman makes explicit the theoretical link between land-use response to temporal and spatial variations in received prices in the following terms:

The series of stages of development...brought about...in consequence of progressive strengthening of the demand for agricultural products shows, in relation to the intensity, exactly the same behaviour as the differentiation of the zones at a given stage of development. The vertical differentiation of the zones, or the non-synchronous succession of the degrees of intensity, corresponds to the horizontal arrangement or the synchronous juxtaposition of the zones of intensity [i.e. Brinkman is referring here to the Isolated State model]. This applies not only to the degrees of intensity but also to the differentiation as to the form of intensity.¹

This points to the need to compare the response of the study industry to secular price changes with the results of the analysis of locational adjustment.

Table 5.9 shows the relationship between the prices offered at alternative markets for fatstock in 1957 and their 1966 equivalents.

Table 5.9: Comparison of temporal and spatial variations in prices for fatstock, 1957 and 1966

<table>
<thead>
<tr>
<th>Market</th>
<th>1957 price ($)</th>
<th>1966 price ($)</th>
<th>1957-1966 differential</th>
<th>Percentage increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brisbane</td>
<td>65.00</td>
<td>123.10</td>
<td>58.10</td>
<td>189.4</td>
</tr>
<tr>
<td>Adelaide</td>
<td>65.00</td>
<td>139.75</td>
<td>74.75</td>
<td>215.0</td>
</tr>
<tr>
<td>Alice Springs</td>
<td>53.10</td>
<td>127.85</td>
<td>74.75</td>
<td>240.7</td>
</tr>
<tr>
<td>Mt Isa</td>
<td>37.55</td>
<td>94.70</td>
<td>57.15</td>
<td>252.2</td>
</tr>
<tr>
<td>Wyndham</td>
<td>50.00</td>
<td>70.00</td>
<td>20.00</td>
<td>140.0</td>
</tr>
<tr>
<td>Darwin</td>
<td>41.00</td>
<td>73.75</td>
<td>32.75</td>
<td>179.9</td>
</tr>
<tr>
<td>Katherine</td>
<td>41.00</td>
<td>70.00</td>
<td>29.00</td>
<td>107.7</td>
</tr>
</tbody>
</table>

Table 5.9: Comparison of temporal and spatial variations in prices for fatstock, 1957 and 1966

<table>
<thead>
<tr>
<th>Year</th>
<th>Received price at periphery ($)</th>
<th>Maximum received price ($)</th>
<th>Spatial differential</th>
<th>Percentage differential</th>
</tr>
</thead>
<tbody>
<tr>
<td>1957</td>
<td>20.45</td>
<td>53.10</td>
<td>32.65</td>
<td>259.7</td>
</tr>
<tr>
<td>1966</td>
<td>51.95</td>
<td>127.85</td>
<td>75.90</td>
<td>246.1</td>
</tr>
</tbody>
</table>

Sources: Tables 3.1 and 4.1; and index calculations. It is assumed that all beasts dress out at 500 lb.

The choice of base years has been made to assist comparison with the work on spatial equilibrium. The increase in returns to producers varies from 140 to 250 per cent but it seems reasonable to suggest that on average proceeds from sales doubled for the industry over the decade. Table 5.10 gives the total production of all stations in the Northern Territory (excluding inter-Territory transfers) for the years 1949-50 to 1966-67. Since increases in productivity may result from either a rise in the number of cattle carried or the more intensive use of existing resources, the stock population and imputed turn-off rates for the period are also given. The general picture presented by the three sets of figures is one of near static production, though there is some tendency for the turn-off rate to rise slightly and irregularly.

According to Brinkman the general rise in market prices over the study period should have led to an overall increase in the intensity of land-use and a consequent supply response. Comparing the temporal range in prices to the variation in receipts over space for the two base years as given in Table 5.9b, it appears that the order of difference in both dimensions was much the same. This suggests that the failure of the industry to adjust over time and space might be explained by the same set of reasons. It is then necessary to examine elasticity of supply at the firm level.
Table 5.10: Production and physical productivity in the Northern Territory beef industry, 1949-50 to 1966-67

<table>
<thead>
<tr>
<th>Year</th>
<th>Cattle population (June) ['000]</th>
<th>Total turn-off ['000]</th>
<th>Turn-off rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1949-50</td>
<td>1,019</td>
<td>121</td>
<td>11.9</td>
</tr>
<tr>
<td>1950-51</td>
<td>1,058</td>
<td>169</td>
<td>16.0</td>
</tr>
<tr>
<td>1951-52</td>
<td>936</td>
<td>102</td>
<td>10.9</td>
</tr>
<tr>
<td>1952-53</td>
<td>966</td>
<td>105</td>
<td>10.9</td>
</tr>
<tr>
<td>1953-54</td>
<td>969</td>
<td>150</td>
<td>15.5</td>
</tr>
<tr>
<td>1954-55</td>
<td>1,028</td>
<td>101</td>
<td>9.8</td>
</tr>
<tr>
<td>1955-56</td>
<td>1,902</td>
<td>156</td>
<td>8.2</td>
</tr>
<tr>
<td>1956-57</td>
<td>1,176</td>
<td>151</td>
<td>13.7</td>
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<tr>
<td>1957-58</td>
<td>1,252</td>
<td>155</td>
<td>12.4</td>
</tr>
<tr>
<td>1958-59</td>
<td>1,138</td>
<td>192</td>
<td>16.9</td>
</tr>
<tr>
<td>1959-60</td>
<td>1,089</td>
<td>165</td>
<td>15.1</td>
</tr>
<tr>
<td>1960-61</td>
<td>1,117</td>
<td>198</td>
<td>17.7</td>
</tr>
<tr>
<td>1961-62</td>
<td>1,055</td>
<td>162</td>
<td>15.3</td>
</tr>
<tr>
<td>1962-63</td>
<td>1,096</td>
<td>152</td>
<td>13.9</td>
</tr>
<tr>
<td>1963-64</td>
<td>1,068</td>
<td>159</td>
<td>14.9</td>
</tr>
<tr>
<td>1964-65</td>
<td>1,049</td>
<td>138</td>
<td>13.1</td>
</tr>
<tr>
<td>1965-66</td>
<td>1,051</td>
<td>172</td>
<td>16.4</td>
</tr>
<tr>
<td>1966-67</td>
<td>1,106</td>
<td>136</td>
<td>12.3</td>
</tr>
</tbody>
</table>

Source: NTAAIB Annual Reports (figures are not adjusted for late returns.

Drawing from the discussions of the input structure and the production function, it is useful to characterise the industry in the following terms:

(i) there is no reason to suppose that economies or diseconomies of scale exert any real influence at the firm level,
(ii) resource quality directly conditions the return on fixed capital investment,
(iii) fixed capital investment is highly discontinuous,
(iv) variable costs are likely to increase in line with expenditure on improvements.

From this series of propositions it is possible to formulate a set of hypothetical cost curves for the components of the industry. Consider first the form of the production function of a land unit of homogenous quality, as shown in Fig. 5.5A. In its unimproved state the number of cattle run is directly related to the quality of the pasture, and costs are incurred entirely as a result of the labour involved in mustering. This means that the marginal cost curve, MC₁, is likely to be markedly kinked at the point of diminishing returns to labour. To expand output the operator must therefore add in other factors of production to increase the productivity of the herd. This will shift the marginal cost curve upwards (to MC₂) and again land quality will determine the ultimate scale of output at Q₂.

At the holding level the operator has an alternative method of increasing turn-off, for he may be able to bring into production areas of progressively poorer use capacity. This means that the overall production function will be stepped, as shown in Fig. 5.5B. Since all forms of capital investment are discontinuous or 'lumpy', he will tend to be particularly conscious of uncertainty and will be unable to adjust output in the short-term. Broadly speaking all types of land will cost the same to develop so that the marginal productivity of investment will fall steeply as lower quality pastures are brought into use. This means that with static technology the slack for expansion is likely to be extremely small since the best opportunities will be exploited early with very little reference to the prevailing price situation.

The sum of these influences is seen in Fig. 5.5C, where the cost curves for the industry indicate an almost completely inelastic response to price, and scale is endogenously determined. Disaggregating again to the property level it is easy to see why scale and economic rent adjustments of the type shown in Fig. 2.1 may be absent in reality.
Fig. 5.5: Hypothetical production function forms at various scales in the Northern Territory beef industry.
If the sole aim of this analysis of the reasons for non-adherence to spatial equilibrium in the open range cattle industry was to arrive at the rather negative conclusion that land quality and technology invalidate a Thünen style approach, the practical relevance of the study would be narrow. Its justification lies in two additional inferences. First, given the structure of the study industry it lays open the issues involved in emphasising investment in transport as a trigger to production expansion. This topic forms the main interest of the second major part of this thesis, which looks in some detail at the economic aspects of the Government's Beef Roads Programme in the Northern Territory. Second, it raises an important point which relates to the influence of location on agricultural production at a more general level. Some agricultural economists have suggested that the form of production function shown in Fig. 5.5C is in fact typical of a wide range of industries and enterprises. Wilcox, for instance, argues that the use of moderately upward sloping marginal cost curves in farm production analysis is misleading. He points out that many inputs, particularly on family farms, are fixed in the short-term so that it is impossible for operators to adjust their input structure to variations in commodity and factor prices. In addition, continuous technological advance brings improvements that are cost reducing to such an extent that they are profitable under any level of product prices that permit the producer to stay in business. The high fixed cost of many of these investments, however, makes it profitable to maximise their use so that there is a general tendency for scale to increase. In this sense the output of holdings is technologically determined. Returning again to the Isolated State analogue it is apparent that two main factors

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have destroyed the theoretical relationship between location and land-use that von Thünen deduced. The first and most obvious of these is the fact that transportation costs have decreased in relation to other inputs. The second is the no less important point that the supply function in modern agriculture is no longer price conditioned, except in the broadest sense. The implications of this finding to the body of agricultural location theory remains to be explored. What is apparent is that Lösch's strictures on the ordering of facts and hypotheses must be taken to heart.
PART 3

THE RELATIONSHIP BETWEEN IMPROVEMENTS IN TRANSPORTATION
AND THE EXPLOITATION AND DEVELOPMENT OF
PASTORAL RESOURCES
CHAPTER 6

LOCATION RENTS, ROAD INVESTMENT BENEFITS AND THE ROLE OF TRANSPORT TECHNOLOGY IN PRODUCTION

The calculations on transport costs are based on the very bad roads as they existed in Mecklenburg in the first years of this century. But it is certainly not rational to maintain roads in such a bad condition; and in Mecklenburg the construction of numerous highways has already much reduced the number of such roads. But since we endowed the Isolated State with inferior roads, determining on their basis the entire farming pattern and the extent of the cultivated area, we must be consistent with the need for rationality, ask ourselves the following:
(a) In which districts and to what point of the Isolated State will highways and railroads be constructed to advantage? (b) What effect will their construction have on the size of the cultivated plain, on tillage and on national wealth?

von Thünen, The Isolated State

INTRODUCTION

The empirical work presented in Part 2 of this thesis was designed to test the hypothesis that accessibility may condition the intensity and profitability of land-use in the Northern Territory beef industry. The analyses given in Chapters 3 and 4 were based on the assumption that spatial variations in transport payments and net received prices for a uniform quality of stock were adequate parameters of the comparative locational advantages of individual production units. The farmgate prices were defined by debiting the rate payments incurred in transporting fatstock from each property to its most favoured market from receipts. The relationships between these values and indices of the output and net returns of properties at particular time periods were considered using a range of techniques. It was assumed that, with homogeneous production functions, adjustments would be made in scale which would primarily depend on
locational differences in marginal returns. The methodology and rationale for the work were derived from von Thünen's exposition of the generation of situation and intensity rents in the Isolated State. Though this approach has provided valuable insights into the interaction between accessibility and land development at given points in time, it is of limited use in the evaluation of the effects of changes in the individual components of comparative locational advantage. Furthermore, it emphasises adherence to spatial equilibrium at the industry level and says little about the temporal adjustments that are made by firms or groups of producers. Thus, to explore a particular facet of the general problem considered in this thesis the systematic Thünen framework must be abandoned, though the empirical and deductive inferences that have been made in Part 2 provide a point of reference for the evaluation of the results of partial equilibrium analyses.

Part 3 marks a break in methodology and scale. Interest narrows to the consideration of the relationship between mode and network changes in transportation and pastoral land development. The adoption of road transport in the Northern Territory beef industry has affected the returns and opportunities of producers and this is resulting in adjustments to the scale and form of enterprises and land-use. Some of these changes are already apparent while others will require the employment of additional resources and represent a long-term potential for development. The empirical work in Chapter 6 is concerned with the interpretation of the existing evidence in 1966, while Chapter 7 looks at the future and presents both optimistic and pessimistic views of production response. Here the emphasis is on the relationship between the quality of accessibility and the optimum intensity of land-use. In this case the adjustment process may be primarily directed towards a shift from a system that is constrained by location to one in which spatial variations in accessibility play a decreased role in the allocation of resources.
The first section of the present chapter looks at the ways in which improvements in transportation may affect a dependent agricultural industry. The work uses a deductive approach based on the Thünen analogue and demonstrates the interaction between land-use and transport in a simple Isolated State model. This is then developed to encompass the theory of benefit-cost analysis to provide a framework for the evaluation of short-term and long-term supply response in the beef industry to the provision of improved roads. A range of theoretical and methodological issues are raised which are interwoven in the structure of the empirical work that follows. Among these is the need to define the temporal and spatial dimensions of total economic adjustment to mode and network changes. A second major problem is the identification of the causative elements in shifts in the scale and range of production that are linked to changes in the quality of transport. In particular, it is important to distinguish between elasticity effects which influence the allocation of resources through the net received prices of commodities, and mobility effects which arise from external economies. Finally, it is useful to separate changes which result in the local redistribution of economic activity from those that affect all producers. Frequently this involves a dichotomy between responses to an improved route that are manifested in the pattern of location rents, and responses to a new mode which are part of the spin-off from technological progress.

In the study industry the adoption of road transport and the improvement of some segments of the road network under a number of public works programmes have changed the comparative value of different locations and reduced the absolute importance of transportation as a determinant of the form and scale of production. The enumeration of the benefits of these developments is one of the main aims of the two chapters that make up Part 3 of this thesis but first it is necessary to describe the origin, aims, and specifications of the road programmes that have been initiated in the Northern Territory, primarily to stimulate
the expansion of the beef industry. The second section of this chapter supplies this information, and considers the relationship between road standards and the possibility and cost of using road haulage to deliver cattle to fatteners, killing plants and railheads. Although the theme of the thesis is the relationship between accessibility to markets and the intensity and profitability of land-use it would be simplistic to restrict comment on the efficacy of the road programmes to this topic alone: a brief survey of other possible social and developmental benefits is therefore included.

The third section of the chapter is an attempt to draw up an account of the benefits of the use of road transport to producers in 1966. Necessarily this emphasises short-term changes and the advantages of flexibility in marketing since insufficient time has elapsed to permit the observation of adjustments in property resource use. In reality it is not possible to dissociate the benefits of an improvement in transport from the effects that follow the introduction of new markets and demands. Thus the opening of the meatworks at Katherine and Darwin, the continuing United States demand for boner-beef, and the use of road haulage are all elements in the upgrading of the accessibility of northern producers in the general sense.

This assessment of observable short-term adjustments for the whole industry sets the scene for two sub-regional studies in Chapter 7. These consider a range of possible levels of long-term response to specific projects in the Beef Roads Programme, and attempt to estimate the net benefits of the employment of both public and private capital to develop pastoral land in the Northern Territory. Just as it is impossible to discuss the benefits of improvements in transportation without including a qualification on the certainty and level of demand for the traded product, so the definition of what constitutes the efficient allocation of factors of production must be made in terms of the alternatives which exist to meet a given end. This means that the evaluation of investment and the estimation of future levels of output in the sub-
regions affected by particular road proposals must be related to the opportunities that are evident for the expansion of beef production in other parts of Australia. Hence, though the interest in the relationship between accessibility and land development narrows in Part 3 to the evaluation of changes in the form and quality of transport, the context of the study is widened and the Northern Territory is no longer regarded as an Isolated State.

A. THE ENUMERATION AND VALUATION OF THE BENEFITS OF IMPROVEMENTS IN TRANSPORTATION

1. Spatial equilibrium and the benefits of improvements in transport

Using a single crop, Isolated State analogue it is easy to deduce the effects of a localised reduction in transport costs on the pattern of production. Where the price of the agricultural commodity is invariant at the central market the producers using an upgraded access route will receive an immediate increase in situation rent. If rate payments are a direct function of distance the reduction in freight costs will lead to an increment in receipts which will become proportionally greater towards the periphery of the cultivated area. This would result in a levelling of rents. Two other effects might also follow under special conditions. First, the rent margin would be extended and idle land would be brought into production provided the resources were available. Second, the increases in situation rent would call forth adjustments in the scale of enterprises that would, in turn, be reflected in a rise in intensity rents. The level of this response

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1 It is assumed that (i) all transport is unimodal, (ii) producers freight produce on their own vehicles, (iii) transport costs vary linearly with distance from the market, (iv) and the improvement in the quality of routes is exogenous to the system (i.e. producers do not pay for the improvement).
depends upon the supply functions of the component farms of the industry.

Removing the constraint of a fixed market price, it can be seen that the elasticity of demand for the product can exert a critical influence on the level and distribution of changes in location rents. If the extension of cultivation at the margin and the intensification of production at intermediate distances increase supplies to the extent that market prices are reduced, all producers who do not use the upgraded route will suffer total rent losses, as will users nearest the demand centre. However the comparison of before and after gross rent values will give a measure of the total benefit of the project to the industry. In addition there will be a concurrent increase in consumption, and benefits will accrue at the market that must be added to the net rent gain if the objective is to identify the overall value of the development.

When multiple markets are included in the model the location of the improved facility will determine the allocation of benefits between sets of producers and consumers. Where, for example, a new road diverts a commodity from one supply area to another the resultant trade flows will tend to equalise the market prices offered at the two centres; producers nearest to the market, which initially offered the highest price, will suffer a reduction in net received prices and concomitant decreases in both forms of location rent. Again a comparison of the old and new rent levels under spatial equilibrium will reveal the net benefit of the improvement to the industry. In this case one group of consumers will gain while the other will lose. Where two or more crops are produced further complications

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1 A discussion of the spatial distribution of the benefits of road investment to rural areas is given by W.L. Garrison in Allocation of Road and Street Costs. The Benefits of Rural Roads to Rural Property, Part IV, Washington State Council for Highway Research, Seattle, 1956, pp.88-95.
are caused by the possibility of the mutual adjustment of their displacement rent boundaries. It is easily seen that the final effects of the investment in transportation might reverberate through the whole economy as factor prices were altered to a new general equilibrium.

The causative element in the redistribution of economic activity in this simple example is the differential in farmgate prices -- the elasticity effect. Two points must be considered briefly in relating these deductions to reality. First, where a group of producers receive an increase in net receipts from a lowering in transport charges, the rise is not likely to be large in comparison to temporal fluctuations in market prices. For example, in the study industry a reduction in rate payments of one cent per beast-mile will increase farmgate receipts by $2.00 per bullock on a 200-mile trip. This is well within the monthly range of movements of prices at the northern meatworks where variations are relatively small. Consequently, production response might be expected to be insignificant or non-existent. However, a second point may counteract this tendency: producers may view changes in the market price and transportation cost components of accessibility in a different manner. Reductions in transport payments caused, for instance, by the construction of a new road represent a certain and comparatively irreversible change in locational advantage, while price shifts at the demand centre may be short-term and uncertain. Hence it can be argued that adjustment is more likely to follow from a dollar decrease in unit transport costs than a dollar increase in market prices.

The upgrading of a segment of a network may also stimulate external economies. These occur where what is done in one industry reacts upon the conditions of production in the other industry in some way other than through the possible effect upon the prices of the product or of the factors in that other industry.

The mobility effects that follow changes in the reliability of transport are in this category. An example is provided by the expenditure of funds on the stock-routes of the Northern Territory. Between 1946 and 1964 ninety-five water points were provided by the NTA to assist movements. These facilities had no tangible effect on drovers charges, but they may have assisted in marketing cattle of a younger or weaker type (e.g. females) that could not have been walked over long, dry stages. If station revenue has been created from the extension of selling opportunities, the additional income can be counted as an external economy. This could result in further adjustments in the form and scale of production. In general, though, it would appear that external economies are relatively unimportant where the change in accessibility is restricted to the upgrading of routes under unimodal transportation. One further point may be made before considering a bimodal case. The simultaneous improvement of all the segments in a network would lead to adjustments in the level of output of farms but would not alter the ranking of locational advantages or the pattern of production. Here the measurement of response must be made on a 'before or after' basis, rather than in the spatial dimension by a 'with or without' comparison.

The introduction of a cheaper rival form of transport on specific routes will also lead to a redistribution of activity and changes in consumption, under the conditions of spatial equilibrium, in the ways that have been discussed above. If the new form is technically superior its main

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2. Note: The term 'with or without' is used here to express the fact that benefits could be measured by comparing the changes in production levels of the user group with a control group in the same industry. The phrase can also imply a methodology which fails to take account of suppressed and normal growth trading over a temporal span but this is not intended in the present usage.
advantages may lie in the generation of external economies. The consequent reorganisation of the user enterprises to maximise the value of their new opportunities will lead to shifts in their economic rents. If the effect is localised it seems reasonable to retain the terms situation rent and intensity rent to describe the comparative advantages of users and non-users. However, the main causative element of the difference is the mobility component of accessibility and not the elasticity aspect. This distinction becomes more important where the adoption of the new form of transport can be characterised as a diffusion process. Here all producers will eventually reap the benefits of the improvement in technology and changes in rents will be evident at different times in separate localities. It is therefore useful in this case to classify economic rents in temporal terms. Three states and two adjustment periods may usefully be distinguished. The 'existing state' is the level of economic rent that the unit earns under the elasticity and mobility constraints of the old transport form. The 'immediate state' is reached in the short-run after adoption, and can be defined as the net value of production following the exploitation of new marketing opportunities, with the 'existing' cost structure. The 'attainable state' is reached in the long-run when the structure and scale of the production function has been altered to maximise the use of resources under the new range of prices and demands. These terms allow for a situation which von Thünen did not consider in the Isolated State where the mode of transport may determine the form of production within one land-use zone.

The timing and level of the immediate and attainable responses will be conditioned by the fixity and scarcity of resources and the stability of demand. The foregoing observations assumed ceteris paribus conditions and rational management with perfect mobility of factors of production. In reality, production responses to changes in the quality and cost of transportation are likely to be subsumed in the decisions that operators make in the light of their best estimate of future returns. However, the extension of the
Thünen deductive framework does clarify the issues which are involved in attributing secondary or developmental benefits to investments in transport. First, benefits may accrue on existing or generated production, and gains may also be realised from an increase in consumption. In addition, the reallocation of resources might affect other industries so that the ideal evaluation framework would be based on a general equilibrium approach. Second, with stable market prices, production adjustments to improvements in transport can be seen as shifts towards a new steady state. Where the effect is localised a 'with or without' comparison of economic rents will measure the net benefit of the change to the user group. If the new opportunities extend to producers on all parts of the network the evaluation must be made on an industry-wide 'before and after' basis. Finally, it is important to distinguish the cause of adjustment, which involves an assessment of the relative contribution of changes in the elasticity and mobility influences on net receipts and raw materials; and of factors that are unrelated to the transport component of accessibility.

The problem of identifying the total complementarity effect of an improvement in transport can be recast in terms of spatial equilibrium changes under strict limiting assumptions. Models of the activity analysis type have been proposed by several authors to determine transport-induced shifts in production and consumption. Bos and Koyck, using a framework suggested by Tinbergen, found that benefit-cost procedures based on the enumeration of savings to existing and generated traffic considerably understated the value of upgrading a route in a simple economic landscape. A more complex formulation has been proposed.

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by Mohring and Harwitz\textsuperscript{1} based on work by Moses.\textsuperscript{2} This requires
the estimation of the technical coefficients, resource inputs, and final demands of transport using industries, within the constraints of linear programming. Some of the difficulties associated with using this approach to assess change in a real situation can be realised by referring to the study industry. Supposing the aim was to predict the optimum pattern of production following the completion of the Beef Roads Programme, it would be necessary to specify the supply functions of each property, the elasticity of demand at each destination, and the routes available for all possible consignments. Given the difficulty of defining a clear relationship between variations in net received prices and the intensity of land-use, as demonstrated in the empirical work given in Part 2, it would not be possible to calculate shifts in supply that might follow from the elasticity effect. The estimation of the impact of external economies would require the definition of alternative forms of the production functions of every unit and the probable response of producers to new opportunities. Here again the organisation of the input data from empirical work would be almost impossible. Thus, though programming methods have the merit of internal coherence, the specification of constraints and supply parameters precludes their use in all but the simplest cases.

In considering allocation, it is clear that the Transportation Problem offers a means of predicting exchange responses to the improvement of particular routes under inelastic supply and demand schedules. The sensitivity of the optimal solution for fatstock in 1966 was tested by running the programme with three cost matrices: Four classes of roads were distinguished, (i) bitumen highways

\begin{footnotesize}
\begin{enumerate}
\end{enumerate}
\end{footnotesize}
(the Barkly and Stuart Highways), (ii) beef roads designated for sealing, (iii) gravel surfaced beef roads, and (iv) all other tracks. The distribution of roads of these types is shown on Map 6.1. The expense of moving stock over the different segments of the network was approximated for the years 1957, 1966, and 1970 using the following assumptions about costs in terms of cents per beast-mile:

<table>
<thead>
<tr>
<th>Year</th>
<th>(i)</th>
<th>(ii)</th>
<th>(iii)</th>
<th>(iv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1957</td>
<td>3.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>1966</td>
<td>3.5</td>
<td>4.0</td>
<td>4.0</td>
<td>4.5</td>
</tr>
<tr>
<td>1970</td>
<td>3.5</td>
<td>4.0</td>
<td>4.0</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Only one supply point changed market allegiance as a result of the differentiation of rate costs. This was a property on the Gulf of Carpentaria that produced seventy head which were diverted to Katherine from Queensland by the 1957 to 1966 road improvements. This confirms that the pattern of final demand is the main determinant of supply area boundaries in the study industry and suggests that road improvement projects will have little effect on the pattern of allocation.

The total cost of transporting the 1966 fatstock turn-off to meatworks and railheads under the three sets of rate assumptions varied as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1957</td>
<td>$917,000</td>
</tr>
<tr>
<td>1966</td>
<td>$891,000</td>
</tr>
<tr>
<td>1970</td>
<td>$873,000</td>
</tr>
</tbody>
</table>

The savings represent gains in the situation rents of the producers in the industry. It is noteworthy that the total saving between 1957 and 1970 is rather less than the gains that could have been made in 1966 if producers had adhered to the optimal pattern (approximately $44,000 as against $46,500). Thus the elasticity effects of the Beef Roads Programme are likely to be small if the evaluation is made in a unimodal context and deterioration savings are not of major importance. Though the Transportation Problem is
little more than a convenient way of calculating total costs in this case, it is possible to visualise a situation where linear programming could be used to determine the most efficient distribution of road expenditure. Such a scheme has been proposed by Quandt in which the arcs or segments of the network are specified in the matrix and the objective function is to minimise both construction costs and total transport costs.\(^1\) The marginal value products on arc-capacity would provide a guide to the benefits of upgrading particular routes. At present there are difficulties in making this model operational and it has the obvious fault of dealing solely with existing and diverted traffic. Where generated benefits are thought to be particularly important the method would have to be linked to an activity analysis approach.

In summary, it can be seen that the concept of spatial equilibrium lies at the basis of many of the observations that are made on the relationship between investment in transport and the stimulation of economic activity. Models that have much in common with the Isolated State may eventually provide the best way of dealing with the complexity of the total impact of schemes on user and non-user industries, production and consumption, and the role of the various segments of a network. Some of the problems that would be met in such an approach are evident from the discussion of the impact of the adoption of road transport and the provision of upgraded roads in the study industry. Here the evidence suggests that the link between variations in net received prices and the intensity of land-use is weak. Furthermore, many of the benefits of the change of mode arise as external economies so that the estimation of response in terms of the pre-adoption production function would not have much meaning. In the face of these difficulties it has been found necessary to employ

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conventional accounting techniques, including benefit-cost analysis, to pursue the theme of the relationship between the transportation component of accessibility and pastoral land development. The following section is devoted to a discussion of some of the theoretical issues which arise in their use.

2. Rents and benefits

The use of benefit-cost analysis in the evaluation of investment in improved transportation is widespread and the theory of highway benefits has developed with special reference to urban and freeway projects. Here the general approach appears to be based on the premise that it is best to identify and value the most obvious benefits first. This is usually done by observing traffic flows on the network segments that are upgraded. It is useful to distinguish five types of traffic: (i) the existing (pre-improvement) flow; (ii) diverted movements (those that arise from substitution between different parts of the network or changes in mode); (iii) suppressed traffic (latent trips that were impossible on the existing facility); (iv) dormant flow (movements that are generated as a direct result of the improvement, but which occur in the long-run following a reallocation of resources); and (v) normal growth (trips that will arise in the future from the general expansion of the economy regardless of the state of the facility). The most obvious benefits are those that arise as a result of savings in vehicle operating costs and route maintenance, and the reduction of losses from the deterioration of goods in transit. The value of the change may easily be estimated for existing and diverted traffic by comparing the new cost levels against the old. However, it is frequently argued that the full difference between costs in the case of suppressed and dormant flows gives an over-estimate of net benefits to these forms of traffic since they would not have materialised without the reduction. This has led to the application of rules-of-thumb such as the one suggested by Adler:
In the many situations where the available data do not permit a judgement on the relationship between the degree of transport cost reduction and the volume of generated traffic, perhaps the most reasonable assumption is that this traffic would have developed in proportion to the reduction in transport costs; if so, it would be appropriate to apply approximately one-half of the unit cost reductions to this traffic.\(^1\)

This methodology assumes that the main benefits of a road improvement accrue to users, and that so-called 'secondary benefits' from the stimulation of the production and consumption of the products of transport-using industries must be taken into account under a separate heading. Highway users in this context are vehicle operators so that the degree to which elasticity and mobility effects are transferred to commodity buyers and sellers will depend upon the efficiency and rate policies of hauliers and other transport suppliers. The presence of an intermediate industry between the producers of an agricultural good and the market introduces a complication that was absent in the Isolated State where farmers used their own transport to dispose of their crops. If the main benefits are transferred they will be reflected in increases in the net income of producers. Ignoring the advantages that may be gained by consumers, a scheme can be drawn up which relates changes in economic rents to stages in the build-up of traffic:

<table>
<thead>
<tr>
<th>Incremental traffic benefit</th>
<th>Stage of user enterprise response in net income</th>
<th>Type of shift in economic rent</th>
</tr>
</thead>
<tbody>
<tr>
<td>existing</td>
<td>Immediate</td>
<td>Situation</td>
</tr>
<tr>
<td>diverted</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>suppressed</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>dormant</td>
<td>Attainable</td>
<td>Intensity</td>
</tr>
</tbody>
</table>

This gives an inclusive framework for the enumeration of the total net benefits of an improvement.

The theory of urban highway benefits recognises that movements in property rents mirror reductions in the cost of transportation. As Mohring comments,

Increases in land value are not in themselves 'net' highway benefits, however. Rather, they reflect an actual or potential transfer of benefits from highways from one population group to another.¹

These are immediate responses in situation rents. Economic activity will not be generated in this case because residential land is non-productive. Where, however, the location has value for an agricultural or industrial enterprise, and the improvement raises commodity receipts, adjustments may be expected in the scale of production and development will be triggered. An additional impetus will be given if the increase in mobility allows a flow of suppressed traffic. Finally, resources will be used more effectively and the enterprise will adapt to new marketing opportunities and higher net received prices. At this attainable stage the change in production will be evident in a shift in the intensity rent of the user-firm and the commencement of dormant flows. Hence there is no need to treat the categories of incremental benefits in different ways, or to distinguish the stimulation of economic activity as a secondary benefit. The total impact of an improvement in transport on a user-industry will be reflected in changes in economic rents.

One important point must be raised here concerning the ability of an improvement in transport to trigger the use of additional resources. An increase in the intensity rent of an enterprise depends upon the cost and availability of factors of production, and it seems illogical to impute gains solely to the transport investment. Considering this problem, Mohring and Harwitz conclude that the whole of the rise in the value of production may only be attributed to the improvement if:

part or all of the induced investment in the industry would not have taken place in the absence of the change in the supply of transport;

the investment in question does not result in a reduction in the level of economic activity elsewhere in the economy;

it uses resources that would otherwise have been partly or totally unemployed. \(^1\)

If these qualifications are met the net value of the increase would have to be apportioned between the transport investment and the value of the resources brought into use. Where normal growth occurs in the industry which is not influenced by the state of transportation this must be excluded. In reality, production response may be influenced simultaneously by a rise in market prices and a reduction in the cost of consignment, and it would seem logical to try to separate these causes and value changes in rents on a pro rata basis.

Moving to the consideration of the impact of improvements in transportation on the development of agricultural land, Adler distinguishes three possible relationships between the provision of transportation and economic land development. \(^2\) First, the transport facility may be an integral part of a planned agricultural project in which all investments are made by a government agency. Second, the supply of transportation may be one of a series of infrastructural needs that are provided by the agency to stimulate the investment of private capital in an industry or region. Third, there may be situations in which all other developmental resources are available and transport is the only factor that is lacking. In the first two cases the investment in the new facility must be evaluated concurrently with the cost of the additional inputs that

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1 Mohring, H., and Harwitz, M., 1962, p.43.
are required to produce the new level of production; only in the last case would it be legitimate to ascribe the development solely to the transport improvement. In practice projects of the third type appear to be rare though the immediate external economies that might accrue to the study industry following the adoption of road transport could be taken as an example. However, where long-term changes in factor usage are expected it is erroneous to consider transport as the only causative agent. Adler points out that...

...if the economic development can be achieved only if the transport improvement is supplemented by other investments, extension service to farmers, land reform, etc., then these other measures become an essential condition of the project. This ... has been recognised in the field of irrigation, but unfortunately not yet fully in transport.

Where the objective of the project is to calculate the net benefit of an improvement to a regional economy, the best function for calculating the ratio of benefits to costs may be the following formula which values additional net benefits against additional capital costs at present value:

\[
\frac{B}{C} = \sum_{t=1}^{n} \left( \frac{1 + d}{d} \right)^{-t} (E_{ta} - E_{tb} - E_{tc} + E_{td} - E_{te})
\]

\[
\sum_{t=1}^{n} \left( \frac{1 + d}{d} \right)^{-t} (E_{tf} + E_{tg} - E_{th})
\]

Each estimated item of income or cost is represented by the term \(E_{tz}\) where \(t\) denotes the year of occurrence and \(z\) stands for the item measured. The function \((1 + d)^{-t}\) represents the coefficient of present value at the discount rate \(d\). The items taken into account are:

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$E_{t_a} =$ gross farmgate receipts with the project;

$E_{t_b} =$ total farm operating costs with the project;

$E_{t_c} =$ gross farmgate receipts without the project;

$E_{t_d} =$ total farm operating costs without the project;

$E_{t_e} =$ total maintenance costs on the transportation improvement;

$E_{t_f} =$ total increase in the capital cost of production with the project;

$E_{t_g} =$ total capital cost of the transportation improvement;

$E_{t_h} =$ total increase in the capital costs of production without the project.

The net value of the increase in economic rent to producers will depend on the extent to which the investment agency is able to recoup its spending on the capital and maintenance costs of the improvement. In most cases the government is the agent and the provision of the facility is rarely priced; hence it becomes possible that the investment involves some transference of resources to the affected industry.

Certain other problems also arise in the valuation of the increase in production. First, it may be argued that where the additional output is exported some account should be taken of the gain in foreign exchange. The benefit to the national economy from an increase in the trade of a product will depend on the elasticity of demand for the commodity. Since the precise effect, according to Gwilliam, will be conditioned by 'a host of political imponderables', it seems valid to restrict the evaluation to efficiency costs and benefits that accrue internally. Second, the aim of the project may be the redistribution of income to a particular industry, region, or class. In this case the benefit-cost ratio will not incorporate the value of these

---

social objectives. The best method of dealing with this problem seems to be to determine a trade-off rate between the efficiency benefits and social benefits after the completion of the initial analysis. ¹ Third, the objection can be raised that the factor prices used in the measurement of the capital and operating costs of producers may be determined by government policy decisions that are not based on efficiency criteria. For instance, when a nation erects discriminatory tariffs against manufactured goods the price of agricultural inputs is raised and this will influence the profitability of operations. ² Here the counter argument can be used that all current decisions are bound to be conditioned by past policies and that efficiency is a relative term.

Finally, all benefits and costs must be related to the life of the project and the degree of risk involved in the development. Most commentators suggest that the discount rate should be set with reference to the social opportunity cost of capital. Prest and Turvey recommend the 4 to 8 per cent range as offering a stable basis for analyses. ³ The research staff of the United Nations advise rates up to 20 per cent for transportation projects in underdeveloped countries and fix on the 6 to 8 per cent band for proposals in highly-developed economies. ⁴ In many

² Note: This and related points are discussed by Mackay, F.K., 'Economic Analysis of Development Projects: some practical issues', unpublished paper given at the 41st Congress of the ANZAAS, 1969, pp.5-7.
Australian studies of public investment in agriculture and transportation the low rate of 5½ per cent has been used to take account of national development goals. In the benefit-cost analyses that are given in Chapter 7 this rate has been used for comparability, and may be regarded as consisting of 5 per cent: the 1967 Commonwealth Bond Rate, plus ½ per cent allowance for risk. It is employed to evaluate both public and private investment and, since it is well below the current bond and overdraft rates, the assessments present a generous view of the efficacy of resource allocation. Variable discount rates are often used to suggest the ways in which uncertainty may influence outcomes, but it has been found preferable in this study to offer optimistic and pessimistic sets of input data and retain the same value, since this emphasises the cause of fluctuations in the benefit-cost ratio.

In summary, it can be seen that the deductions that were made on the origin and distribution of benefits from an improvement in transportation within the Isolated State model can be recast in terms of formal benefit-cost analysis. This helps to clarify many of the issues which arise in the identification and enumeration of developmental effects. Given the problem of separating the relative contribution of highway investment and the deployment of additional resources on farms, it seems best to consider the impact of a rural road project in terms of an integrated scheme involving public and private capital. Certain other valuation problems have also been raised and it has been suggested that efficiency criteria based on actual prices received and paid, and the opportunity cost of capital offer the most logical constraints for a regional analysis. Having developed this framework the discussion can proceed

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1 See for example, Economics of Land Development - Belyando-Sutton Rivers Region, Queensland, BAE, Canberra, 1968, and, Report on the Economics of Upgrading the Birdsville Track, South Australian Highways and Local Government Department, 1967.
to a consideration of the particular problems met in the study industry.

B. ROAD INVESTMENT, ROAD QUALITY, AND ROAD USE IN THE NORTHERN TERRITORY

1. The assumptions and objectives of road investment to assist the beef industry up to 1961

The first serious proposal to use road transport to solve some of the marketing and movement problems of beef producers in the Northern Territory was put forward in 1933. In that year a group of pastoralists holding leases on the Barkly Tableland submitted what became known as the Vanderlin Island Scheme for consideration by the Commonwealth Government. It asked for a loan of $2 million to construct a meatworks and port facilities on the island and a 150-mile all-weather gravel road from Walhollow (on the edge of the Barkly Tableland) to Borroloola at the mouth of the McArthur River. Transportation was to have been provided by diesel tractors, each with a capacity of 12 to 15 tons, from the Walhollow depot to the coast. This scheme is particularly interesting in the light of post-war developments because it envisaged an integrated approach to transport and marketing and resulted from the initiative of lessees. The Government refused to advance the loan on the grounds that it would have had no control over the investment and that the properties were generally run at a loss. As will be seen in the description of subsequent proposals by the Government, the issues raised on the pricing and control of capital investment in roads for the benefit of the beef industry have since been viewed in an entirely different manner.

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1 This proposal is described in the Report of the Board of Inquiry into the Land and Land Industries of the Northern Territory of Australia (The Payne-Fletcher Report), Canberra, 1937, pp.33-8.
In the period from 1945 to 1949 two rail construction programmes were considered by the Government, which were based on the premise that the provision of inter-regional links, as part of a trans-continental plan, would stimulate the development of regional specialisation in the beef industry and an overall increase in the value of production. The Clapp Report recommended a line from Larrimah to Dajarra partly for purpose of national defence and this proposal received the support of the Northern Australia Commission and the Australian Meat Board.\(^1\) According to Kelly the main portion of the railway (from Dajarra to Newcastle Waters) would have cost approximately $22 million at 1945 price levels (track and structures alone), and might have generated annual stock movements of 210,000 head in the long-run.\(^2\) The second scheme was proposed by the Queensland Bureau of Investigation in 1947, following a similar recommendation in the Clapp Report, and envisaged the construction of a line between Boulia and Quilpie via Windorah and Monkira.\(^3\) The Bureau estimated that the properties of the Channel Country could fatten from 85,000 to 425,000 head each year, depending upon flood conditions, with a long-term average of 170,000. It was suggested that 70 per cent of the store stock requirements would have been drawn from the Northern Territory and the northwest of Queensland. Clearly both schemes were interdependent.

Although Kelly was careful to point out that the realisation of increased production in the Northern Territory of the necessary scale would require a range of land tenure and on-property improvement measures, these were not incorporated in the plans.\(^4\) Furthermore, no

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account was taken of the difficulties that producers would have faced in adjusting their output to highly variable demands for store cattle. The main reasons given for the abandonment of these proposals were their high capital cost and the 'shortage of steel and other essential materials in the post-war reconstruction period.' As a substitute for these rail extension plans finance was made available to Queensland and Western Australia for the construction of roads under the States Grants (Encouragement of Meat Production) Act 1949. The strategy of this programme seems to have been to extend the use of existing rail and meatworks investment, rather than to promote a large-scale increase in inter-regional trade. The grant to Western Australia was used to upgrade the road from Wyndham to Nicholson in the hope that this would stimulate the use of road transport, and the feeder roads from the Victoria River District to this route (from Wave Hill and Timber Creek to the border) also received attention. As far as is known the roads were never used and by 1955 all government reports had ceased to mention the scheme. Considering the problems met in the Alice Springs District during the innovation phase it is surprising that any hope was held that the roads to Wyndham would solve the transportation difficulties of local pastoralists, particularly since prices at this market were poor.

In 1952 money was made available for four 'developmental roads' in the Northern Territory as a back-up investment to the Australian-United Kingdom Meat Agreement. The major justification for this expenditure was that better quality road surfaces would promote the inflow of materials for property improvement, particularly on new subdivisions. The routes chosen were

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Tobermorey to Jervois Range,
Napperby to Mt Doreen,
Rockhampton Downs to the Barkly Highway,
Katherine to Timber Creek (Victoria River Depot).

The cost of this scheme was not made public and it is difficult to judge whether it had any effect on investment in the industry. A second developmental or 'pastoral' roads programme began in 1957 and ten roads received attention under this plan up to 1964. The timing of works on these projects is given by regions in Table 6.1. Annual expenditure on construction averaged $475,000 between 1957 and 1964, and over the same period approximately $200,000 per year was spent on the maintenance of these roads.

The location of the routes selected under the second programme, as shown on Map 6.1, is evidence that priorities were perceived in terms of the local needs of producers in the Northern Territory and little thought seems to have been given to possible benefits from regional specialisation. The pattern of expenditure foreshadows that of later programmes in that special attention was given to the roads of the Victoria River District. A marked feature of the scheme was the absence of investment in the Barkly Tableland District despite the fact that the transportation of fat-stock to Queensland by road from properties on the Tableland had become well established by 1961 (for instance, over 11,000 head were moved by road in the 1960 season.) In general, though, the programme seems to have been based on the sensible objectives of encouraging the adoption of road

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1 Eight other roads were upgraded under this programme between 1951 and 1953. All of these roads improved the access of individual stations to existing higher quality secondary routes. The programme is detailed in the Annual Report of the Australian Meat Board, No. 18, Sydney, 1953.


3 Unpublished Quarterly Returns of Stock Movements supplied to the Commonwealth Statistician by the NTAAIB.
Map 6.1: The location and standards of road investment projects in the Northern Territory, up to June 1968.

Sources: see text.
<table>
<thead>
<tr>
<th>District</th>
<th>Route location</th>
<th>Timing of work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alice Springs</td>
<td>(i) Alice Springs - South Australian Border</td>
<td>1958-61</td>
</tr>
<tr>
<td></td>
<td>(ii) Stuart Highway - Plenty River</td>
<td>1960-61</td>
</tr>
<tr>
<td></td>
<td>(iii) Stuart Highway - Mt Doreen</td>
<td>1960-61</td>
</tr>
<tr>
<td>Barkly Tableland</td>
<td></td>
<td>No expenditure</td>
</tr>
<tr>
<td>Victoria River</td>
<td>(iv) Timber Creek - Western Australian</td>
<td>1957-60</td>
</tr>
<tr>
<td></td>
<td>Border</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(v) Katherine - Timber Creek</td>
<td>1959-61</td>
</tr>
<tr>
<td></td>
<td>(vi) Willeroo - Top Springs</td>
<td>1959-61</td>
</tr>
<tr>
<td></td>
<td>(vii) Top Springs - Timber Creek</td>
<td>1959-61</td>
</tr>
<tr>
<td></td>
<td>(viii) Stuart Highway - Top Springs</td>
<td>1961</td>
</tr>
<tr>
<td>Darwin and Gulf</td>
<td>(ix) Stuart Highway - Daly River</td>
<td>1959-61</td>
</tr>
<tr>
<td></td>
<td>(x) Stuart Highway - Borroloola</td>
<td>1959-61</td>
</tr>
</tbody>
</table>

Source: Northern Territory: reports.

transport in the Alice Springs District and providing the infrastructural investment for potential use in the two northern regions where marketing problems were particularly acute. The standards used in construction were a fairly high order with graded earth or gravel surfaces and culverts.
and causeways over stream crossings. In fact, since the first projects under the Beef Roads Programme were not completed until 1965, it can be argued that the pastoral road scheme provided the basis for the general adoption of the use of road haulage. It may also be noted that no extravagant claims were made for the developmental benefits of the projects and special financial arrangements were not found necessary.

2. The Beef Roads Programme

The period from 1949 to 1960 was marked by a growing awareness on the part of the Government that road transport offered the possibility of an adequate solution to the transport difficulties of the beef industry in northern Australia. As has been documented above, this led to the introduction of three road programmes which were primarily designed to meet local needs and to reinforce the utility of existing investment in meatworks, and highway and rail facilities. However, a complete re-evaluation of opportunities was undertaken in 1960 and 1961 in response to the need to stimulate export earnings following a recession in the national economy. At this time the trade in boner-type beef to the United States was expanding and there was a widespread belief that the expansion of the beef industry presented the best means of overcoming the nation's balance of payments difficulties. In 1961 the Commonwealth Government announced a commitment to provide infra-structural investment in transport for the beef, coal, and steel industries. The criteria used in the choice of these projects were:

(i) that transport facilities constituted broken links in the chain of processes leading to the production of an exportable product, and

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1 See for example, Clark, C., 'Economic Growth', Chapter 1 in Economic Growth in Australia, ed. Wilkes, J., Australian Institute of Political Science, Sydney, 1962, pp.21-5.
(ii) that the investment of private capital in the industries chosen was closely tied to large-scale public expenditure, and that the amounts of capital required were beyond the resources of the industries and States concerned.\(^1\)

In June 1962 the Northern Territory Administration announced that five roads had been nominated as 'beef roads', following grants from the Commonwealth which matched the provisions of the Queensland and Western Australian *Beef Cattle Roads Acts 1961*.\(^2\) The planning strategy of the whole of the programme for northern Australia revived in some measure the concepts that had been put forward in support of the trans-continental railway scheme. Its major assumption was that the increased use of road transport would lead to the growth of inter-regional trade, and in particular to the expansion of store movements from the Northern Territory to the Queensland Channel Country.\(^3\) The roads initially selected for upgrading in the Northern Territory were:

1. Dunmarra to the Western Australian border via Top Springs, and Timber Creek,
2. Top Springs to Wave Hill,
3. Barkly Highway to Anthony Lagoon,
4. Stuart Highway to Yuendumu via Mt Doreen,
5. Stuart Highway to Plenty River.

The first two proposals were designed to ease the movement of store stock from the Victoria River District to the Barkly Tableland and Queensland by linking the region to the Stuart and Barkly Highway (see Map 6.1). The third was planned to provide egress from the Barkly Tableland to the Channel Country and the Mt Isa railhead. The last two proposals were arterial roads to serve producers to the

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\(^3\) Patterson, R.A., 1961, p.164.
west and east of the Alice Springs rail terminal. Some of the locational problems associated with this programme in the three northern districts will be considered in Chapter 7.

As has been suggested, the plan for northern Australia was based on the assumption that regional specialisation would stimulate increases in turn-off of an order that could be compared to the predictions of the proponents of the post-war railway schemes. By 1962 the comparison of possible freight rates under the two modes showed clearly in favour of road transport. Patterson estimated that an actual cattle traffic component of 550,000 head per year would have been required to reduce charges to 2.5 cents per beast-mile on a railway from Dajarra to Anthony Lagoon. This can be compared with current charges by road hauliers of 3.0 to 3.5 cents per beast-mile for large-scale lifts from the Barkly Tableland, for a property to destination service.

In 1963 the objectives of the road proposals for the Victoria River District were undermined by the opening of the Katherine and Darwin meatworks. Since the operations of these plants were based on the exploitation of the stock reserves of the Victoria River District and the Darwin-Gulf Region for the trade in boner-quality meat to the United States the expansion of the traffic in store cattle to Queensland posed a direct threat to their viability. Following a recognition that the road programme should be reorientated to Katherine, the route from Willeroo to that centre replaced the Top Springs to Dunmarra road as the main arterial link from the Victoria River District to the Stuart Highway, with feeders from Wave Hill and Timber Creek. More recently roads have been commenced to link properties in the Roper Bar and central Gulf Country areas to the highway. In addition the latter route also provided

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access to the mouth of the McArthur River, where the exploitation of local deposits of lead and zinc in the future may create a suitable location for a meat processing plant through the provision of town and port facilities. The final road that must be considered in this brief inventory is the link from Anthony Lagoon to Borrolpola which has the same long-term objectives and also provides egress from the Gulf to Queensland and an alternative route for movements from the Barkly Tableland to Katherine. The locations of these roads are shown on Map 6.1 and details of costs and standards are given in Table 6.2. Two points may be noted. First, the break in policy in 1963 is evident in the staging of works and the change of standards. Second, the scale of spending on the Programme is far above that of the earlier schemes with a total commitment of around $30 million. Of this, just under half has been allocated to roads in the Victoria River District.

3. Road quality and road use.

The level of benefits that can be attributed to a rural road investment will depend upon whether it is a necessary condition for the adoption of road transport. In the study industry a change from consignment by droving to the use of road haulage allows producers to reap a number of important external economies. These have been discussed in Chapter 5 and involve increases in the flexibility of marketing, through the widening of both the range of output and the opportunity of choosing the time and place of sales. It is therefore important to consider the relationship between road standards and road usage to assess whether these developmental benefits can be attributed to the Beef Roads Programme. The re-appraisal of construction standards after 1963 was also based on a belief that sealed roads could be justified by savings in road maintenance costs and the reduction of deterioration losses on cattle in transit. The following section will consider these questions to provide a datum for the sub-regional studies of long-run response in Chapter 7.
Table 6.2: Details of projects authorised under the Northern Territory Beef Roads Programme

<table>
<thead>
<tr>
<th>Location of project</th>
<th>District</th>
<th>Mileage</th>
<th>Standard</th>
<th>Authorised cost ($m)</th>
<th>Submission date</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Stuart Highway - Plenty River</td>
<td>Alice Springs</td>
<td>138</td>
<td>Gravel</td>
<td>0.61</td>
<td>1962</td>
</tr>
<tr>
<td>(2) Stuart Highway - Yuendumu</td>
<td>Alice Springs</td>
<td>168</td>
<td>Gravel</td>
<td>0.61</td>
<td>1962</td>
</tr>
<tr>
<td>(3) Barkly Highway - Anthony Lagoon</td>
<td>Barkly Tableland</td>
<td>140</td>
<td>Gravel</td>
<td>1.54</td>
<td>1962</td>
</tr>
<tr>
<td>(4) Dunmarra - Top Springs</td>
<td>Victoria River</td>
<td>106</td>
<td>Gravel</td>
<td></td>
<td>1962</td>
</tr>
<tr>
<td>(5) Top Springs - Timber Creek</td>
<td>Victoria River</td>
<td>148</td>
<td>Gravel</td>
<td>5.04</td>
<td>1962</td>
</tr>
<tr>
<td>(6) Timber Creek - Western Australian border</td>
<td>Victoria River</td>
<td>110</td>
<td>Gravel</td>
<td></td>
<td>1962</td>
</tr>
<tr>
<td>(7) Top Springs - Wave Hill</td>
<td>Victoria River</td>
<td>100</td>
<td>Sealed</td>
<td>2.70</td>
<td>1964</td>
</tr>
<tr>
<td>(8) Katherine - Willero</td>
<td>Victoria River</td>
<td>80</td>
<td>Sealed</td>
<td>3.30</td>
<td>1964</td>
</tr>
<tr>
<td>(9) Willero - Top Springs</td>
<td>Victoria River</td>
<td>100</td>
<td>Sealed</td>
<td></td>
<td>1962</td>
</tr>
<tr>
<td>(10) Barkly Highway - Anthony Lagoon</td>
<td>Barkly Tableland</td>
<td>140</td>
<td>Sealed</td>
<td>1.25</td>
<td>1967</td>
</tr>
<tr>
<td>(11) Anthony Lagoon - Borroloola</td>
<td>Darwin and Gulf</td>
<td>162</td>
<td>Sealed</td>
<td>5.20</td>
<td>1967</td>
</tr>
<tr>
<td>(12) Daly Waters - Cape Crawford</td>
<td>Darwin and Gulf</td>
<td>167</td>
<td>Sealed</td>
<td>3.40</td>
<td>1967</td>
</tr>
<tr>
<td>(13) Willero - Timber Creek</td>
<td>Victoria River</td>
<td>98</td>
<td>Sealed</td>
<td>3.35</td>
<td>1968</td>
</tr>
<tr>
<td>(14) Nataranka - Roper Bar</td>
<td>Darwin and Gulf</td>
<td>108</td>
<td>Sealed</td>
<td>3.00</td>
<td>1968</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>1,765</td>
<td></td>
<td>30.00</td>
<td></td>
</tr>
</tbody>
</table>

The 1959 BAE report on the economics of road transport of beef cattle in the Northern Territory distinguished four types of road surface.

(i) Class A roads: All-weather except for flood periods. Clearing 40 feet wide, formation 26 feet wide, pavement 18 feet wide within 12 feet bitumen strip in centre, low level bridges and concrete causeways.

(ii) Class B roads: Near all-weather roads, clearing 40 feet wide, formation 26 feet wide, pavement 18 feet wide, gravelled or stabilised throughout, with low level bridges and concrete causeways.

(iii) Class C roads: Dry weather roads, clearing 40 feet wide, formation 26 feet wide, gravelled in weak spots as necessary. Stone and gravel stream bed crossings, with graded approaches.

(iv) Graded earth tracks: Dry weather tracks with an average width of 18 feet.

The report considered that the minimum standard for regular usage was Class C, though the importance of a good surface varies with the terrain and rainfall of the area traversed. In the Alice Springs District many trips in the early stages of adoption were on graded tracks which were only 12 feet wide, and the risk of the bogging of vehicles in the main turn-off season is relatively slight: Class C roads were thus judged adequate for most routes. In 1959 the four unsealed major arterials that converged on Alice Springs were judged to be of this standard and the Stuart Highway to Plenty River road was in the process of being upgraded to Class B. These works were financed under the 'pastoral roads' programme.

The black soils of the Barkly Tableland make good dry-weather roads when the surface is formed and rolled and left to settle. However, such tracks rapidly become

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Information given in this section on the state of the road network in 1959 is derived from The Economics of Road Transport of Beef Cattle, Northern Territory and Queensland Channel Country, BAE, Canberra, 1959.
impassable after rain and the report supported the upgrading of major routes to Class C and suggested that a Class B road might be provided from Soudan to Rankin Dip along the line of the Barkly stock-route. In the remaining two districts the roads were classified as 'little better than tracks', with the exception of the route from Katherine to Willeroo which had been formed to Class C. This standard was taken as the minimum in the Victoria River and Darwin-Gulf Districts; and Class B roads were thought desirable in many cases due to the relatively high probability of substantial falls of rain in March and November. The report predicted that pastoralists would be prepared to walk cattle up to 100 miles to a central loading facility on a good quality road. As has been seen in Chapter 5, the diffusion of the use of road transport from 1960 was extremely rapid, and both hauliers and graziers favoured origin to destination trips. Many of these included some very poor stretches of surfacing on which cattle and vehicles were put at risk, but by 1962 expenditure under the Pastoral Roads Programme had provided a basic network of roads which were Class C or better.

The first part of the Beef Roads Programme provided for gravel surfaces and formations of Class B standard. This represented a rise in construction costs from $7,000 per mile (1959) to $14,500 per mile (1962)\(^1\) for roads in the Victoria River and Darwin-Gulf Districts. Following the re-assessment of the Programme in 1963, the decision was taken to recommend the bitumen sealing of all subsequent proposals to bring them up to Class A standard. Current (1970) construction costs vary between $14,000 to $17,000 for formed gravel Beef Roads, and $20,000 to $25,000 for sealed Class A roads.\(^2\) If the 855 miles designated for sealing had been constructed to Class B standard, at an average cost of $15,500 per mile, approximately $9 million

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\(^1\) For example, $5,040,000 was allocated for the 364 miles from Dunmarra to the Western Australian border (see Table 6.2).

\(^2\) Interview, Department of National Development, Canberra, February 1970.
would have been saved, which would have allowed the up-grading of a further 580 miles of the network. Since road transport was being used for over 80 per cent of consignments in 1966, when the first sealed Beef Road (from Katherine to Willeroo) was opened, it is clear that this quality of surface is not a necessary condition for adoption and continued use.

The main justification for sealing was the claim that lower maintenance costs on sealed roads would cover the additional capital costs. If gravel roads are re-sheeted every five years, the current annual cost of upkeep varies from $600 to $1,000 per mile. The latter figure represents an extreme in which the route is heavily used and is built in a high rainfall area where gravel supplies are absent locally. Bitumen roads must be resealed at intervals of eight years at a cost of $4,000 per mile, and shoulder maintenance costs $300 per mile per year, giving a total annual cost of $800 per mile. Thus, on average, costs are equal for the two standards. The level of use is a critical consideration in determining standards, and flows in the Northern Territory may be compared to the guidelines used elsewhere. The United Nations' Introduction to Transport Planning suggests that the additional cost of sealing roads will be repaid when annual average daily usage exceeds 125 traffic equivalents (125 trucks or approximately 200 cars), while Australian experience puts the break-even point on maintenance costs alone at 55 vehicles per day. The evidence provided by the sporadic traffic counts made by the Department of Works in the Northern Territory show that daily flows on upgraded routes rarely exceed 40 vehicles per day even in the Dry Season, and it must be remembered that the transportation of 20,000 head (the maximum movement over any one road) could be undertaken with just over 300 road train trips.


Turning to the possibility of savings on vehicle operating costs, it may be noted that the major haulier located at Katherine estimated that if all trips were over sealed surfaces his variable vehicle costs would be cut by between one-third and one-half. It is not possible to calculate with any certainty the difference that this would make to total costs, but a large proportion of his operations were on dirt tracks of a much inferior standard to the gravelled beef roads. The reports made by Allen and Moulden conclude that the major determinants of costs in the haulage of beef cattle are the capacity of vehicles and the number of loaded miles travelled during the turn-off season. Some concept of the value of savings can be gained from a comparison of rate structures for movements over bitumen and all other forms of roads. During fieldwork in 1968 fifteen hauliers were asked to supply rates for trips over and under 100 loaded miles, and the results are given in Table 6.3. The comparison shows that station owners located on sealed roads would gain an average of 10 cents per K-mile from lower-freight charges; this is equivalent to 0.5 cents per beast-mile for movements of fatstock. In judging these rates account should be taken of the tendency for hauliers to equalise charges so that the full value of savings on better surfaces may not be transferred to consignors. Equally, though, it could be argued that the pavement, formation, and grades of the gravel surfaced beef roads would lead to very insignificant extra costs and that these standards should not be included in the general category of non-bitumen roads which covers a wide range of types.

The importance of losses from the deterioration of stock on roads of different standards is almost impossible to judge since these will also depend on the skill of

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1 Field interview, July 1967.

2 See, for example, The Economics of Road Transport of Beef Cattle, Northern Territory and Queensland Channel Country, Canberra, 1959, and Road Transport of Beef Cattle in Queensland, Beef Research Report No.1, BAE, Canberra, 1965.
Table 6.3: Rate cost quotations for the haulage of Northern Territory cattle, 1967

(cents/K-mile)

<table>
<thead>
<tr>
<th>Operators</th>
<th>Northern Districts</th>
<th>Alice Springs</th>
<th>Queensland</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4</td>
<td>1 2 3 4 5 6 7</td>
<td>8 9 1 2</td>
</tr>
<tr>
<td>Dirt roads</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>under 100 miles</td>
<td>80 80 80 70</td>
<td>90 90 85 90</td>
<td>85 90 85 90</td>
</tr>
<tr>
<td></td>
<td>70 70</td>
<td>80 70 80 70</td>
<td>85 85 90</td>
</tr>
<tr>
<td></td>
<td>80 70 70 70</td>
<td>70 70 75 80</td>
<td>75 70 60</td>
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<tr>
<td></td>
<td>60 60</td>
<td>80 70 70 70</td>
<td>75 70 60</td>
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<td>75 70 60</td>
</tr>
<tr>
<td></td>
<td>60 60</td>
<td>60 60 60</td>
<td>75 70 60</td>
</tr>
</tbody>
</table>

Source: Field interviews, 1967. Three of these operators were based at Katherine, and one at Darwin.

drivers, the length of the trip, and the climatic conditions encountered. According to Condon, losses of cattle moving to Katherine in 1964 averaged 2.7 per cent,1 and a proportion of these animals would have been saved if they had been transported over sealed surfaces. Deaths are occasioned by hornning, trampling, and suffocation, which occurs on movements over stretches of bull dust (fine dust that is created on unformed roads). A further 2 per cent of the saleable meat from carcases (i.e. about 10 lb per beast) were lost because of bruising. Comparisons with nation-wide estimates for 1952-53, which exclude cattle transported by road, suggest that half of this loss may be attributed to the mode.2 The remaining losses would be due

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1 Minutes of evidence relating to the proposed construction of the Top Springs to Wave Hill Road, Northern Territory, Parliament of the Commonwealth of Australia, Canberra, 1965, pp.21-9.
to the poor condition of stock and bad handling. A reasonable guess at the influence of road quality would be that Class B roads prevent one quarter of the total loss, in comparison to graded tracks, and rather less in comparison to Class C formations. There is no evidence to suggest that movements over sealed surfaces have a notably lower rate of bruising than those on Class B routes and, since both surfaces are near all-weather the risk of hold-ups is much the same. In fact, cattle transported over the Yuendumu and Plenty River gravelled roads are amongst the highest in quality that are produced in the Northern Territory.

Since the main concern of this thesis is with pastoral land development the emphasis in the empirical work that follows is placed on the benefits that accrue to producers. Benefits also arise from the upgrading of road surfaces through the reduction of the transport difficulties of mining companies, tourists, and administrators. From bitter field experience it is recognised that personal mobility is also inhibited by poor roads, and there may be significant benefits from the provision of better access in the form of a reduction in labour turn-over. Since the peopling of northern Australia is a national aim this could give rise to gains which cannot be evaluated in strict efficiency terms. A further benefit may be gained from the prevention of accidents, though a confrontation with a fleet of road trains driven by over-worked drivers is a harrowing experience on any surface. However, all the efficiency gains that could arise from these sources should be reflected in the level of daily traffic and, as the evidence suggests that usage is relatively small, these savings would be unlikely to affect the results of benefit-cost analyses based on the advantages to the beef industry. All in all, it seems difficult to appreciate the reasons for sealing roads in preference to extending the mileage of Class B surfacing. In this respect the Beef Roads Programme may reflect the truth of Owen's observation that:
the temptation to overdesign highways is global. Sometimes the error is unconscious... But more commonly the construction of high-type pavements where low-type designs would suffice is a foible that engineers from more developed countries find difficult to suppress.

C. AN ASSESSMENT OF THE IMMEDIATE BENEFITS OF ROAD TRANSPORT USAGE IN 1966

From the discussion given in section A of this chapter, it is apparent that two aspects of the problem of the relationship between improvements in transportation and pastoral land development must be separated in considering the study industry. First, it is necessary to examine the role of road transport in promoting changes in the form and scale of production and, second, the link between road quality and the generation of additional net regional income must be explored. In both cases a distinction must be drawn between immediate effects and those that may follow in the future from the redeployment of resources. The following sections look at the problem of defining the impact of the adoption of road transport in the short-term. This involves the assessment of the value of savings and disbenefits in rate and non-rate costs compared to consignment by droving, and the identification of suppressed traffic. Four major categories of new sales may give rise to external economies; the disposal of culled cattle, the marketing of stock over a longer turn-off season, the sale of cattle from drought affected districts, and specialisation in the production of younger stock. The importance of road transport in extending the flexibility of operations will be examined in each case. Finally, a budget is drawn up which gives an estimate of the additional income gained by producers in the 1966 season from the change of mode.

1 Owen, W., Strategy for Mobility, Washington D.C., 1964, p.137.
1. Rate and non-rate costs on existing movements

a. Rate costs

The rate costs of droving mobs of varying sizes and types to alternative markets in 1959 were given in Table 3.2. Limited evidence is available on changes in charges up to 1966, though two field interviews in 1967 suggested that rates have remained almost static.\(^1\) The drover of a mob of 1,200 stores was paid $4.40 per week for cattle moving from Tallalah Downs to Alice Springs. The stock walked seven miles each day which puts the payment at about 0.75 cents per beast-mile. A contract drover in Camooweal quoted a rate of 0.59 cents per beast-mile for store mobs moving across the Barkly Tableland. These charges are very similar to the 1959 figures although it is impossible to compare the quality of service. It seems almost certain, however, that a widespread return to on-the-hoof movements would result in some increase in rates. Furthermore, the reduction in the average trip distance and the consignment of smaller mobs, following the opening of the two northern meatworks, would have created additional pressure for higher charges. It has therefore been assumed that producers would have paid 1.0 cent per beast-mile for store consignments and 1.5 cents per beast-mile for fatstock in 1966, in the absence of road transport.

The rate costs charged by hauliers in 1967 are given in Table 6.3. The estimation of payments on a per trip basis would be impossible so a charge of 80 cents per K-mile has been adopted for all movements and it is assumed that this will result in per beast-mile payments of 4.0 cents for fats and 3.2 cents for stores.

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1 Field interviews, July and August 1967.
2 The Economics of Road Transport of Beef Cattle - Northern Territory and Queensland Channel Country, BAE, Canberra, 1959, p.13.
b. Non-rate costs

(1) Fats

According to the 1959 BAE survey, average dressed weight losses on cattle moved on the hoof from the Victoria River District were about 60 lb per beast.¹ The same report suggested a loss of 40 lb on trips from the Barkly Tableland to Queensland railheads. A controlled experiment conducted in the late 1950s on a consignment of 200 bullocks from Humbert River to Wyndham put losses at 40 lb per beast on the 28-day trip (about 250 droving miles).² Origin and destination data for 1966 indicate that the average trip distance for fat cattle was about 225 miles, with an upper limit of 500 miles. Although it is possible that some of the longer road transport movements could not have been made under droving, it is difficult to estimate the proportion of income that has been gained from this aspect of modal change. It is assumed, therefore, that any consignments of fats made on the hoof in 1966 would have incurred losses of 60 lb per beast and the value of this meat has been calculated for each supply area at the current price.

The Bureau's survey also found that between one and two per cent of the stock moved on-the-hoof were lost from straying, crippling, and poisoning. A two per cent total loss rate would seem to be a fair estimate on movements in 1966.

The deterioration losses that are caused in transit on road trains depend upon the condition and type of stock moved, as well as the characteristics of the trip. During the 1966 season at the Katherine meatworks 873 of the total of 21,076 cattle received could not be processed.² Of these, 474 were condemned as unsuitable for treatment, 125 were classed as 'downers' (that is beasts which had been severely trampled by other stock), and 274 died in transit or at the

¹ Field interview, June 1968.
² Data supplied by Northern Meat Exporters Pty. Ltd., field interview, June 1967.
meatworks' yards. It is probable that a large proportion of these cattle were scrub bulls that had been trapped in holding yards or knocked down by land-cruisers prior to loading, while others may have been diseased. In these cases it is clear that road transport cannot be blamed for the full loss to producers. In the budget given for the 1966 allocation it has been assumed that one per cent of the cattle dispatched to the northern meatworks were lost as a result of employing this form of movement. This may be a rather high estimate but, in compensation, consignments to the other demand centres are assumed to suffer no fatalities.

According to Condon, the average loss of saleable meat on the cattle processed at Katherine, through bruising, was about two per cent in 1963, though the value of this wastage may be understated at the overall price paid to producers since it prevented the preparation of high quality cuts from the affected animals. In consequence a two per cent estimate has been retained for 1966, despite the fact that handling has improved. Some station operators suggested in 1967 that weight losses through fatigue, exhaustion, and stress could be significant on road transported animals, but these have not been valued in the absence of reliable evidence.

(2) Stores

Losses from store mobs moved on the hoof have been estimated to vary between two and six per cent, according to the length of the trip, availability of feed, and the terrain traversed. Here a figure of three per cent has been adopted for all movements. In addition store cattle may receive a set-back in their growth to maturity from the rigours of a droving trip. Consultation with growers

1 Minutes of evidence relating to the proposed construction of the Top Springs to Wave Hill Road, 1965, p.22.

2 The Economics of Road Transport of Beef Cattle, BAE, 1959, pp.11-17.
suggests that this could cost an average of $5.00 per beast
in extra operating costs and this figure has been used in
the budget.\(^1\) Condition losses of the same type may occur
on long road transport movements, but it has been assumed
that these costs would be negligible over the total range of
consignments.

2. **Benefits from the extension of marketing opportunities --
the value of suppressed trade.**

   a. The sale of culled cattle

   One of the main advantages of road transport is that
it permits the marketing of classes of cattle that could
not be walked to meatworks or railheads. Some concept of
the magnitude of the income generated from this source can
be gauged from the examination of the composition of the
kill of the Katherine meatworks in 1966.\(^2\) In that year
twenty per cent of the total consisted of bulls and a
further nine per cent was made up of cows and heifers.
The importance of bull beef sales was accentuated in this
case because the opening of the plant in 1963 allowed
properties in the Victoria River District and the Darwin-and
Gulf region to market inferior male stock that had been
previously shot or left to run wild. These animals cannot
be herded or handled by conventional means and the
opportunities offered by the new market and the use of
road haulage made possible their exploitation. As this
form of stock is likely to be eliminated in the near future,
through greater on-property control, it does not represent
a permanent gain to producers. However, a rise in sales
of barren and aged females may offset a decline in income
from this source. In the 1966 budget it has been assumed
that both classes of sales represent a direct gain (that is,

\(^1\) This figure is necessarily arbitrary and is probably an
overestimate. It represents one ninth of the value of a
$45.00 two-year-old steer.

\(^2\) Data supplied by Northern Meat Exporters, field interview,
June 1967.
no allowance is made for the cost of trapping and mustering) and that the proportion of slaughterings of this type was the same at the Darwin works.

In the case of movements to South Australia and Queensland it is by no means clear that the adoption of road transport has increased marketings of female stock. Table 6.4 shows the contribution of this class to total consignments for the financial years from 1959-60 to 1965-66 for the two supply areas. The sex ratio in movements to South Australia seems to have remained fairly constant despite the general increase in road transport usage over the seven year period. This observation also appears to be true for consignments of the fatstock to Queensland markets. Here the proportion of females in the total trade is very similar in 1959-60 and 1965-66 despite a completely different modal split. Store sales to Queensland exhibit a more variable trend but again there is little evidence that the use of road transport is directly linked to the composition of turn-off. Analysis of the movements to this market in 1966 shows that nearly 8,000 of the stock classified as 'fats' were females and that all these cattle were moved by road. In the store category 63 per cent of the cows and heifers marketed were dispatched on the hoof, so that it does not seem justifiable to identify any benefit in this sector. Some 3,000 head of the fatstock sent to South Australia were females that might otherwise have been sold as breeders in the Alice Springs District. The 1966 'with and without' budget assumes that producers in both supply areas gained an additional $20.00 per head on their sales of fattened females -- a necessarily arbitrary estimate in the absence of more detailed evidence.

1 Unpublished Quarterly Returns of Stock Movements supplied to the Commonwealth Statistician by the NTAAIB.
Table 6.4: The type, sex, and age composition of turn-off to South Australia and Queensland

<table>
<thead>
<tr>
<th>Year</th>
<th>Fats as a percentage of Total</th>
<th>Stores</th>
<th></th>
<th>Fats</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Percentage of females of calves</td>
<td>Percentage of stores moved by road</td>
<td>Percentage of females of calves</td>
<td>Percentage of fats moved by road</td>
</tr>
<tr>
<td>1959-60</td>
<td>58.3</td>
<td>32.0</td>
<td>21.0</td>
<td>52.6</td>
<td>16.7</td>
</tr>
<tr>
<td>1960-61</td>
<td>33.2</td>
<td>27.7</td>
<td>26.3</td>
<td>77.3</td>
<td>16.1</td>
</tr>
<tr>
<td>1961-62</td>
<td>23.4</td>
<td>30.0</td>
<td>28.7</td>
<td>85.5</td>
<td>16.2</td>
</tr>
<tr>
<td>1962-63</td>
<td>69.0</td>
<td>26.4</td>
<td>13.7</td>
<td>70.0</td>
<td>5.7</td>
</tr>
<tr>
<td>1963-64</td>
<td>37.1</td>
<td>25.0</td>
<td>26.2</td>
<td>80.3</td>
<td>6.0</td>
</tr>
<tr>
<td>1964-65</td>
<td>17.8</td>
<td>27.4</td>
<td>17.9</td>
<td>82.1</td>
<td>20.3</td>
</tr>
<tr>
<td>1965-66</td>
<td>36.4</td>
<td>33.8</td>
<td>27.2</td>
<td>100.0</td>
<td>21.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Fats as a percentage of Total</th>
<th>Stores</th>
<th></th>
<th>Fats</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Percentage of females of calves</td>
<td>Percentage of stores moved by road</td>
<td>Percentage of females of calves</td>
<td>Percentage of fats moved by road</td>
</tr>
<tr>
<td>1959-60</td>
<td>29.2</td>
<td>7.9</td>
<td>0.3</td>
<td>17.4</td>
<td>33.3</td>
</tr>
<tr>
<td>1960-61</td>
<td>23.7</td>
<td>8.6</td>
<td>1.3</td>
<td>7.6</td>
<td>30.4</td>
</tr>
<tr>
<td>1961-62</td>
<td>30.6</td>
<td>18.4</td>
<td>2.8</td>
<td>28.3</td>
<td>46.7</td>
</tr>
<tr>
<td>1962-63</td>
<td>19.0</td>
<td>12.2</td>
<td>1.9</td>
<td>20.2</td>
<td>31.8</td>
</tr>
<tr>
<td>1963-64</td>
<td>51.1</td>
<td>5.2</td>
<td>22.8</td>
<td>28.4</td>
<td>35.3</td>
</tr>
<tr>
<td>1964-65</td>
<td>46.1</td>
<td>27.3</td>
<td>7.4</td>
<td>31.1</td>
<td>40.5</td>
</tr>
<tr>
<td>1965-66</td>
<td>63.6</td>
<td>13.3</td>
<td>3.0</td>
<td>50.0</td>
<td>30.9</td>
</tr>
</tbody>
</table>

a estimated

Source: data derived from the Annual Reports of the NTAAIB.
b. The benefits of increased flexibility of turn-off over time

As has been noted in Chapters 4 and 5, the use of road transport enables producers to dispatch cattle in small numbers throughout the turn-off season (the onset of the Wet Season usually begins in November in northern areas and operations cease at this time). This may result in benefits from higher prices, increased liquidity, and a reduction in station costs. An example of the effect that adoption has had on the staging of turn-off is provided by a comparison of dispatch dates on permits issued in the Victoria River District in 1957 and 1966.1 In 1957 over half of all movements commenced in May to give stock sufficient time to walk to Queensland and the Barkly Tableland before the onset of the Wet. In contrast the 1966 figures show a spread in turn-off dates between May and July and some movements were made as late as November (see Figs. 6.1. a and b). The possible financial advantages of the increased flexibility in turn-off can be gauged by considering price variations between May and September at the two northern meatworks. In 1967 average prices at these centres for the two months were, in dollars per 100 lb dressed weight.2

<table>
<thead>
<tr>
<th></th>
<th>ox beef</th>
<th>cow beef</th>
<th>bull beef</th>
</tr>
</thead>
<tbody>
<tr>
<td>Katherine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>15.50</td>
<td>12.50</td>
<td>14.50</td>
</tr>
<tr>
<td>September</td>
<td>19.00</td>
<td>13.00</td>
<td>18.00</td>
</tr>
<tr>
<td>Darwin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>16.50</td>
<td>13.50</td>
<td>17.50</td>
</tr>
<tr>
<td>September</td>
<td>19.00</td>
<td>13.00</td>
<td>18.00</td>
</tr>
</tbody>
</table>

In this case a general rise in prices is superimposed on the seasonal variation but it seems fair to suggest that producers might gain an additional $5.00 per head, on average, for the fifteen per cent of total sales that are

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1 Derived from an analysis of NTAAIB stock permits.
Fig. 6.1: Dates of consignment of cattle to all markets from holdings in the Victoria River District.

A 1957

B 1966

Source: NTAAIB stock permit data.
made at the end of the turn-off period. A similar level of benefit is probably gained on movements in the remaining supply areas.

One neglected advantage of the adoption of road transport is the increase in cash flow from quicker delivery. Consider a mob of 1,500 stores worth $40.00 per head net of transport payments. The total value of the consignment would be $60,000. If these animals took four months to walk to market the loss of income, from interest on the capital, would be worth approximately $1,000 at six per cent per annum, which would have been saved with the use of road haulage. In addition it seems reasonable to assume that the spreading of mustering operations over a longer period would give some internal economies on labour usage. However, these benefits are not valued in the 1966 balance because direct evidence of their importance is not available.

c. The movement of cattle in times of drought

The possibility of moving cattle rapidly to agistment or sale in times of drought seems one of the incontrovertible advantages of using road transport. In the drought which affected the northern regions of the Territory in 1952 losses were severe and some concept of the difficulties of moving cattle on the hoof in these conditions can be gained from the following quotation from the Queensland Country Life for August of that year:

Reports of stock movements from the Northern Territory, via Lake Nash, to Queensland tell a grim story of cattle too weak even to be dipped, and it is anticipated that all stock movements from the Territory will cease at the end of the present month. Two mobs of approximately 1,302 and 1,277 head respectively, were reduced on arrival in Queensland to about 1,200 head in each mob, and these were so weak that it was decided to make one mob, of about 1,200 head, from the strongest in the two mobs and leave the rest to take their chance of survival... No rain is expected in the Northern Territory until November, at the earliest, and cattle not
on the road by the end of the present month will have a very remote chance of being saved, as it will be impossible to shift them.

In the Alice Springs District the adoption of road transport was linked to the onset of the drought which began in 1958 and, over the seven years that followed, the percentage of all stock moved by road to railheads for shipment to South Australia increased from 34.0 to 82.1. Over the period from 1958 to 1965 the cattle population of the region decreased from 353,174 to 136,032 which indicates the impact of deaths, increased exports, and lower cow fertility. It is difficult to estimate the number and value of the stock that would have been lost without the use of road haulage but the Bureau of Agricultural Economics has suggested that the greater proportion of the 19,000 stores road transported in 1959 would otherwise have died. The animals were worth between $38 and $52 per head in South Australia. These figures suggest the order of savings that may be made in a bad season but give little guide to their importance over a run of years.

An estimate of the possible annual benefit of the use of road transport can be reached by considering the frequency of the occurrence of good and bad seasons. Climatic data for the Alice Springs District suggests that producers in this region can expect one dry summer every four years and one or more dry summers every five years. If losses of 20,000 head were incurred for the region in every two year spell and 5,000 animals were lost in the single dry years, the annual average would be 5,350 head (this represents 2.27 per cent of the average for the region's cattle population over the period from 1950 to

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2 The Economics of Road Transport of Beef Cattle, BAE, 1959, p.61.
In the three northern regions of the Northern Territory the incidence of drought is not so marked and it is even more difficult to assess potential savings. In the tabulations for 1966 at the end of this section this class of benefit is excluded, but it should be recognised that adoption could give producers in the Alice Springs District, alone, an additional annual income of nearly $240,000; if the store cattle that are salvaged are valued at $45 per head.

d. Benefits from the sale of younger cattle

The benefits of turning off younger cattle are determined by the ratio of prices between different classes of stock, their relative costs of production and the effect of the choice of enterprise on the use of pasture resources. Over the study period there has been an increasing demand for younger beef which is tending to reduce the ages of the store and fat cattle traded. In the Alice Springs District which is tied to the Adelaide market a comparison of prices in the 1968 season indicates that the maximum return per animal per year held is gained on the sale of eighteen month old store steers. The position of the various categories of stock marketed in Adelaide is given in Table 6.5 for 1959 and 1968. It would seem from these figures that the situation has not changed markedly over the decade, except that the value of two year old store steers has suffered a relative decline. The comparison of returns on the sale of young store and fat cattle has led some commentators to suggest that specialisation in the production of weaner stores would be the most profitable form of enterprise for northern growers with access to South Australian and Queensland fattening areas. McNeil pointed out that the proportion of stores in the exports from the

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1 This compares to an estimate of annual losses from drought of 2.85 per cent for the Queensland Channel Country. Report on the Economics of upgrading the Birdsville Track, The South Australian Highways and Local Government Department, Adelaide, 1967, p.36.
Alice Springs District to South Australia increased steadily from the declaration of the Central Australian Pleuro-pneumonia Protected Area in 1956 to 1961, and took this as confirmation of a general trend towards the integration of northern and southern production patterns. However, from 1962, there has been a swing to a more variable turn-off composition and in 1966 stores made up only four per cent of the stock railed south. It appears that producers prefer a flexible enterprise structure, selling store cattle in poor years and topping off their own stock in good seasons.

In the three northern Districts the opening of the Katherine and Darwin meatworks has accentuated the tendency to specialisation in the production of slaughter animals.

Table 6.5: Returns per beast for different qualities of Northern Territory stock at Adelaide 1959 and 1968

<table>
<thead>
<tr>
<th>Category of stock</th>
<th>Age (years)</th>
<th>1959</th>
<th>1968</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Market price per year ($)</td>
<td>Return kept ($)</td>
</tr>
<tr>
<td>Stores</td>
<td>1½</td>
<td>36.00</td>
<td>24.00</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>54.00</td>
<td>27.00</td>
</tr>
<tr>
<td>Fats</td>
<td>3</td>
<td>68.00</td>
<td>22.67</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>80.00</td>
<td>20.00</td>
</tr>
</tbody>
</table>

Sources:
1959 The Economics of Road Transport of Beef Cattle, BAE, 1959.
1968 Quotations from Elders-Goldsborough-Mort Pty Ltd, Alice Springs, field interview, June 1968.

Three factors would appear to be important in maintaining this trend in the future. First, the price structure in the North has not favoured sales of stores to Queensland. From a comparison of prices for different ages of stock, and the estimation of the additional capital costs that are incurred in dealing with younger cattle, Rayner concluded that breeding and fattening was more profitable than breeding alone for stations in North-West Queensland between 1962 and 1967.\(^1\) Nearly sixty per cent of the turn-off of this region is sold for immediate slaughter, and the remaining percentage is largely composed of inter-station transfers within companies. This suggests a second advantage that comes from breeding and fattening. The market for store cattle reflects both the prevailing demand for beef and the availability of feed in receiving areas, and is therefore relatively uncertain. Where operators can transfer animals between linked properties this uncertainty is minimised and the attraction of specialisation is accentuated. Finally, it seems probable that breeding and fattening reduces the risk of failure during times of drought. If a run of bad seasons strike a property that is producing weaner stores, the grower may be forced to sell a substantial part of his breeding herd to lighten the stocking rate, whereas, with the turn-off of older bullocks, grazing units can be saved with extra sales of a range of maturing cattle and the breeding nucleus remains intact. This feature of breeding and fattening gives producers the opportunity to 'roll up' in unfavourable years and 'unroll' rapidly when season improve.\(^2\)

A complete evaluation of the merits of the two types of enterprises demands some reference to the possibility

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of increasing the intensity of stocking on breeding properties. This brings the discussion to a consideration of adjustment in the long-term as evidenced by dormant rather than suppressed trade flows, and this point will be raised again in Chapter 7. At this stage it may be noted that the adoption of road transport has permitted an increase in the range of production but the absence of clear trends in the sale of younger cattle makes it impossible to value this gain.

3. The structure of benefits in 1966

The short-term benefits of the adoption of road transport have been divided into those that affect existing movements, and those that follow from the extension of marketing opportunities. These have been termed the immediate benefits to existing and suppressed traffic. Table 6.6 sets out the estimates of these classes of savings that have been made by applying the assumptions, discussed in the previous section, to the 1966 allocation pattern. Comparison of the total cost of transporting store cattle under the two modes suggests that road transport was relatively more expensive. In fact some 29,000 head of store stock were walked from properties on the Barkly Tableland to Queensland markets. The generalised figures in Table 6.6 may therefore overstate the disadvantages of droving in this supply area, in respect to losses and the deterioration in the condition of delivered stock. However, there is no way of calculating the possible savings that may have accrued to producers who used road transport from an increased flexibility in the size and timing of consignments. The similarity of the levels of total costs makes it justifiable to conclude that no benefits were earned from adoption on this class of movement.

In the study year all fatstock were marketed by road. If sales of culled females and scrub bulls are excluded from the allocation figures, approximately 73,250 head are left as the number that would have been dispatched regardless of the means of transport available. The sums that would
### Table 6.6: Estimated 'immediate' gains from the adoption of road transport: Northern Territory total, 1966 turn-off season

<table>
<thead>
<tr>
<th>Destination</th>
<th>Number of stock</th>
<th>Movement cost without use of road transport ($)</th>
<th>Movement cost with road transport ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. stores</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. Australia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queensland</td>
<td>1,000</td>
<td>9,200</td>
<td>9,600</td>
</tr>
<tr>
<td></td>
<td>9,000</td>
<td>82,800</td>
<td>86,400</td>
</tr>
<tr>
<td>B. fats</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. Australia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queensland</td>
<td>15,000</td>
<td>324,800</td>
<td>184,000</td>
</tr>
<tr>
<td></td>
<td>25,000</td>
<td>411,800</td>
<td>272,500</td>
</tr>
<tr>
<td></td>
<td>5,000</td>
<td>64,600</td>
<td>52,000</td>
</tr>
<tr>
<td></td>
<td>15,250</td>
<td>197,500</td>
<td>138,600</td>
</tr>
<tr>
<td></td>
<td>12,000</td>
<td>155,900</td>
<td>124,800</td>
</tr>
<tr>
<td>Total movement cost</td>
<td></td>
<td>1,246,600</td>
<td>887,900</td>
</tr>
<tr>
<td>b. Suppressed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fats</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Katherine 6,250</td>
<td>Culled bulls and cows</td>
<td>437,500</td>
<td>350,000</td>
</tr>
<tr>
<td>Darwin 5,000</td>
<td>Fattened cows</td>
<td>160,000</td>
<td>60,000</td>
</tr>
<tr>
<td>Queensland 8,000</td>
<td></td>
<td>1,007,500</td>
<td></td>
</tr>
<tr>
<td>S. Australia 3,000</td>
<td></td>
<td>+ 119,600</td>
<td></td>
</tr>
</tbody>
</table>

**Additional Suppressed Trading gains:**

1. Increased flexibility in timing of consignments. $49,000
2. Average annual drought savings. $240,000
3. Increased flexibility in age of turn-off. not valued

**Sources:** Table 4.2 and text.
have been lost from deaths and the deterioration in the quality of delivered animals under droving have been estimated by supply area and in each case comparison with rate payments for road haulage shows a clear advantage to the latter. The total saving to producers on these movements is about $362,700 under the tabulated assumptions, which allow for a loss of 10 lb of meat from bruising on all fat-stock transported by road. This suggests that producers may have gained an extra $1.95 per best on their sales of fats from the switch of mode -- a significant increase in marginal returns. Looking at the spatial distribution of these benefits it seems clear that their level within supply areas will largely be a function of the distance from the properties to the market centre, so that the use of road transport will tend to equalise net received prices. However, the absolute level of savings is directly conditioned by market prices which will reinforce disparities between supply areas.

Turning to the estimates of gains from the increase in marketing opportunities, it is apparent that the figures given in Table 6.6 require some qualification. It has been assumed that 11,250 of the cattle slaughtered at Katherine and Darwin would have been lost to the industry without the use of road transport, and that these animals were worth $70 each. No account is taken of the cost of trapping scrub bulls, and culled cows are considered to have no alternative use. In reality neither of these assumptions is completely justifiable so that the net gain to the industry might be substantially below the estimated value of $787,500. Two other points must be considered. First, the trade in bull beef will probably cease in the near future, which means that this benefit must be disregarded in longer-term evaluations of the benefits of modal change. Second, these flows are dependent upon the processing structure of the two northern meatworks, and this emphasises the linkage between transport and demand. It is possible to argue that these plants would not have opened in 1963 unless they had been assured of supplies by road, but it is nevertheless clear that the benefit must be credited to the joint developments.
A sum of $220,000 has been estimated to accrue to producers in the Queensland and South Australian supply areas from the sale of fat cows that would otherwise have been disposed of as stores. These benefits will be distributed among properties that have the greatest density of cattle and the best fattening pasture, since they are conditioned by the existing intensity of land-use. The quality of transport in this case will therefore increase the importance of locational variations in land fertility. A third category of dormant sales has been identified. These are consignments that are made at the end of the Dry Season, which may receive higher market prices. The value of this increase does not appear great in comparison to other classes of benefits and the additional returns will be spread over the whole industry. Of the other immediate advantages of the use of road transport the possibility of moving cattle in times of drought seems to be financially important, and the reduction in the uncertainty of production that this allows may promote the more intensive use of resources. Finally, flexibility in the age and quality of turn-off may result in some immediate benefits from the sale of younger stock, but the level of these gains is conditioned by price and uncertainty influences on production.

In conclusion it can be seen that the adoption of the use of road transport has probably led to a permanent gain to producers of between $300,000 to $400,000 from the reduction in the cost of moving fat cattle. In addition the flexibility of the new mode has allowed the marketing of stock that might otherwise have been lost or diverted to less profitable uses. Although the estimates that have been used in Table 6.6 need many qualifications, they do point to the fact that these gains may have been very considerable. The tabulations show savings of about $1,400,000, excluding the benefit of reduced drought losses. The next chapter will examine the potential impact of the addition of this income to the industry and will attempt to determine how far producers will adjust their scale of operations to the
new marketing possibilities that have been opened up by the adoption of road transport.

The first part of this chapter surveyed briefly the theoretical concepts that are available to describe the relationship between improvements in transportation and the development of a user industry. The deductions that can be made by using a closed analogue of agricultural production of the type suggested by von Thünen suggest that reductions in the cost of transport may occasion local adjustments in the intensity of land-use. These gains in situation and intensity rents follow from the constraints of spatial equilibrium, and the level of the change in total rents will serve as an index of the net benefit of the improvement. However, a different case arises when an advance occurs in transport technology. Here the adoption of a new mode of transport may permit the reaping of external economies in the dependent industry which could, in turn, lead to an adjustment to a new general equilibrium. The major difference between the two cases of the linkage between improved accessibility and land development is that the latter will affect the form of the production function of user firms. In the study industry the use of road transport has led to a decrease in the cost of transporting fat cattle and it seems reasonable to assume that this will tend to equalise basic situation rents and will lessen the influence of differences in comparative locational advantages. However, the major value of the change appears to be the extension of marketing opportunities and this has resulted in windfall gains to producers throughout the industry. The construction of the Katherine and Darwin meatworks has allowed producers in the northern regions to increase their range of sales, but the primary locational impact of the change in transport technology will be to favour units with the most productive land, rather than to discriminate between situations.

The following chapter will consider the secondary results of the shifts in product and enterprise marginal returns that have just been described. This involves the
prediction of attainable levels of production and the identification of the spatial pattern of future development. Intervened with this analysis is a further discussion of the benefits of road investment for the beef industry in the Northern Territory, and the degree to which it may be credited with both internal and external economies.
CHAPTER SEVEN

PASTORAL LAND DEVELOPMENT IN THE NORTHERN TERRITORY IN THE FUTURE AND THE ROLE OF ROAD INVESTMENT

This, then is the justification of our method of focusing on the steady state and making it the basis of our argument; because the insight such a method gives us will shed light on the obscure occurrences of periods of transition and development. When we apply this mode of reasoning to the Isolated State, we find that we have to compare the initial with the subsequent effects on the welfare of society of industrial inventions, improved communications and so forth. Thus we shall be looking into the mysterious process of development.

von Thünen, The Isolated State

INTRODUCTION

The first part of Chapter 6 reviewed the ways in which the benefits of rural road investment may be identified. An important distinction was drawn between the benefits that may accrue as a result of a reduction in the cost of transportation, where a single mode monopolises exchange, and those that may occur as a result of substitution between alternative forms of movement. In the former case it is possible to visualise the net production gains that follow from the adjustment as shifts in situation and intensity rents. This concept required modification to incorporate the influence of the external economies that may be reaped when superior transport technology is employed. Here all user enterprises may receive gains which are undifferentiated in space and spring from new opportunities rather than the re-evaluation of the marginal productivity of resources. Three production stages were defined, namely the existing, immediate, and attainable levels of response. The comparison of the value of trade at each of these stages allows the systematic enumeration of total benefits.
The final part of Chapter 6 looked at the immediate impact of the adoption of road transport on the study industry; simple accounting, based on the 1966 turn-off pattern, suggested that the change in transport technology may have brought producers more than $1 million in additional income. The level and distribution of these benefits are largely a function of local and national demands for different types of stock, because the immediate elasticity and mobility gains from an innovation in transport quantify the difference in the efficiency of allocation under the two modes. Provided that producers are aware of new marketing opportunities and act in a rational way, the gains will be realised. The work that follows focuses on the capacity of improvements in transport to generate an expansion of economic activity through an adjustment in production. Here the role of modal change is indirect — it may give growers new openings and make their existing enterprises more profitable, but they will take any decisions on reorganisation in the light of a variety of other considerations. These include their judgement of the stability of market prices in the future; the current return on capital; the marginal cost of increasing output; and a number of additional factors which are not incorporated in the traditional view of the farm firm.

The first part of the chapter looks at the efficiency of capital usage in the beef industry and the possibilities for increasing output. Future expansion may come from intensifying stocking rates and exploiting cattle herds more effectively, and these two topics will be considered in turn. This provides a context for two sub-regional studies which examine the relationship between long-term adjustment and road investment. The studies use official estimates of the attainable value of production based on the assumption that market prices will be maintained at current levels. The two cases are used to point up some of the problems that arise in attempting to predict response to a localised route improvement. Benefits are set against costs in a series of formal analyses that illustrate the need to consider uncertainty and causality in development.
These measure the net value of the additional production which results from the investment of private and public capital and thus allows judgements to be made on the level of adjustment that would be required to repay a given road investment. Over-spending has taken place in the Northern Territory following confusion about the construction standards and route priorities of the Beef Roads Programme: the two case studies have been chosen to show the effects of alternative decisions on the level of benefits. The analyses cannot distinguish the causative elements in the expansion of output, but they do allow inferences to be drawn on the importance of modal change, route reconstruction, and the deployment of resources at the firm level.

The final part of the chapter places the development of the industry in the context of a wider consideration of the use of personal and national funds. Private capital is used for station improvement for a variety of motives, which include speculation and tax sheltering, and it is obvious that these joint-products must be considered in assessing the likelihood of the intensification of land-use. However, investment for these ends may not contribute net gains to the national economy. The allocation of resources on efficiency criteria would also demand reference to the alternative opportunities which exist outside the Northern Territory for the expansion of beef production. Some of these are reviewed in the last section, and the trends that are evident in the industry as a whole are used to draw further conclusions on the motives for public investment in the Territory.

A. ECONOMIC AND PHYSICAL CONSTRAINTS ON EXPANSION

1. Returns and development

The theoretical relationship between improvements in transportation and the development of pastoral properties in the Northern Territory was discussed in Chapter 6. Here it was seen that long-run adjustments in the scale and form of production could be expected to follow from
the adoption of road transport and the construction of higher quality roads as a result of

(i) the increase in marginal returns that arises from the reduction in the cost of transporting the existing turn-off,
(ii) the income gains that may arise from the external economies of modal substitution,
(iii) the removal of physical constraints on property specialisation,
(iv) the reduction in the delivered cost of imported goods and raw materials.

The cumulative effects of these changes provide the justification for the Beef Roads Programme. According to the Parliamentary Standing Committee on Public Works

The objectives of the beef roads programme are, briefly, to provide pastoralists with improved access to outlets for cattle and to enable cattle to reach their destination in better condition and at an earlier age than previously. The increased return to producers following the construction of the new roads is expected to result in more improvements being made to properties and stock and these will, in turn, result in the production of more and better cattle.¹

The scheme implicitly assumes that the net value of the marginal increase in output will cover the cost of the roads. To evaluate this possibility it is necessary to look at the current level of returns in the industry and the difficulties that may arise in expanding production.

There are frequently differences between the appreciations that are made by academics of the economics of agricultural enterprises and those that are made by farmers. Some compensation can be made for this by reworking survey figures under various assumptions. Table 7.1 sets out four measures of returns to capital and management income in the Northern Territory beef industry

by Districts for the years 1962-63 to 1964-65. The first set refers to the BAE sample of eighty-two properties and has been calculated by expressing capital and management income as a percentage of total invested capital. The income figures include an assessment of the change in the inventory value of cattle herds, with adjustment for annual variations in cattle prices. The second set refers to a modified sample of seventy-two units and has been calculated on the same basis, except that the inventories are estimated by using an average price series for the three years. These measures present a judgement of returns from the national viewpoint, and the results may be compared with the opportunity cost of capital. If this is taken as 5.5 per cent (the interest rate suggested for benefit-cost analyses of public investment in Chapter 6), the returns may be considered clearly inadequate, though the properties in the Barkly Tableland fare relatively well under the first definition. Judgement against the bank overdraft rate, which is around seven per cent, makes the use of private funds in the industry look even more unfavourable.

Table 7.1: Percentage returns to Capital and Management Income in the Northern Territory Beef Industry (station average under different definitions), 1962-63 to 1964-65, by Districts

<table>
<thead>
<tr>
<th>Definition</th>
<th>Alice Springs</th>
<th>Barkly Tableland</th>
<th>Victoria River</th>
<th>Darwin and Gulf</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>-3.5</td>
<td>6.6</td>
<td>4.5</td>
<td>4.6</td>
</tr>
<tr>
<td>ii</td>
<td>-4.5</td>
<td>3.2</td>
<td>-4.5</td>
<td>-1.4</td>
</tr>
<tr>
<td>iii</td>
<td>-8.4</td>
<td>-0.6</td>
<td>-2.6</td>
<td>-10.9</td>
</tr>
<tr>
<td>iv</td>
<td>-6.8</td>
<td>21.7</td>
<td>18.4</td>
<td>19.4</td>
</tr>
</tbody>
</table>

a. For definitions see text.

It could be argued that from the growers' point of view calculations under the first two definitions do not give realistic parameters of profits. Suppose producers are only interested in returns to structural capital and view their cattle herd as a resource with a low or negligible opportunity value. In this case, an estimate of the average percentage return can be made by excluding the inventory change from income and debiting the book value of herds from total capital. The results of re-calculating the survey results for the sample of eighty-two stations on this basis are given in Table 7.1 (definition iii). These figures show that the return on fixed assets is universally low, and point to the importance of taking some account of cattle if the survival of the industry is to be explained in economic terms. The fourth set of figures uses the same survey material and has been calculated by expressing capital and management income, with the inventory change adjusted for annual variations in prices, as a percentage of the value of structural capital. This set gives an appreciation of returns from the viewpoint of a producer who saw stock as a land resource when he entered production, but now perceives the rise in their capital worth as a windfall gain. Though this definition gives an unrealistic picture of the health of the industry in national terms, the re-worked figures demonstrate that the established units may show handsome profits in the eyes of their owners.

Despite this reservation, which may help to explain private investment in the cattle industry, the tabulations suggest that resources were being used inefficiently at the time of the survey. Three points must be considered in extrapolating these results into the future. First, it is legitimate to ask whether the sample was representative. An average of 154 units marketed cattle in the three calendar years 1963 through 1965, and the mean outputs of the stations in each District can be compared with those of the 82 properties in the survey (the number of units in each District is shown in brackets):
The similarity of the two sets of figures suggests that the sample presents a reasonably accurate picture of the state of the whole industry. Second, it is important to know the range of returns within the survey material. Under the first definition of the percentage return to capital and management income, 13 properties had a rate of return between five and ten per cent, 7 showed returns of between ten and fifteen per cent, and 5 averaged over fifteen per cent for the three year span. This can be taken as an indication that a high level of profit can be earned, particularly when inventory gains are taken into account. However, an industry in which forty-six per cent of the enterprises (38 stations) recorded a loss on the same criteria would appear to be a poor proposition for expansion.

Third, the survey period has several disadvantages as a basis for projections. The properties in the Alice Springs District were affected by drought, and the stations in the three northern Districts were in the process of adjustment to the marketing opportunities created by the opening of the Katherine and Darwin meatworks and the adoption of road transport. In addition, prices have risen markedly over the last few years, for instance, the June average monthly price for first and second export quality stock at Brisbane was $19.20 per 100 lb dressed weight in 1964 and $27.87 in 1969. In the light of these changes, it is interesting that the survey showed that producers were making large investments in improvements. During the three years total capital expenditure on structures averaged fifteen per cent of the gross value of these items.
on all Northern Territory units: the lowest percentage (8.6) was recorded in the Alice Springs District and the highest (24.5) in the Darwin and Gulf District. One reason for this increased spending may be the difficulty of finding sufficient skilled labour. Wage costs have also risen markedly since the introduction of Award Wages for aboriginal workers in December 1968, which will partially offset the influence of higher beef prices. Although conditions have become generally more favourable to producers in the Territory since the early sixties, it must be remembered that the whole of the beef industry has shared in the general rise in stock prices, so that relative returns may still be low. A comparable survey of properties in Queensland showed that returns for 1962-63 to 1964-65 averaged 7.0 per cent for the State, and varied between 4.7 for the Coastal Central Region and 9.6 per cent for the Coastal South Region. These figures are directly comparable with those given in Table 7.1 (definition i). In conclusion, it would appear that recent developments have probably increased the rate of return to capital and management income in the Northern Territory and made viable many of the enterprises that were unprofitable at the beginning of the decade. However, from a national point of view, there are sound reasons for questioning the expenditure of large sums on road projects, which are undertaken in the belief that their costs will be covered by the net value of induced production.

2. Potential productivity and development

The third part of Chapter 5 discussed the form of the industry production function under the assumption that technology was static. The two major conclusions were that the discontinuous nature of investment in improvements suggests that adjustment to higher prices and new opportunities

1 BAE, unpublished data referring to the modified sample of 72 properties (property average 1962-3 to 1964-5).

will depend to a large degree on the long-term certainty of returns, and that the quality of natural pasture is probably the main determinant of the productivity of investment and the intensity of land-use. In the following section the physical and economic constraints on expansion will be discussed at the industry level. Two possible forms of development exist; land may be stocked more intensively or cattle resources may be exploited more efficiently. Each of these will be reviewed in turn.

a. The potential for heavier stocking

The intensity of stocking of an area of natural pasture is largely conditioned by the availability of water. In the Victoria River and Darwin and Gulf Districts natural supplies are fairly widespread, though their unreliability in periods of drought makes it desirable to provide permanent made waters in the form of bores and dams. The properties of the two other Districts depend largely on artificial supplies. The difficulties associated with estimating the carrying capacity of different types of natural pasture arise because little is known about the grazing habits of semi-feral cattle under open range conditions. Approximately 78 square miles are contained within a five mile radius of a bore, so that the stocking rate can be calculated at 15 per square mile if 1,200 head are run on the land. If, in reality, these animals are restricted to within a three mile radius of the water, the effective carrying capacity of the utilised pasture is 42 per square mile. This means that assessments of the potential of natural grasslands are subject to wide margins of discrepancy. As an example, Perry estimated that the maximum stock population of the Alice Springs District was between 423,000 and 723,000 head depending upon whether stock graze the area between the third and fifth miles from

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natural and artificial supplies. He found that only 64 per cent of the usable country in the region was serviced by waters at 10 mile intervals in 1956, so that there would appear to be considerable scope for development, even if the greater grazing range is accepted. From the measurements of the areas of different pastures within current pastoral leases described in Appendix 1, it can be estimated that about 2,400,000 head could be run in the Northern Territory if stocking rates are determined on a three mile spacing of waters.

Relating these figures to the economic potential of the industry poses many problems. Kelly suggested that the cattle population of the Northern Territory could have been raised profitably from 1,018,710 to about 1,650,000 in 1951 with 'adequate water supply to enable any part of the usable country to be utilised at any period of the year'. He assumed that a watering point would have been needed for every 40 square miles which would have increased the number of artificial waters from 950 to about 4,500.

Chapter 5 showed that the productivity of investment in station improvements is largely a function of the effective stocking rate of the developed land, and thus returns would probably decline rapidly as areas of poorer use capacity were stocked. A bore costing $11,000 would have to cover annual costs of $1,430 (interest at 5.5 per cent, and depreciation at 7.5 per cent), so that the cost per beast would vary from $10.14 to $3.37 according to whether the stocking rate was five or fifteen beasts per square mile within a radius of three miles. In this light it seems valid to suggest that Kelly's figures are over-optimistic. It may be noted here that the total number of made waters in the Northern Territory at June 1965 can be

estimated at 1,850.\footnote{The Northern Territory Beef Cattle Industry, 1962-63 to 1964-65, BAE, Canberra, 1968. According to the survey there were 1,287 made waters on 82 properties carrying 769,039 head in June 1965. Adjustment for the unsurveyed areas, on a beast-water ratio, gives the estimate of 1,850 for the whole industry.} The cattle population at this time was about 1,106,000 so that the doubling of the number of watering points between 1951 and 1965 seems to have had a very marginal impact on stocking.

Kelly quoted with approval the development policies of Rosewood and Brunette Downs up to 1952. In that year the former property had twenty-two equipped bores and the latter had thirty-three.\footnote{Kelly, J.H., Report on the Beef Cattle Industry..., pp.139-42.} The corresponding figures in 1968 were thirty-five and one hundred and nineteen,\footnote{Field interviews, June/July 1968.} and it is relevant to note that these two properties have wide areas of good pasture. According to the index of land quality given in Appendix 1, Rosewood would rank seventh and Brunette Downs fourth in the Northern Territory. While Kelly argues from the 1952 situation that these stations indicate the potential for the whole industry, it seems more reasonable to conclude from the comparisons over time that these properties have been highly developed because they contain unusually fine land. This reflects the tendency (suggested in Chapter 5) for favoured areas to increase their differential in productivity over poorer quality land and, as has been seen from the analysis in Part 2 of spatial equilibrium in 1957 and the mid-1960s, the adoption of road transport will probably accentuate this process. The general conclusion to be drawn from this brief survey of the potential of the Northern Territory is that considerable opportunities do exist, but that it seems likely that marginal increases in stocking on natural pastures will be bought at a high cost in investment in made watering points. Furthermore, future development may
well be most profitable on units which can be considered heavily stocked at present.

Some exceptions to the latter conclusion may be noted where a change in range technology has permitted the re-evaluation of certain types of grassland. One example is given by the use of the Tippera Tall Grass Plains Country of the northern Victoria District. This land has been grazed extensively at very low stocking rates in the past, since it was believed that the rank feed produced during the wet season would not support and fatten stock.\(^1\)

Experiments have shown that heavy grazing increases the nutritional value of the grass and the adjustment of management techniques, with additional fencing and the use of mineral supplements, could give this area a considerable potential.\(^2\) The managers of Delamere and Willeroo, which contain land of this type, suggested that their herds could rise from 8,000 and 9,000 to 20,000 and 24,000 head, respectively (that is, a carrying capacity of about one beast to 30 acres).\(^3\) Other limited areas of potential in the natural grasslands of the Northern Territory include the perennially flooded Kangaroo Grass pastures of the Katherine-Darwin Region and isolated pockets of good country elsewhere, particularly in the lands classed as 'rugged and inaccessible' by Perry.\(^4\) However, the overall increases from these sources are likely to be small.

Far greater increases in stocking may occur as a result of the introduction of improved pastures. The chief type being sown at present is Townsville Stylo [Lucerne] (\textit{Stylosanthes humulis}), and up to 1968 an estimated

\(^1\) Perry, R.A., 'Pasture Lands of the Northern Territory', \textit{Land Research Series}, No.5, CSIRO, Melbourne, 1960, p.46.


\(^3\) Field interviews, July 1968.

100,000 acres had been developed.\(^1\) Establishment costs vary from $5 to $17 per acre.\(^2\) In the former case the seed may be sown from the air with one hundred weight of superphosphate per acre, and full stocking at one beast to five acres can be reached in the third year. The more expensive method involves timber pulling and sowing after ploughing, and stocking rates up to one beast to two acres may be possible in the second year. According to the Northern Territory Administration, a property carrying 2,000 head on this pasture could be developed in seven years and would show a return to capital and management of eight per cent after this period (1968).\(^3\) Two main types of development can be distinguished. First, new units may be created from land in the Top End that is not held under pastoral lease, or from the subdivision of existing properties. The future pattern here may be the operation of 20,000 acre blocks in which the whole area is improved. Second, the existing stations may establish areas of Townsville Stylo to act as a drought reserve and to supplement breeding stock.

The area that can be developed with the new species is restricted by rainfall to the land north of the 25 inch isohyet and it may be that an annual figure of 30 inches is required for secure establishment (see Map 2.2). Table 7.2 shows the areas within these rainfall belts that are covered by four natural grassland associations which would seem to be favourable to development. Hypothetical stocking rates have been assumed which vary with the productivity of the natural grasses and the annual rainfall. Though

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\(^2\) Personal communication, Gunn Rural Management Pty Ltd, 20 August 1968.
these figures must be regarded as speculative, they do indicate that the long-term potential of this small area (about 30,000 square miles) could exceed that of the whole of the natural pasturelands of the Northern Territory.

Table 7.2: Land areas under different natural pasture associations, within existing pastoral leases, that may be suitable for development with Townsville Style

<table>
<thead>
<tr>
<th>Natural pasture type</th>
<th>Area (square miles)</th>
<th>Hypothetical stocking rate under Townsville Style</th>
<th>Hypothetical future stock population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tippera Tall Grass</td>
<td>10,217</td>
<td>1 to 7 years</td>
<td>919,530</td>
</tr>
<tr>
<td>2. Tippera Tall Grass on low hilly country</td>
<td>484</td>
<td>1 to 10 acres</td>
<td>30,976</td>
</tr>
<tr>
<td>3. Upland Tall Grass plains</td>
<td>11,029</td>
<td>1 to 15 acres</td>
<td>474,247</td>
</tr>
<tr>
<td>4. Short Grasses and Forbs on hilly country</td>
<td>349</td>
<td>1 to 20 acres</td>
<td>11,168</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>22,079</strong></td>
<td></td>
<td><strong>1,435,921</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Area (square miles)</th>
<th>Hypothetical stocking rate under Townsville Style</th>
<th>Hypothetical future stock population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tippera Tall Grass</td>
<td>1,767</td>
<td>1 to 7 acres</td>
<td>159,030</td>
</tr>
<tr>
<td>2. Tippera Tall Grass on low hilly country</td>
<td>124</td>
<td>1 to 10 acres</td>
<td>7,936</td>
</tr>
<tr>
<td>3. Upland Tall Grass plains</td>
<td>4,775</td>
<td>1 to 15 acres</td>
<td>205,325</td>
</tr>
<tr>
<td>4. Short Grasses and Forbs on hilly country</td>
<td>1,207</td>
<td>1 to 20 acres</td>
<td>38,624</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>7,873</strong></td>
<td></td>
<td><strong>410,915</strong></td>
</tr>
<tr>
<td><strong>Overall Total</strong></td>
<td><strong>29,952</strong></td>
<td></td>
<td><strong>1,846,836</strong></td>
</tr>
</tbody>
</table>

**Source:** See Appendix 1, the stocking rates on Townsville Style on the various pasture associations have been estimated by scaling intensity on their unimproved carrying capacities.
By far the greater part of the area lies within 150 miles of Katherine so that the adoption of improved pasture in this area would tend to fill in the intensity lacuna that exists at present between the two northern meatworks and their main sources of supply. A further portion would be well served by a killing plant at McArthur River so that the coincidence of these developments would tend to create an economic landscape in which the distribution of production was nearer to the pattern of the Isolated State. It seems obvious that the opportunities presented by the United States market from 1963 have promoted experimentation with pasture improvement. However, it is more difficult to assess how the Beef Roads Programme will influence intensive production. Where development takes place on small units in the Top End, integrated local road plans will be needed to service the holdings; this will require an expensive new programme. The major feeder roads that are now planned will be more useful in encouraging the sowing of supplementary areas on the existing stations, where rainfall and accessibility are more marginal (particularly the Victoria, Roper, and McArthur River Areas). The future pattern could therefore result in very significant changes in the location of production and, in turn, could lead to new trade flows in store stock from natural pastures; some of the implications of these possible changes will be considered in more detail in the conclusion to this chapter. More limited possibilities exist for sowing buffel grass and Hunter River Lucerne, and stock farming could become important on the land irrigated by the Ord River Scheme; but these developments have not been evaluated in this brief survey.

b. The potential for the better use of stock resources

A wide range of techniques can be applied to increase the productivity of cattle herds, and the introduction of more advanced forms of husbandry could lead to significant gains in the volume and value of the production of the industry in the Northern Territory. However, to evaluate this potential it is necessary to look at the impact of such
changes on the cost structures of properties. The work that follows does not attempt to consider the complete range of factors which may affect developments of this type, and offers only a series of guidelines to help judge the official predictions of the long-term response of producers to the Beef Roads Programme. The impact of a change of husbandry on turn-off depends upon the interaction between herd mortality, the pattern of marketing, and the property stocking rate. The possible effects of mutual alterations in these factors can be illustrated by the application of a model of herd structure. Table 7.3 sets out composition of the herd and turn-off for a hypothetical station in the Northern Territory under four groups of assumptions. The model was proposed by Granger and Walsh and cases B and C are taken from their article which includes a description of the method of determining the components of a herd.\(^1\) It is assumed that the station covers 1,400 square miles and is 300 miles from a railhead or meatworks. The characteristics of the unit under different management techniques are discussed below.

Case A The 'existing' situation

Here the property is assumed to be poorly equipped with improvements and all stock are marketed by driving them to the terminal. The stocking rate is about four beasts to the square mile and the total herd is 5,670 head, of which 270 animals are unbranded. Animal husbandry is primitive and the branding rate (calves to active breeders) is 55 per cent. Annual mortality among breeders and calves is 10 per cent but subsequent losses on growing stock are negligible. Due to poor management and the lack of marketing opportunities the station also carries about 245 cows which are too old to breed and these perish annually in addition to the mortality among active females.

\(^1\) Granger, W., and Walsh, J.D., 'Equations relating to composition of beef cattle herds to certain basic data!', *Australian Journal of Agricultural Economics*, 3 (1959), pp.58-63.
Table 7.3: Hypothetical herd and turn-off structures for a property under four management systems

<table>
<thead>
<tr>
<th>Herd Composition</th>
<th>STAGE OF DEVELOPMENT</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number</td>
<td>Cattle Equivalents</td>
<td>Number</td>
<td>Cattle Equivalents</td>
<td>Number</td>
</tr>
<tr>
<td>Breeders</td>
<td>1,687</td>
<td>1,687</td>
<td>1,553</td>
<td>1,553</td>
<td>2,211</td>
</tr>
<tr>
<td>Branded calves</td>
<td>923</td>
<td>185</td>
<td>1,155</td>
<td>231</td>
<td>1,644</td>
</tr>
<tr>
<td>2 yr old bullocks</td>
<td>416</td>
<td>208</td>
<td>572</td>
<td>286</td>
<td>814</td>
</tr>
<tr>
<td>3 yr old bullocks</td>
<td>416</td>
<td>373</td>
<td>572</td>
<td>458</td>
<td>814</td>
</tr>
<tr>
<td>4 yr old bullocks</td>
<td>416</td>
<td>416</td>
<td>572</td>
<td>572</td>
<td>-</td>
</tr>
<tr>
<td>5 yr old bullocks</td>
<td>416</td>
<td>416</td>
<td>572</td>
<td>572</td>
<td>-</td>
</tr>
<tr>
<td>1 yr old heifers</td>
<td>416</td>
<td>208</td>
<td>572</td>
<td>286</td>
<td>814</td>
</tr>
<tr>
<td>2 yr old cull heifers</td>
<td>-</td>
<td>-</td>
<td>183</td>
<td>147</td>
<td>260</td>
</tr>
<tr>
<td>3 yr old cull heifers</td>
<td>-</td>
<td>-</td>
<td>183</td>
<td>183</td>
<td>-</td>
</tr>
<tr>
<td>4 yr old cull heifers</td>
<td>-</td>
<td>-</td>
<td>183</td>
<td>183</td>
<td>-</td>
</tr>
<tr>
<td>Cast cows</td>
<td>245</td>
<td>245</td>
<td>233</td>
<td>233</td>
<td>332</td>
</tr>
<tr>
<td>Bulls</td>
<td>49</td>
<td>49</td>
<td>78</td>
<td>78</td>
<td>111</td>
</tr>
<tr>
<td>Clean skins</td>
<td>270</td>
<td>270</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>TOTAL HERD</strong></td>
<td>5,400</td>
<td>4,433</td>
<td>7,000</td>
<td>5,354</td>
<td>7,000</td>
</tr>
<tr>
<td>Approximate Stocking rate</td>
<td>4 per square mile</td>
<td>5 per square mile</td>
<td>5 per square mile</td>
<td>6 per square mile</td>
<td></td>
</tr>
<tr>
<td>Turn-off</td>
<td>2 yr old bullocks</td>
<td>416</td>
<td>572</td>
<td>814</td>
<td>957</td>
</tr>
<tr>
<td></td>
<td>5 yr old bullocks</td>
<td>-</td>
<td>-</td>
<td>260</td>
<td>307</td>
</tr>
<tr>
<td></td>
<td>2 yr old cull heifers</td>
<td>-</td>
<td>-</td>
<td>183</td>
<td>390</td>
</tr>
<tr>
<td></td>
<td>4 yr old cull heifers</td>
<td>137</td>
<td>233</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL TURN-OFF</strong></td>
<td>573</td>
<td>988</td>
<td>1,406</td>
<td>1,654</td>
</tr>
<tr>
<td>Turn-off percentage</td>
<td>10.6</td>
<td>14.1</td>
<td>20.1</td>
<td>20.1</td>
<td></td>
</tr>
</tbody>
</table>

* Branded stock only.

Source: Granger and Walsh, 1959, and additional calculations based on assumptions detailed in the text.
Thus the proportion of calves branded to all cows and heifers over one year of age is about 40 per cent. Male animals are marketed as five year old fats of sufficient maturity to withstand droving to the terminal, and approximately 157 females of all ages are sold each year as stores or breeders. Under these assumptions the annual turn-off is 573 head and the turn-off rate is 10.6 per cent. As an alternative it could be assumed that the operator marketed the male stock as stores at three years of age. Since this would allow the property to retain more breeders the turn-off rate would rise to about 12 per cent. This case has been termed the existing situation and represents the firm in adjustment to low prices and poor marketing opportunities.

Case B Improvement under existing marketing conditions

If prices rise the operator may find it profitable to invest in additional yards, fencing, and bores and to take steps to reduce mortality by segregating females, controlling joining, and introducing measures to deal with disease and parasites. This allows the carrying capacity to rise to 7,000 head (approximately five beasts per square mile). Unbranded stock are eliminated and the wastage in breeders and branded calves is reduced to 10 and 7 per cent respectively. The branding rate rises to 80 per cent of breeders (nearly 50 per cent of all females excluding cull heifers), and the lowering of wastage allows the operator to semy a proportion of heifers and reduce the average age of breeders by casting 15 per cent each year. The change in the composition of the herd allows the producer to market 14.4 per cent of his stock annually, of which about 40 per cent would be females. If it proved impossible to dispose of the older cows on the hoof the rate of turn-off would be reduced to 10.8 per cent. In an ideal development sequence for the Northern Territory this might correspond to the actions of a producer in the Wyndham supply area between 1952 and 1960.
Case C The impact of the adoption of road transport

Here it is assumed that the producer adopts the use of road transport, and this makes a turn-off rate of 1/4 per cent secure. In addition, the possibility unfolds of selling two to two and a half year old male stores, and the enterprise is re-orientated to the new marketing opportunity. This allows the turn-off rate to rise to 20.9 per cent of the total herd. If sales were restricted to three year old animals for the United States trade in the Katherine, Wyndham, and Darwin supply areas, the proportion turned-off would be lowered to about 17 per cent because the extra year of fattening would demand a reduction in the number of breeders grazed. At this stage two possible advantages have accrued to the producer from the adoption of road transport. First, he has been given a secure market for his cast female stock -- an 'immediate' gain; and, second, he has been able to reduce the age of turn-off and specialise in a different form of production -- an 'attainable' gain.

Case D Long-run adjustment to the change in opportunities

This case illustrates the importance of considering the relationship between the composition of herds and the apparent stocking rate. The sale of younger cattle reduces the amount of feed that is consumed by the whole population, and it is possible to calculate the extent to which this would allow herd numbers to rise. If each class of animal is related to a feed scale based on the consumption of a mature beast, the number of stock equivalents used can be estimated. The following values have been adopted:1

Calves 0.2
Steers and heifers (1 year old) 0.5
Steers and heifers (2 years old) 0.8
All other animals 1.0

It is assumed that heifers entering the breeding herd at two years old will consume a full stock equivalent. From the calculations of the amount of feed utilised in Case B it is possible to estimate that the reorganisation of production would allow the number of breeders carried to rise to about 2,600. This would result in an increase in the stocking rate to about six per square mile, and the number of beasts marketed each year would rise by nearly 250. This intensification of land-use is a further attainable gain from the adjustment to new marketing opportunities. The relative increase under a turn-off pattern based on the sale of three year old fat bullocks would, of course, not be as great.

As has been pointed out, the profitability of changing management practices will depend upon the level of capital investment required and the increase in operating costs that will result from the more intensive use of resources. Unfortunately, there is very little data available on the economics of better husbandry in lightly stocked areas. The best study on this topic covers the reduction of mortality in North-West Queensland using hypothetical figures for a property carrying 15,000 head. The authors, Jenkins and Hirst, consider the level of return that could be gained from a capital investment of $94,500 on a breeding and fattening unit and $102,800 on a store breeding enterprise. They assume that operating costs would rise by $17,500 and $18,500 respectively. If these reorganisational measures reduced average herd mortality in the breeding and fattening herd from 9.9 to 5.6 per cent, the rate of return to capital would be 8.6 per cent, on prices assessed at the farmgate, 1963 to 1965. Comparable figures for a reduction

from 11.7 to 6.3 per cent in a breeding herd would show a return of 13.7 per cent. No account is taken of the possibility of increasing the stocking rate or the fact that quality of the stock marketed could rise as husbandry improves.

Interpolation from these results to the profitability of the more intensive use of stock in the Northern Territory in the future is difficult but a regional comparison points up three important facets of the problem. First, survey results show that the existing return on capital in North-West Queensland is significantly higher than in the Northern Territory. If this region is equated with the Barkly-Gulf Region, as defined in the 1962-63 to 1964-65 BAE survey of the Queensland beef industry, the average return to capital and management income over the three year period was 6.1 per cent with a variable price inventory gain and 8.1 per cent with the inventory assessed at constant cattle values. Reference to Table 7.1 shows that these figures are well in excess of those of the four Northern Territory regions. This suggests that the profitability of marginal increases in the intensity of the use of cattle resources would probably be far higher. Second, it is important to note that a programme of the type discussed by Jenkins and Hirst, would require the employment of four extra men. If their hypothetical property had the regional ratio of cattle to workers (790 : 1) prior to the change, it would involve a 21 per cent increase in labour usage. The new relationship of 652 : 1 may be compared to the following figures for the Districts of the Northern Territory which refer to cattle equivalents per man-year worked:

<table>
<thead>
<tr>
<th>District</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alice Springs</td>
<td>401</td>
</tr>
<tr>
<td>Barkly Tableland</td>
<td>1,343</td>
</tr>
<tr>
<td>Victoria River</td>
<td>783</td>
</tr>
<tr>
<td>Darwin and Gulf</td>
<td>1,153</td>
</tr>
<tr>
<td>Northern Territory Total</td>
<td>850</td>
</tr>
</tbody>
</table>


2 Unpublished BAE data, station averages 1963-4 to 1964-5 (two year average), modified sample of seventy-two units.
Since the use of cattle equivalents much understates the ratio to all cattle, it may be concluded that the increment in labour usage that would be required to raise productivity to the level suggested for North-West Queensland would be far greater in the Northern Territory. Under present conditions of labour shortage the number of workers required would not be forthcoming, while the payment of Award rates to aboriginal hands, and upward wage adjustments, will further inhibit profitable expansion.

The third important point is that the carrying capacity of the rangelands of North-West Queensland is comparatively high. The average stocking rate in the region was 11.2 beasts per square mile, which compares to an average for the Northern Territory of about five per square mile. The importance of land quality as a determinant of operating costs has already been discussed in Chapter 5, and it seems clear that the cost of applying improved techniques would rise markedly in marginal country. As Jenkins and Hirst comment, 'the larger the property and the lower the effective stocking rate, the more difficult it would no doubt be to obtain the degree of herd control postulated'.

In conclusion it seems fair to suggest that the cost of developing most of the properties in the Northern Territory to these standards would have been prohibitive in 1966, unless advantages were also gained from more intensive stocking and the upgrading of the quality of production. Since that date the increase in cattle prices has probably made it more attractive to intensify the use of stock resources, though returns on natural pastures may be low when account is taken of the risks involved.

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1. See, for example, Prospects of Agriculture in the Northern Territory (Report of the Forster Committee), Commonwealth of Australia, 1959, p.52. In a survey of twenty-eight stations in 1965, Stevens found that eight had insufficient aboriginal labour and nine had insufficient white labour in the manager's or owner's judgement: F. Stevens, unpublished data.

This discussion provides a context for the sub-regional studies that follow. Here both optimistic and pessimistic views are presented of the potential for development in two areas influenced by the Beef Roads Programme. The optimistic figures are based on projections made by the Northern Territory Administration to justify the road expenditure, and assume that additional operating costs will arise on a standard per-beast-marketed basis. The pessimistic estimates are based on the supposition that the long-term rise in turn-off and stocking rates will be more modest. In the latter case it is assumed that production may be redistributed in favour of the best natural pastures, though no account is taken of the possibility of a decline in the quality of ranges through continued use.

B. THE BENEFITS AND COSTS OF DEVELOPMENT AND ROAD CONSTRUCTION

Case Study 1: The Anthony Lagoon-Barkly Highway Road

The Anthony Lagoon - Barkly Highway road was built on a new alignment as a gravelled beef road in 1965 and was recommended for sealing in 1968. The route stretches 140 miles and a continuation from Anthony Lagoon extends the road a further 162 miles to Borroloola via Cape Crawford. The main function of the proposal is to provide all-weather access to the Barkly Highway for the properties on the western part of the Tableland, but it also serves to link the stations on the Gulf of Carpentaria to these units and the Queensland market. For the purposes of the analysis that follows it is assumed that the proposal directly affects seven properties on the Barkly Tableland. These are Mallapunyah Springs, Creswell Downs, Walhallow, Anthony Lagoon, Brunette Downs, Beetaloo, and Mungabroom. This definition has been employed because official projections

are available for future production, though, from local knowledge, it would seem preferable to substitute Eva Downs for Beetaloo. This is not likely to affect the validity of the results of the benefit-cost analyses. The aggregate area of the units is 17,929 square miles of which about 62 per cent can be classed as usable. The proportions of the sub-region occupied by different pasture associations can be estimated as follows:

<table>
<thead>
<tr>
<th>Pasture Association</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley Mitchell Grass Country</td>
<td>20.7</td>
</tr>
<tr>
<td>Inferior Mitchell Grass and other</td>
<td>18.7</td>
</tr>
<tr>
<td>Perennial Grasses</td>
<td></td>
</tr>
<tr>
<td>Northern Bluebush</td>
<td>2.7</td>
</tr>
<tr>
<td>Broken Mitchell Grass Country</td>
<td>19.9</td>
</tr>
<tr>
<td>Short Grasses and Forbs</td>
<td>0.3</td>
</tr>
<tr>
<td>Useless Country</td>
<td>37.7</td>
</tr>
</tbody>
</table>

Reference to Appendix 1 shows that the area is of a high overall quality in comparison to similar expanses in the Northern Territory.

In the official figures immediate benefits are expected to occur from the encouragement given to the use of road transport. They include sales of previously unmarketable cull cattle and savings in deterioration losses on existing movements. The attainable level of production is expected to be reached within fifteen years, given:

(i) the improved road access
(ii) adequate finance for property development
(iii) the application of known agronomic and animal husbandry techniques
(iv) comparative efforts of more advanced management.

Under these conditions the output and characteristics of the subregion are forecast to change as follows:

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1 See Appendix 1.

2 Minutes of Evidence relating to the proposed construction of Beef Roads, Western Barkly Tablelands, Northern Territory, Parliament of the Commonwealth of Australia, Canberra, 1968, p.5.
<table>
<thead>
<tr>
<th></th>
<th>Cattle Population</th>
<th>Annual turn-off</th>
<th>Turn-off rate per cent</th>
<th>Average Value per beast ($)</th>
<th>Total value of production ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>140,000</td>
<td>22,000</td>
<td>15.7</td>
<td>60.0</td>
<td>1,320,000</td>
</tr>
<tr>
<td>Immediate</td>
<td>140,000</td>
<td>28,000</td>
<td>20.0</td>
<td>65.0</td>
<td>1,820,000</td>
</tr>
<tr>
<td>Attainable</td>
<td>162,000</td>
<td>36,000</td>
<td>22.2</td>
<td>80.0</td>
<td>2,880,000</td>
</tr>
</tbody>
</table>

Accepting these estimates of potential as an optimistic view of the future the benefits of constructing the road and intensifying land development have been calculated using the formula described in Chapter 6.

Table 7.4 sets out the structure of benefits and costs for the 50 years from 1967 to 2017 under these assumptions:

(i) the immediate benefits of the change in operations are worth $500,000 per year. They consist of the value of the sale of 6,000 head of culled cattle, and a $5 per beast rise in the value of existing sales from the reduction of weight losses etc. These benefits accrue annually from the third to the seventh years and no additional on-property operating costs are incurred;

(ii) road maintenance costs are increased by $500 per mile by the construction of the road (it is assumed that $300 per mile would have been spent annually to maintain a fire-plough access road in the absence of the project). This results in an annual disbenefit of $70,000;

(iii) the increase in revenue from immediate gains and the opening of new opportunities encourages producers to invest in improvements. The necessary input of private capital has been estimated from field interviews with owners or managers in 1968, who were asked 'What improvements are needed on the station in the next five years?' The expenditure is estimated very approximately at around $1,580,000 and no account is taken of money spent in 1967. The improvements consist of 70 bores valued at $11,000 each, 450 miles of suspension fencing at $450/mile, 550 miles at 4-barb fencing at $600/mile and 70 yards at an average cost of $4,000;
Table 7.4: Summary of Benefit-Cost Analysis of road investment and property development, Anthony Lagoon - Barkly Highway Sealed Beef Road - Optimistic assumptions

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12-20 (Respectively)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>712</td>
<td>924</td>
<td>1,136</td>
<td>1,358</td>
<td>1,560</td>
<td>1,560</td>
<td></td>
</tr>
<tr>
<td><strong>Benefit Estimates at Current Values</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E (_a) - E (_c) (Gross Benefits)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E (_b) - E (_d) (Additional property operating costs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Operating costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Depreciation</td>
<td>47</td>
<td>47</td>
<td>47</td>
<td>47</td>
<td>47</td>
<td>47</td>
<td>47</td>
<td>47</td>
<td>47</td>
<td>47</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>E (_e) (Road maintenance)</td>
<td></td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>E (_a) - E (_b) - E (_c) + E (_d) - E (_e) (Net Benefits)</td>
<td></td>
<td>430</td>
<td>430</td>
<td>430</td>
<td>430</td>
<td>533</td>
<td>747</td>
<td>1,111</td>
<td>1,703</td>
<td>1,1203</td>
<td>1,1203</td>
<td></td>
</tr>
<tr>
<td>((1+0.055)^{10}) (Present value factor discount rate = 5%)</td>
<td>1.000</td>
<td>0.948</td>
<td>0.899</td>
<td>0.832</td>
<td>0.765</td>
<td>0.725</td>
<td>0.684</td>
<td>0.646</td>
<td>0.610</td>
<td>0.576</td>
<td>0.542</td>
<td>0.500</td>
</tr>
<tr>
<td><strong>Net Benefits in Present Values</strong></td>
<td></td>
<td>387</td>
<td>366</td>
<td>347</td>
<td>329</td>
<td>334</td>
<td>464</td>
<td>542</td>
<td>609</td>
<td>669</td>
<td>1,073</td>
<td>1,073</td>
</tr>
<tr>
<td><strong>Cost Estimates at Current Values</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E (_f) - E (_g) (Additional property capital investment)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E (_h) (Capital cost of road)</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td></td>
</tr>
<tr>
<td>E (_e)</td>
<td>930</td>
<td>930</td>
<td>930</td>
<td>930</td>
<td>930</td>
<td>930</td>
<td>930</td>
<td>930</td>
<td>930</td>
<td>930</td>
<td>930</td>
<td></td>
</tr>
<tr>
<td>Total Capital Costs</td>
<td>1,194</td>
<td>1,194</td>
<td>1,194</td>
<td>1,194</td>
<td>1,194</td>
<td>1,194</td>
<td>1,194</td>
<td>1,194</td>
<td>1,194</td>
<td>1,194</td>
<td>1,194</td>
<td></td>
</tr>
<tr>
<td>Total Capital Costs at Present Values</td>
<td>1,194</td>
<td>1,194</td>
<td>1,194</td>
<td>1,194</td>
<td>1,194</td>
<td>1,194</td>
<td>1,194</td>
<td>1,194</td>
<td>1,194</td>
<td>1,194</td>
<td>1,194</td>
<td>1,194</td>
</tr>
</tbody>
</table>

| Benefit/Cost Ratio = |     |     |     |     |     |     |     |     |     |     |     |                      |
| n \(\frac{1}{1-0.055^{10}}\) \(\frac{(E \(_a\) - E \(_b\) - E \(_c\) + E \(_d\) - E \(_e\))}{(E \(_f\) - E \(_g\)) + (E \(_f\) - E \(_h\))}\) |     |     |     |     |     |     |     |     |     |     |     |                      |
| \(\frac{1}{1-0.055^{10}}\) \(\frac{(E \(_a\) - E \(_b\) - E \(_c\) + E \(_d\) - E \(_e\))}{(E \(_f\) - E \(_g\)) + (E \(_f\) - E \(_h\))}\) |     |     |     |     |     |     |     |     |     |     |     |                      |
| B \(\frac{E \(_a\) - E \(_b\) - E \(_c\) + E \(_d\) - E \(_e\)}{E \(_f\) - E \(_g\)}\) | 3.73 | 3.73 | 3.73 | 3.73 | 3.73 | 3.73 | 3.73 | 3.73 | 3.73 | 3.73 | 3.73 |                      |
| C \(\frac{E \(_a\) - E \(_b\) - E \(_c\) + E \(_d\) - E \(_e\)}{E \(_f\) - E \(_g\)}\) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |                      |
(iv) Development takes place over 6 years, and from the seventh year an annual sum of about $47,000 is included as disbenefit to cover depreciation at three per cent;

(v) As output expands between the eighth and twelfth years, additional operating costs are incurred, which are estimated at $30 per beast sold. This figure has been calculated by distinguishing 12 categories of variable costs in the tabulations of regional costs in the 1962-63 to 1964-65 BAE survey. These are - fuel, fertiliser, pest destruction, livestock supplies, repairs, inward freight, plant hire, agistment, miscellaneous costs, labour payments, rations costs and contract labour charges. Their total value for properties on the Barkly Tableland for the average of the three survey years was $46,842 per property. Allocated against net sales of 1,728 head this gives a cost of $27.11 per beast marketed. Assuming a 3 per cent rise in costs per year from 1964 to 1967 this gives a figure of $29.55 which has been rounded upwards. It compares to a figure of $28.88 per additional sale on a breeding and fattening property as estimated by Jenkins and Hirst;

(vi) Road construction costs $2,790,000 which is spread over 3 years;

(vii) Full development is reached in the twelfth year (i.e. 1980). This involves a compound increase in the cattle population of 1.14 per cent over the period;

(viii) Benefits and costs are discounted at 5.5 per cent, and no salvage values are allowed at the end of the 50 year development span.

Under these assumptions the sum of the discounted net benefits of the total scheme is about $15,142,000 and capital costs on public and private investment are $4,039,000. This gives a net present value surplus, which may be viewed as an increase in the economic rent of the subregion, of over $11,000,000, and the benefit-cost ratio is a favourable 3.75:1.00.

At this point it is necessary to clarify some of the inherent assumptions in the official projections. As the analysis stands it measures the profitability of a long-run adjustment to three distinct, and only partially related,
causative elements -- the investment of private capital in improvements, the investment of public capital in road construction, and the adoption of the use of road transport. The comparison lies with a situation in which production is maintained at the existing level 'without' any of the postulated changes. To refine the assessment of the structure of benefits it is necessary to consider the effect of each of these factors separately. In the first place a pessimistic view of the productivity of private investment will be taken while the other two assumptions are maintained.

The details of the value of production at the three stages given in the official estimates can be criticised on a number of grounds but two are particularly important. First, to attain a 1.14 per cent increase in the growth of the cattle population over the twelve year period would require a very significant decrease in herd mortality, especially when it is assumed that an additional 6,000 head will be turned-off annually in the immediate stage, for most of these animals would be cast breeders. Second, it seems unreasonable to link a 22.2 per cent turn-off rate in the attainable state with an increase in the average value of sales to $80 per head. Reference to the herd model data discussed earlier in the chapter would suggest that such a high rate of turn-off could only be achieved by a switch to specialisation in breeding, in which case the average receipts per beast would not increase above those of the existing stage and might even decrease. Since stock permit data shows that fats made up 78 per cent of the production of the subregion in 1966, and the industry as a whole appears to have diversified to breeding and fattening the three northern regions since the opening of the export meatworks, it is probable that the stations on the Barkly Tableland will maintain a mixed output structure in which three year old slaughter bullocks play a major part. If this is so, a reasonable estimate of the turn-off rate would be 17 per cent. The table of benefits and costs has therefore been reworked under the following assumptions:
(i) Road transport saves $5 per head on the existing turn-off of 22,000, due to the reduction of deterioration losses. This gives an annual benefit of $110,000;

(ii) Immediate benefits will be restricted to the annual sale of 4,000 culled females to allow for herd growth. These will be worth $60 per head. This gives a turn-off rate of 18.6 per cent;

(iii) During the first twelve years of the adjustment period the subregional cattle population rises to the projected level of 162,000 head. Sales of culled females gradually decline in importance but the turn-off rate stabilises at 17.0 per cent giving an increment of 5,500 head on the existing production. These animals are bullocks and fattened heifers with an average value of $80 per beast.

(iv) Increasing the turn-off rate and raising the number of head run, results in additional operating costs of $30 per additional beast produced in the attainable stage. However, the steps necessary to reduce mortality result in this expenditure being incurred from the first year of the decision to change operations.

In other respects the calculations are identical to those given in Table 7.4. As shown in Table 7.5, these assumptions result in a negative net present value and a benefit-cost ratio of 0.84 : 1.00. Furthermore, the savings on existing movements, which are essentially costless to the producer, exceed the net benefits of the reorganisation of the operations of properties. The comparison of the results of the optimistic and pessimistic calculations of future benefits illustrates the difficulty of making a reliable estimate of the impact of a road proposal, given the assumption that it is a prerequisite to development. The most reasonable estimate of the benefit-cost ratio would appear to be that given in Table 7.5, in which case the project cannot be considered worthwhile under efficiency criteria. Moreover, it seems likely that the high overall quality of land in the subregion would encourage adjustment more readily here than in any other area of natural pasture affected by the construction of beef roads.
Table 7.5: Summary of Benefit-Cost Analysis of Road investment and property development, Anthony Lagoon — Barkly Highway Sealed Beef Road — Pessimistic assumptions

<table>
<thead>
<tr>
<th>Benefit/Cost Ratio</th>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savings on Existing Trade</td>
<td></td>
<td>110</td>
<td>110</td>
<td>110</td>
<td>110</td>
<td>110</td>
<td>110</td>
<td>110</td>
<td>110</td>
<td>110</td>
<td>110</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>Immediate Gains</td>
<td></td>
<td>240</td>
<td>240</td>
<td>240</td>
<td>240</td>
<td>240</td>
<td>280</td>
<td>320</td>
<td>360</td>
<td>400</td>
<td>440</td>
<td>480</td>
<td></td>
</tr>
<tr>
<td>Operating costs</td>
<td></td>
<td>165</td>
<td>165</td>
<td>165</td>
<td>165</td>
<td>165</td>
<td>165</td>
<td>165</td>
<td>165</td>
<td>165</td>
<td>165</td>
<td>165</td>
<td></td>
</tr>
<tr>
<td>Depreciation</td>
<td></td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>(Road Maintenance)</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(benefits - costs)</td>
<td></td>
<td>115</td>
<td>115</td>
<td>115</td>
<td>115</td>
<td>68</td>
<td>108</td>
<td>148</td>
<td>188</td>
<td>228</td>
<td>267</td>
<td>268</td>
<td></td>
</tr>
<tr>
<td>(1+0.055)^n (Present value factor)</td>
<td></td>
<td>1.000</td>
<td>0.984</td>
<td>0.982</td>
<td>0.899</td>
<td>0.908</td>
<td>0.765</td>
<td>0.873</td>
<td>0.969</td>
<td>0.692</td>
<td>0.586</td>
<td>0.536</td>
<td>0.892</td>
</tr>
<tr>
<td>Net Benefits in Present Values</td>
<td></td>
<td>104</td>
<td>98</td>
<td>93</td>
<td>88</td>
<td>49</td>
<td>73</td>
<td>96</td>
<td>116</td>
<td>134</td>
<td>159</td>
<td>2,399</td>
<td></td>
</tr>
</tbody>
</table>

Note: The cost estimates in this case are identical to those given in Table 7.4

\[
\text{Benefit/Cost Ratio} = \frac{\sum_{t=1}^{n} (1+0.055)^{t} (E_{a} - E_{b} + E_{d})}{\sum_{t=1}^{n} (1+0.055)^{t} (E_{f} + E_{g} - E_{h})}
\]

\[
E = 3.401, \quad C = 3,039, \quad B = \frac{E}{C} = 1.13
\]
This conclusion does not mean that it is necessarily uneconomic for operators to enter into development programmes of the type described because, in reality, success does not depend on the road improvement. Analysis of the stock permits issued in 1966 for the seven stations in the subregion shows that 93 per cent of the total turnoff of 20,671 head was moved by road transport. At this time the road under consideration had been completed to gravelled beef road standard, but field interviews in the 1967 and 1968 seasons indicated that the new route was little used. To explain this it is necessary to consider the pattern of allocation. In 1966, 77 per cent of the fatstock produced in the subregion went to Queensland, and a further 19 per cent were sent to the Katherine meatworks. The shortest road routes to these centres follow the stockroute from Elliott to Soudan, via Brunette Downs (see Map 6.1); this is a graded track which traverses black soil plains for most of its length and, in dry conditions, provides an adequate surface for road trains. According to the manager of Brunette Downs, hauliers will not offer preferential rates for trips on gravel or bitumen surfaces, so that to use the new road for consignments to Queensland would involve an extra cost of about $2.30 per beast for a detour of seventy miles. However, it must be noted that the new alignment would have significant advantages for any future trade between the subregion and the Alice Springs District.

The problem of maximising the return on capital in road improvement schemes consists of selecting the route that will gain the greatest amount of diverted traffic and choosing the most economic standard of construction. As has been seen, the location of the Anthony Lagoon - Barkly Highway road does not encourage the diversion of traffic. The second aspect of the problem can be explored by measuring the net benefit of sealing the route. Table 7.6 sets out a reworked version of Table 7.4 under the following assumptions:
Table 7.6: Summary of Benefit-Cost Analysis of road investment and property development. Anthony Lagoon - Barkly Highway Gravel Reef Road - Optimistic assumption

(1980)

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13-50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefit Estimates at Current Values</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$E_b - E_c$ (Gross Benefits)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Unadjusted Benefits</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>712</td>
<td>924</td>
<td>1,136</td>
<td>1,348</td>
<td>1,560</td>
<td>1,560</td>
<td>1,560</td>
<td>1,560</td>
<td>1,560</td>
</tr>
<tr>
<td>b) Rate cost disbenefit</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>c) Deterioration loss disbenefit</td>
<td>43</td>
<td>43</td>
<td>43</td>
<td>43</td>
<td>43</td>
<td>50</td>
<td>56</td>
<td>61</td>
<td>67</td>
<td>72</td>
<td>72</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>$E_b - E_d$ (Additional property operating costs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Operating costs</td>
<td>47</td>
<td>47</td>
<td>47</td>
<td>47</td>
<td>47</td>
<td>47</td>
<td>47</td>
<td>47</td>
<td>47</td>
<td>47</td>
<td>47</td>
<td>47</td>
<td>47</td>
</tr>
<tr>
<td>b) Depreciation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$E_s$ (Road Maintenance)</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>$E_b - E_c - E_d + E_s$ (Net Benefits)</td>
<td>711</td>
<td>771</td>
<td>771</td>
<td>771</td>
<td>771</td>
<td>724</td>
<td>482</td>
<td>659</td>
<td>798</td>
<td>955</td>
<td>1,113</td>
<td>1,113</td>
<td></td>
</tr>
<tr>
<td>$(1+0.05)^n$ (Present value factor discount rate = 4.4%)</td>
<td>1.000</td>
<td>0.948</td>
<td>0.899</td>
<td>0.852</td>
<td>0.808</td>
<td>0.765</td>
<td>0.723</td>
<td>0.698</td>
<td>0.672</td>
<td>0.619</td>
<td>0.586</td>
<td>0.556</td>
<td>8.932</td>
</tr>
<tr>
<td>Net Benefits in Present Values</td>
<td>733</td>
<td>716</td>
<td>700</td>
<td>284</td>
<td>233</td>
<td>336</td>
<td>417</td>
<td>494</td>
<td>560</td>
<td>619</td>
<td>9,964</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost Estimates at Current Values</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$E_f - E_c$ (Additional property capital investment)</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
</tr>
<tr>
<td>$E_f^h$</td>
<td>700</td>
<td>700</td>
<td>700</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Capital Costs</td>
<td>964</td>
<td>964</td>
<td>964</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
<td>264</td>
</tr>
<tr>
<td>Total Capital Costs at Present Values</td>
<td>964</td>
<td>914</td>
<td>867</td>
<td>225</td>
<td>213</td>
<td>202</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Benefit/Cost Ratio =

\[
\frac{\sum_{t=1}^{n} (1+0.05)^t (E_b - E_c - E_d + E_s)}{\sum_{t=1}^{n} (1+0.05)^t (E_f - E_c)}
\]

\[
\frac{13,848}{3,385} = 4.09
\]
(i) the road is constructed to gravelled beef road standards, at a capital cost of $15,000 per mile. Maintenance costs are equal to those incurred on a sealed surface;

(ii) all the beasts produced in the subregion travel 100 miles on the road. Hauliers charge 70 cents per K-mile for trips over the route, but would reduce this to 60 cents per K-mile if the road was sealed. This results in excess rate costs which rise as turn-off is adjusted (vis-à-vis the calculations given in Table 7.4);

(iii) losses from bruising, and other forms of damage on the gravel surface equal 2.5 per cent of the value of all sales. This disbenefit would be avoided by sealing.

These assumptions almost certainly over-estimate the disbenefits associated with gravel surfaces. Despite this fact the benefit-cost ratio is superior to that for the sealed road, though the present value of total net benefits, less costs, is slightly lower. In view of the risks involved and the long-term nature of the investment, the analysis suggests that sealing is unwarranted. This confirms the conclusions reached in Chapter 6, which were based on an evaluation of savings on existing and immediate movements. There seems little doubt that the money spent on upgrading the road to bitumen standard would have been better spent on the reconstruction of neighbouring roads to pastoral road standards.

The general conclusion that can be drawn from the case study is that public capital has probably been spent unwisely on the Anthony Lagoon - Barkly Highway beef road, though two qualifications must be made to this statement. First, the project is part of a wider plan to open up the Northern Territory Gulf Country. Official projections for the whole scheme show gross attainable benefits of approximately $2,400,000 per year from twenty-two stations and the total capital investment in roads is about $11,390,000.1 The realisation of the full potential would involve an increase in the average stocking rates of the

1 Minutes of Evidence ... Beef Roads, Western Barkly Tablelands... , 1968, p.2.
stations in the Gulf Country from 1.19 per square mile to 5.17 per square mile. Although there may be limited potential for the establishment of Townsville Stylo in this area, it appears that the greater part of the development would be on natural pastures, which would entail high capital and operating costs to attain the postulated turn-off rate of 16 per cent at such low stocking densities. Furthermore, the increase in the cattle population of nearly 100,000 head could not be met within fifteen years unless imports ran at a high level. This makes it unlikely that benefits from this source would add to the viability of the study road in the short-term. Second, the exploitation of mineral bodies at McArthur River might lead to the creation of a settlement of 6 to 10,000 people, with a deep-water port on Vanderlin Island. This could encourage the erection of a meatworks to process cattle from the Gulf and Tableland properties, while the local market would provide an additional stimulus to expansion. In this case benefits might accrue through a wide range of developmental effects and the road investment would be one causative element. Returning to the existing state of the beef industry, it appeared from field interviews in the Borroloola area that many operators were speculating on capital gains from this source and the cheapening of production with improved pastures.

The analyses that have been given of the future development of the subregion have shown that it is possible to examine the long-term impact of the adoption of road transport and better husbandry techniques, and the provision of sealed roads; though the figures are subject to a wide margin of error. The return on private capital in future development seems unlikely to be high considering the survey results for the early 1960s and the fact that operating costs will rise as marginal land is brought into use. In view of this it is highly improbable that the

1 Minutes of Evidence ... Beef Roads, Western Barkly Tablelands..., 1968, p.12.
investment of public capital in roads will be repaid from the net earnings of the industry. This does not mean, of course, that additional motives might not make such investments beneficial to the community. On this point, it may be wise to leave the last word to one of the pastoralists affected by the Anthony Lagoon - Barkly Tableland Highway road.

They never asked anyone here where that road ought to go. So far as I am concerned it is a nuisance, for although it runs within 200 yards of here, they didn't even bother to grade the eight foot rise onto it. Look at those properties further north -- eight and twenty miles off it -- when the Wet comes it might as well be in South Australia for all the good it is to them. Let's face it, the road was built for defence -- they certainly didn't have the cattleman in mind.

Case Study 2: The Roads of the Eastern Victoria River District

The Eastern Victoria River District has been chosen as a second case study to illustrate the importance of considering the total cost of all the road proposals that affect the production units in a subregion. For the purposes of the analysis that follows the area is regarded as being composed of the following stations -- Willeroo, Innesvale, Coolibah, Fitzroy, Humbert River and Bullita, Delamere, Killarney, Birrimba, Victoria River Downs, Montejinni, Camfield, Wave Hill, and the eastern half of Auvergne Station (excluding Newry). These active properties contain within their boundaries or dominate the use of five roads which have received attention under the Beef Roads Programme. The estimated cost, standards, and mileages of these roads are:

---

1 Field interview, June 1968.
<table>
<thead>
<tr>
<th>Standard</th>
<th>Cost($)</th>
<th>Mileage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Katherine - Willeroo - Top Springs</td>
<td>sealed</td>
<td>3,311,760</td>
</tr>
<tr>
<td>Top Springs - Wave Hill</td>
<td>sealed</td>
<td>2,710,904</td>
</tr>
<tr>
<td>Willeroo - Timber Creek</td>
<td>sealed</td>
<td>3,350,000</td>
</tr>
<tr>
<td>Dunmarra - Top Springs</td>
<td>gravel</td>
<td>1,484,000</td>
</tr>
<tr>
<td>Top Springs - Timber Creek</td>
<td>gravel</td>
<td>2,070,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>12,926,664</strong></td>
</tr>
</tbody>
</table>

The thirteen leases influenced by these roads cover 30,812 square miles of which 52 per cent may be considered usable for grazing. The percentage distribution of the pasture associations identified in Appendix 1 is as follows:

<table>
<thead>
<tr>
<th>Pasture Association</th>
<th>Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley Mitchell Grass Country</td>
<td>1.9</td>
</tr>
<tr>
<td>Barley Mitchell Grass and other Perennial Grasses</td>
<td>10.4</td>
</tr>
<tr>
<td>Inferior Mitchell Grass</td>
<td>7.6</td>
</tr>
<tr>
<td>Arid Short Grass Plains</td>
<td>2.6</td>
</tr>
<tr>
<td>Short Grasses and Forbs on Lowlands mixed with Hilly Country</td>
<td>12.9</td>
</tr>
<tr>
<td>Tippera Tall Grass Plains</td>
<td>12.3</td>
</tr>
<tr>
<td>Tippera Tall Grass Plains on Low Hilly Country</td>
<td>3.5</td>
</tr>
<tr>
<td>Upland Tall Grass Plains</td>
<td>0.4</td>
</tr>
<tr>
<td>Lowland Tall Grass Plains</td>
<td>0.4</td>
</tr>
<tr>
<td>Useless Country</td>
<td>48.0</td>
</tr>
</tbody>
</table>

The area may be considered to be of relative high quality in terms of its natural pastures but much of the good country is dissected by rugged and spinifex land types.

Official estimates are not available for the production of the subregion in the three stages of development, but figures have been extrapolated from projections made for the units influenced by the Willeroo - Timber Creek road.\(^1\)

\(^1\) Construction costs have been estimated at about $14,000 per mile for the Dunmarra - Top Springs and Top Springs - Timber Creek roads. $5.04 million was allocated for the 364 miles from Dunmarra to the Western Australia border (see Table 6.2).

Checking against field data and confidential information supplied by the NTA suggests that the figures for the present stocking and turn-off rates are reliable. Given the four development conditions described in the first case study, the output and characteristics of the industry are forecast to rise in the following manner:

<table>
<thead>
<tr>
<th>Cattle Population</th>
<th>Annual Turn-off</th>
<th>Turn-off Rate (per cent)</th>
<th>Average Value per Beast ($)</th>
<th>Total Value of Production ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>155,000</td>
<td>17,050</td>
<td>11.0</td>
<td>60.0</td>
</tr>
<tr>
<td>Immediate</td>
<td>155,000</td>
<td>22,475</td>
<td>14.5</td>
<td>60.0</td>
</tr>
<tr>
<td>Attainable</td>
<td>246,500</td>
<td>44,370</td>
<td>18.0</td>
<td>80.0</td>
</tr>
</tbody>
</table>

The projected increases in output are assumed to be linked to the construction of the roads, though it is apparent that the opening of the Katherine and Darwin meatworks has been essential as a complementary development to provide an outlet for stock.

Using these figures as an optimistic view of the future, the costs and benefits that may accrue as a result of the investment in the beef roads have been calculated on the following assumptions:

(i) the immediate benefits of a change in operations are worth $325,000, and this stream lasts from the third to the seventh years. The sum arises from the sale of previously unmarketable stock such as scrub bulls and culled cows. No additional on-property operating costs are incurred from their exploitation;

(ii) road maintenance costs are increased by $500 per mile. This results in an annual disbenefit from the third year of $311,000;

(iii) necessary improvements to permit cattle numbers and the turn-off rate to rise to the attainable stage are estimated to be 100 made waters, 500 miles of suspension fencing, 1,000 miles of more robust 4-barb fencing, and 100 yards. These figures are estimated from discussions with pastoralists in the 1968 season who were asked: 'What improvements will be necessary to bring the
station to full development? The operators of only 10 of the units in the subregion were contracted, and the information supplied is very approximate; it probably much understates the full range of improvements needed. Development is assumed to be restricted to natural pastures. The capital cost of the private investment programmes is about $2,325,000, assuming the same average costs per item as those detailed in the first case study;

(iv) as output expands to the attainable level between the eighth and twelfth years (assumed to be 1975 to 1980), additional operating costs are incurred. These are estimated at $30 per additional beast sold. The procedure adopted is the same as had been described in the first case study. In the Victoria River District variable station costs averaged $50,451 per unit from 1962-63 to 1964-65, and net sales were 1,872 head. Adjusted to 1967 levels by an annual 3 per cent increment, this gives a sum of $29.37 per head. For convenience and comparability this has been rounded to $30;

(v) full development is reached in year twelve, which involves a 3.94 per cent increase in the cattle population;

(vi) in other respects the assumptions and procedures are as described in Case Study 1.

The net costs and benefits of the integrated programmes are shown in Table 7.7, and it can be seen that the benefit-cost ratio is 1.11 : 1.00. According to Duhs a result such as this would be sufficient for the rejection of the proposals. As can be readily appreciated from previous discussions of herd and turn-off rates, the assumptions made in the analysis are optimistic, particularly in

(i) the allowance for a cumulative annual growth rate in cattle numbers of 3.94 per cent;

(ii) the exclusion of additional operating costs up to the eighth year.

---

### Summary of Benefit Cost Analysis of Road Investment and Property Development, Eastern Victoria River District - Optimistic Assumptions

#### ($000)

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12 (Respectively)</th>
<th>13-50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefit Estimates at Current Values</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>$E_t - E_{t-1}$ (Gross Benefits)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$E_t - E_{t-1}$ (Additional property operating costs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>a) operating costs</td>
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<tr>
<td>b) depreciation</td>
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<tr>
<td>$E_t$ (Road Maintenance)</td>
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<tr>
<td>$E_t = E_t - E_{t-1} + E_{t-1} - E_{t-1}$ (Net Benefits)</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>$\frac{1 + 0.055}{50}$ Present value factor discount rate = 5%</td>
<td>1.000</td>
<td>0.948</td>
<td>0.899</td>
<td>0.852</td>
<td>0.808</td>
<td>0.765</td>
<td>0.725</td>
<td>0.698</td>
<td>0.652</td>
<td>0.619</td>
<td>0.586</td>
<td>0.556</td>
<td>8.952</td>
</tr>
<tr>
<td>Net Benefit in Present Values</td>
<td>13</td>
<td>12</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>-41</td>
<td>176</td>
<td>365</td>
<td>577</td>
<td>689</td>
<td>826</td>
<td>13,303</td>
<td></td>
</tr>
<tr>
<td>Cost Estimates at Current Values</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>$E_t - E_{t-1}$ (Additional property capital investment)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>$E_t$ (Capital cost of road)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Capital Costs</td>
<td>4,688</td>
<td>4,688</td>
<td>4,688</td>
<td>388</td>
<td>388</td>
<td>388</td>
<td>388</td>
<td>388</td>
<td>388</td>
<td>388</td>
<td>388</td>
<td>388</td>
<td></td>
</tr>
<tr>
<td>Total Capital Costs at Present Values</td>
<td>4,688</td>
<td>4,688</td>
<td>4,688</td>
<td>4,214</td>
<td>331</td>
<td>331</td>
<td>297</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Benefit/Cost Ratio =**

\[
\frac{\sum_{t=1}^{n} (E_t - E_{t-1} + E_{t-1} - E_{t-1})}{\sum_{t=1}^{n} (E_t + E_{t-1} - E_{t-1})} = \frac{15,202}{14,287} = 1.08
\]
In this case, however, it is certain that nearly all the generated traffic will travel over one of the upgraded roads, since the proposals amount to a reconstruction of the complete network. This does not mean that the projects have been essential for the adoption of the use of road transport. In the 1966 season approximately 93 per cent of movements were made by this mode, though only the Top Springs - Dunmarra road had been completed (to gravel beef road standard). Separating again the three possible causative elements in long-term adjustment -- the adoption of road transport, spending on structural improvements, and the provision of higher quality roads, it seems clear that the latter plays a relatively minor role.

From the developmental viewpoint the subregion presents an interesting case because the whole of the Victoria River District has been given a strong incentive to expand by the opening of the two northern meatworks, which has raised prices for all categories of stock and provided new marketing opportunities. In view of this, detailed field interviews were undertaken in the area, and owners or managers were asked to estimate the additional improvements that would be required to bring their properties to 'full development' on natural pastures, and to predict herd numbers and turn-off at this attainable state. Numerous difficulties are encountered in such an approach; among these are the fact that many operators visualise 'normal' seasons as good seasons, and feel obliged to supply rather optimistic figures to anyone from Canberra. Nevertheless the results, which refer to June 1968, are interesting. For eleven units, in a sample biased towards the properties on better land, the producers estimated that herd numbers could increase by 18 per cent, given a 46 per cent rise in the number of made waters, a 53 per cent rise in the total mileage of fencing, and a 37 per cent increase in the number of yards. Their own estimates of present production give a turn-off rate of 12.6 per cent, and a potential rate on the higher cattle population of 14.3 per cent. Of the sample, all but one expected turn-off to rise, and the operator of this exceptional station
admitted that he had been over-exploiting his cattle herd to service debts. The surprising point about the figures is that producers appear to see an increase in stocking rates as the main source of a rise in output, and do not favour a marked shift to higher technical efficiency.

Using the figures given above as a guide, the benefits and costs of total development have been recalculated on a pessimistic basis and the result is given in Table 7.8. The assumptions differ from those of the previous analysis on the following details:

(i) following the exploitation of immediate sales, turn-off stabilises at 14.5 per cent, but the value of additional sales rises between the eighth and twelfth years from $50 to $80 per head;

(ii) the subregional cattle population rises 18 per cent over the 12 year adjustment phase to about 183,000;

(iii) the rise in operating costs that would be expected to follow the increase in output of 9,500 head (9,500 at $30.00 = $285,000) is incurred in the first year of the adjustment to bring herds under greater control;

(iv) immediate savings on existing movements of $10 per head are made, and this level remains constant throughout the period. It reflects the new opportunities created by the use of road transport, and an increase in the quality of the stock sold.

Under these assumptions the whole development, including the use of public and private capital, would show a negative return for the first eight years and a final benefit-cost ratio of 0.15 : 1.00. Here the capital cost of the road programme completely outweighs the benefits that might accrue from the reorganisation of production. This illustrates the problems that arise in allocating road expenditure in areas of extensive land-use where incorrect judgements on standards and segment priorities are heavily penalised. One of the main reasons for over-spending in the subregion is the switch in the marketing pattern that followed the opening of the two northern meatworks. Stock permit data shows that in 1957, over 27,000 head travelled the Murranji stockroute.
Table 7.8: Summary of Benefit-Cost Analysis of road investment and property development, Eastern Victoria River District - Pessimistic Assumptions ($000)

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13-50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefit Estimates at Current Values</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>( E_t - E_{t0} ) (Gross Benefits)</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
</tr>
<tr>
<td>b) gains on generated trade</td>
<td>416</td>
<td>502</td>
<td>588</td>
<td>674</td>
<td>760</td>
<td>760</td>
<td>760</td>
<td>760</td>
<td>760</td>
<td>760</td>
<td>760</td>
<td>760</td>
<td>760</td>
</tr>
<tr>
<td>a) operating costs</td>
<td>311</td>
<td>311</td>
<td>311</td>
<td>311</td>
<td>311</td>
<td>311</td>
<td>311</td>
<td>311</td>
<td>311</td>
<td>311</td>
<td>311</td>
<td>311</td>
<td>311</td>
</tr>
<tr>
<td>b) depreciation</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>( E_t ) (Road Maintenance)</td>
<td>211</td>
<td>211</td>
<td>211</td>
<td>211</td>
<td>211</td>
<td>211</td>
<td>211</td>
<td>211</td>
<td>211</td>
<td>211</td>
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<td>211</td>
<td>211</td>
</tr>
<tr>
<td>( E_t - E_{t0} + E_t - E_{t0} ) (Net Benefits)</td>
<td>-96</td>
<td>-96</td>
<td>-96</td>
<td>-96</td>
<td>-96</td>
<td>-96</td>
<td>-96</td>
<td>-96</td>
<td>-96</td>
<td>-96</td>
<td>-96</td>
<td>-96</td>
<td>-96</td>
</tr>
<tr>
<td>( (1+0.055)^n ) Present value factor (discount rate = 5%)</td>
<td>1.000</td>
<td>0.948</td>
<td>0.899</td>
<td>0.852</td>
<td>0.808</td>
<td>0.765</td>
<td>0.725</td>
<td>0.698</td>
<td>0.672</td>
<td>0.647</td>
<td>0.622</td>
<td>0.598</td>
<td>0.576</td>
</tr>
</tbody>
</table>

The cost estimates for this analysis are identical to those given in Table 7.7.

\[
\text{Benefit/Cost Ratio} = \frac{\sum_{t=1}^{n} (1+0.055)^t (E_t - E_{t0} + E_t - E_{t0})}{\sum_{t=1}^{n} (1+0.055)^t E_{t0} - E_{t0}}
\]

\[
B = 2.180 \quad C = 0.13
\]

\[
\frac{B}{C} = 16.537 = 1.00
\]
(from the whole of the Victoria River District) while fewer than 600 animals were walked to Katherine via the Coolibah and Dry River routes. By 1966 about 19,000 fats were being road transported over the Willeroo to Katherine road, and 14,500 stores followed the traditional outlet to the Barkly Tableland and Queensland via the Top Springs to Dunmarra road. Thus recent expenditure has been concentrated on the roads leading to Katherine as inter-regional trade has become less important. Ideally, forward planning would anticipate changes in the trading pattern and the components of accessibility would be viewed in a systematic manner.

Reviewing the two case studies it is possible to draw a number of general conclusions on the relationship between road investment and land development. When a project post-dates modal substitution it may only be credited with the value of rate and non-rate cost savings, and the additional production that is stimulated by the concurrent rise in net received prices. This is true of the proposals in the Beef Roads Programme, which makes it unlikely that they will generate new economic activity, for the localised elasticity effects of the improvements are not large in comparison to normal fluctuations in market prices. Where a new road encourages the adoption of road transport the mobility gains may be substantial and the project may be more easily identified as a cause of agricultural adjustment. In the study industry, route and mode changes are only part of a complex of factors that affected the range and profitability of production between 1962 and 1967. Overall, prices in the three northern Districts doubled during this period due to the entry of the Katherine and Darwin meatworks and the continued United States demand for boner-beef. Hence, the relative influence of the exogenous causative elements would have to be separated in the benefit-cost analyses to be able to attribute a discrete return to the transportation component. This is obviously impracticable, and the studies can only give a guide to the viability of development in the context of the current economic environment.
Production may also expand in the future as a result of the cheapening of inputs, technological advances in husbandry, and on-property investment which is directed by motives like speculation. In reality, the economic rents of properties are determined by a host of factors and the possibility of identifying purely locational responses is slight. Nevertheless, the concept of spatial equilibrium provides a valuable aid in distinguishing some of the processes that may link investment in transportation and the intensification of land-use. Finally, from a public policy point of view it seems clear that a planning agency should seek to assure the Government that schemes like the Beef Roads Programme will make a positive contribution to national welfare. This is best done by comparing benefits and costs under efficiency criteria, taking due account of the uncertainty of development and the problems of selecting standards and priorities. If a project is adopted because of its power to generate complementary activity, the additional production should repay the use of public funds for as von Thünen states

If a highway is built, and a tax is levied on all the farms that use it, these farms, despite the new imposition, may still attain a higher value than they had previously.¹

Judgement in this light would prevent benefit-cost analysis being used as a framework for biased estimates of the net value of agricultural adjustment along a route. This would leave the way clear for the evaluation of income redistribution and other national objectives by different standards and techniques.

C. PRIVATE AND PUBLIC ATTITUDES TO LAND DEVELOPMENT IN THE NORTHERN TERRITORY

1. A wider view of the deployment of private capital

The first section of Part A of this chapter noted that the published statistics on the economic viability of the Northern Territory beef cattle industry in the period from 1962 through 1965 indicate a low return to capital and management income. Although prices have shown a tendency to rise more rapidly than costs, it seems unlikely that the industry as a whole is receiving more than a modest annual return for a substantial capital investment. The expenditure on improvements that is being made in the industry can be explained in terms of an adjustment in the scale of the input mix of units to exploit higher prices and new marketing opportunities; the need to substitute capital for labour; and a general desire to decrease the importance of short-term uncertainty from drought and to offset the effects of a long-run decline in pasture quality. Despite the obvious importance of these factors, the presence of low and potentially risky returns suggests that in some cases at least, the expenditure could have been diverted to more productive fields in the national economy. Given the validity of this conclusion, it is necessary to examine briefly some additional hypotheses on investment.

Martin and Jefferies formulated five possible explanations for the behaviour of ranch owners in Arizona from 1962.¹ They found that the return to capital and management income in extensive cattle raising was low or negative, and yet the prices paid for ranches and grazing permits indicated a buoyant industry. Their five hypotheses were:

(i) that early entrants would maintain operations in the hope of capital gains on the sale of their unit;
(ii) that new entrants are often speculators who see land as an avenue for short-term gains;
(iii) that many of the landholders had interests in some other form of enterprise and used ranching as a tax shelter;
(iv) that many ranch buyers were indulging in a form of conspicuous consumption and regarded land holding as a symbol of status;
(v) that many operators were 'ranch fundamentalists' who were attracted to the mode of life and the glamour of being a cowboy.

The authors concluded that conspicuous consumption was probably the most important explanation of the behaviour of the land market, and commented

how much more rewarding it might be to us economists to acknowledge that ranching (like farming) is a complex investment in several outputs. Such an investment requires a great deal more analysis than is offered by our traditional costs-and-returns analyses related only to the most obvious product.

The work that follows will examine how far this holds for the study industry.

In theory, the land market should be based on the productive capacities of the units sold so that the value of a block could be determined by the simple formula

\[ V = \frac{E}{r} \]

where, \( E = \) the annual average economic rent, and \( r = \) the capitalisation interest rate.\(^2\) Thus a property earning an

economic rent or net profit of $20,000 per year would be worth $363,636 to a new owner at a capitalisation interest rate of 5.5 per cent. Where future expectations involve resource depletion or long-term gains the formula must be modified. The state of the land market, therefore, should, under *ceteris paribus* conditions, be a good index of present returns and the potential for development. Indeed the comparison of land values in an area influenced by a highway proposal on a 'before and after' basis, using a similar but unaffected area as a control, provides one method of estimating the impact of road investment. This technique cannot be applied to shifts in resource use in the Northern Territory following the implementation of the Beef Roads Programme because there have been too few sales and insufficient time has elapsed to be able to observe a response. Some conclusions, though, may be drawn on the state of the industry from the behaviour of the land market over the study period.

Virtually all the land under pastoral occupation in the Northern Territory is held on a leasehold basis. The maximum area that can now be held by one individual or company is 5,000 square miles, and development and stocking conditions are imposed on leases. Rents are assessed on a beast-area estimate of potential and tenure is normally given over a fifty-year period. Many leases were renewed in the mid-1950s and nearly all titles, excluding those in the Alice Springs District, had been renewed by 1967. In that year the Crown Lands Ordinance was amended to permit the conversion of leases between the twentieth and fortieth years of their term, and to allow for limited agricultural development on properties. There is no restriction on the sale of leases. Between 1957 and 1967 eighty-six Lease Transfer Orders (LTOs) were issued on the sale of holdings, and examination of these records provides the basis of observations that follow. The data is not a highly reliable index of the state of the land market for four reasons; payments are supposed to refer to the value of land and improvements but may include livestock if herd numbers are

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1 Extracted from the archives of the Attorney-General's Department, Darwin, fieldwork, August 1968.
not known; some transfers are between members of a family who may be charged nominal rates; payments are influenced by the number of years remaining to the new lessee; and too few sales of comparable properties occur to permit generalisations on trends.

For the five years from 1957 to 1962, the average value of the land sold was $42.34 per square mile. Transfers referred to 33 leases and covered 44,631 square miles. Between 1963 and 1967, 73,758 square miles changed hands, 53 leases were transferred, and the average payment was $59.51 per square mile. Taken as the average between the means for the two periods, land values rose $3.43 per square mile per year. Sixteen properties changed hands more than once during the decade, and the average annual rise for these stations was $11.08 per square mile. Although these figures only suggest orders of magnitude, they do show that operators may be making substantial capital gains.

The calculations that have been made from the LTO data mask considerable annual and regional variations which reflect land quality and ingoing differences. All qualities of land appear to be realising an increase in value but this is particularly marked in the area influenced by the two new meatworks and the Top End, which has potential for development with Townsville Stylo. According to Condon, a property running 5,000 head on natural pastures in the Victoria River District or the Darwin-Gulf Region would have been worth $150,000 in 1962 and is now (1969) worth $500,000.¹ This order of increase appears relatively common from rumours of payments which suggest that the current value of stocked and relatively well-developed land in the Barkly Tableland Region is $600 to $800 per square mile. In the Alice Springs District land values slumped during the eight year drought; but have since recovered. LTO data shows that the land and improvements of one holding were transferred for $17,000 in 1962 and $145,200 in 1967.

The increases that have occurred in areas that can be developed with Townsville Stylo have been most spectacular. Mountain Valley, which covers 1,094 square miles and is located 100 miles east of Katherine, was sold for $460,000 in 1967, with about 5,000 head of semi-feral cattle on the place. Irrespective of improvements the same property is reported to be worth $650,000 at present (1970). This station, like a number of others in the northern half of the Northern Territory, has been bought by an American interest. The company intends to spend $10 million on development by 1980. The managing director is reported to have admitted that United States tax incentives were a major factor in the decision to develop, and to have explained that without them it wouldn't have been an economic proposition. We are a public company and we go into things expecting to get some kind of a return. If we didn't our shareholders would be down on us in a hurry.

Similar considerations may explain the actions of Australian companies; for instance, the pastoral division of the Hooker Corporation Ltd, showed a $489,000 loss in 1967-68 and $84,000 deficit in 1968-69 and the general manager was eager to claim at a press conference in 1969 that the group had substantial additional losses which it could claim against tax. The ramifications of company finance are beyond the scope of this thesis, but it will be apparent that these considerations can play an important role in land development.

Of the two remaining hypotheses suggested by Martin and Jefferies, ranch fundamentalism would appear to be the most relevant in the Northern Territory. Though most owner-operators are profit-conscious there are many signs that the quality of life in the 'Outback' is an additional attraction. In other cases the cattlemen feel proud to be 'pioneering', and appreciate the immediate challenge of building up an enterprise. Conspicuous consumption is not yet obvious in

1 The Sunday Telegraph, 15 February 1970, p.25.
the Territory but this may supply a further motive for American investment, for according to the *Wall Street Journal* land is being bought there by experienced ranchers [who] come to settle on a new frontier; multimillionaires seeking novel and exciting outlets for excess funds, or by big landholders to match their big egos.¹

In summary, it is essential to take a wide view of the deployment of private capital and to set land development in the context of national and international trends in investment. This provides further reasons for supposing that variations in accessibility are no longer a critical determinant of the intensity of land-use and demonstrate that, in reality, the Northern Territory cannot be considered an Isolated State.

2. Some development policy issues

In the previous discussions of land development that have been given in this thesis it has been assumed that the Northern Territory can be viewed in isolation from the economy of Australia, except that returns are related to the opportunity cost of capital. It is now appropriate to consider some of the implications of the Government's policy towards the beef industry in the North and to look briefly at the present and future patterns of production at the national and regional level.

Table 7.9 sets out a series of indices of productivity, efficiency, and output for the Australian beef industry by States. Perhaps the most graphic statement of the importance of the industry in the Northern Territory to the national economy is provided by a comparison of its output with that of Tasmania. With one quarter of the number of beef cattle, this State produced over 10,000 tons of beef and veal more than the study region in 1966-67. If adjustment is made for the fact that the Northern Territory turned-off 23,074 store

Table 7.6: Productivity, Efficiency and Output in the Australian Beef Industry by States

<table>
<thead>
<tr>
<th>Beef Cattle Numbers ('000)</th>
<th>Victoria</th>
<th>New South Wales</th>
<th>South Australia</th>
<th>Tasmania</th>
<th>Western Australia</th>
<th>Queensland</th>
<th>Northern Territory</th>
<th>Australia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1957</td>
<td>1967</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,044</td>
<td>1,167</td>
<td>236</td>
<td>158</td>
<td>733</td>
<td>6,087</td>
<td>1,176</td>
<td>11,983</td>
</tr>
<tr>
<td></td>
<td>1,360</td>
<td>1,464</td>
<td>464</td>
<td>269</td>
<td>1,158</td>
<td>6,020</td>
<td>1,206</td>
<td>13,744</td>
</tr>
<tr>
<td>Percentage growth 1954-66</td>
<td>7.9</td>
<td>3.7</td>
<td>9.1</td>
<td>8.5</td>
<td>8.5</td>
<td>1.0</td>
<td>0.5</td>
<td>2.3</td>
</tr>
<tr>
<td>Productivity and Efficiency 1962-63 to 1964-65</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Stocking rate (acres per beast equivalent)</td>
<td>4.0</td>
<td>7.3</td>
<td>4.7</td>
<td>4.4</td>
<td>3.5</td>
<td>96.6</td>
<td>35.0</td>
<td>124.5</td>
</tr>
<tr>
<td>2) Branding percentage</td>
<td>68.4</td>
<td>72.0</td>
<td>87.2</td>
<td>68.5</td>
<td>73.9</td>
<td>51.3</td>
<td>55.4</td>
<td>39.7</td>
</tr>
<tr>
<td>3) Mortality percentage</td>
<td>3.1</td>
<td>4.1</td>
<td>1.6</td>
<td>2.2</td>
<td>2.6</td>
<td>12.6</td>
<td>7.2</td>
<td>10.3</td>
</tr>
<tr>
<td>4) Turn-off percentage</td>
<td>57.8</td>
<td>61.6</td>
<td>66.2</td>
<td>67.9</td>
<td>78.6</td>
<td>12.8</td>
<td>32.7</td>
<td>13.0</td>
</tr>
<tr>
<td>5) Cattle equivalents per labour unit</td>
<td>177</td>
<td>215</td>
<td>198</td>
<td>184</td>
<td>156</td>
<td>396</td>
<td>366</td>
<td>830</td>
</tr>
<tr>
<td>Production ('000 tons)</td>
<td>1966-67 (beef &amp; veal)</td>
<td>225.0</td>
<td>209.4</td>
<td>53.8</td>
<td>24.7</td>
<td>54.8</td>
<td>293.8</td>
<td>18.6</td>
</tr>
</tbody>
</table>

cattle in that year, by crediting each beast with 300 lb of dressed meat, the production total rises to 17,700 tons but this is still well below the Tasmanian total. Thus the study industry holds eight per cent of the national beef cattle herd, but supplies only two per cent of national production. Given this fact, the views of observers and commentators tend to polarise around extremely optimistic and pessimistic assessments of potential. On the one hand, it is argued that the low efficiency of the industry indicates the scope for development while, on the other, it seems reasonable to suggest that the past will speak for the future. This work cannot hope to settle the argument and will only consider some broad issues.

Looking first at the performance of northern and southern Australia, it is relevant to note that beef cattle numbers have increased over the period from 1944 to 1966 by 7.9 per cent annually in Victoria, 3.7 per cent in New South Wales, 1.0 per cent in Queensland, and 0.5 per cent in the Northern Territory. The general trend, therefore, appears to be a growth in the importance of production in southern States and virtual stagnation in the traditional strongholds of the industry. While the percentage of cattle turned-off in the South averaged more than 60 per cent over the three years from 1962-63 to 1964-65, comparable figures for the Northern Territory and the Kimberleys show a 13 per cent rate. This means that output per breeder was far lower in the North. Queensland has both 'northern' and 'southern' components in its output, and it may be noted that between 1958 and 1968 the beef cattle population of the Coastal South (Maryborough, Moreton, and Downs Statistical Divisions) rose by 4.9 per cent annually, while the Channel Country showed a fall of -5.1 per cent. From these trends it appears that growth is associated with intensive stocking, low mortality, and a quick turn-over.

To characterise differences in the industry in terms of the North and South is rather dangerous. It can be argued that the real distinction should be made between Arid and Humid Australia, particularly in regard to future development. The introduction of improved pasture in tropical areas promises to make intensive production possible throughout large areas of Queensland and more limited parts of the Northern Territory and the Kimberleys. Davies and Eyles have estimated that 280 million acres are available north of the thirtieth parallel, which have an annual rainfall of over 20 inches, and could therefore be developed with sown pastures. These authors go as far as to suggest that the long-term cattle population of this area could rise to 52 million head. More immediately, there are 20 million acres that could be developed in the Queensland Spear Grass Zone and 12.3 million acres of Brigalow land. Research in the first half of the decade showed that, at the lower beef prices then offering, returns to capital from clearing and developing these forms of land for beef production would be about fifteen and ten per cent respectively.

Although Davidson estimated that the fattening of store cattle on cleared land in the Top End of the Northern Territory would have been an unprofitable sideline to the cultivation of peanuts in 1965, it seems reasonable to

accept the 1968 estimate of a return to capital of 8 per cent on a specialised breeding and fattening unit, given advances in establishment techniques, higher beef prices and the reduction in the cost of superphosphate from $54.92 to $36.40 per ton\(^1\) (landed at Darwin). If this is correct, the advantages of developing sown pastures in this area may well exceed those of expanding production on the natural pastures of the Northern Territory, though the rate of return would probably compare very favourably with a recalculation of the profitability of the Brigalow Land Scheme, incorporating the rise in beef prices. Given the decision to proceed with the second part of the Ord River Scheme, it appears that beef production will also become part of the operations of farmers in this area, though the total return to public and private capital is unlikely to be high. The implications of this brief survey of future development in the beef industry are

(i) that the industry in the Northern Territory may well be increasingly disadvantaged vis-à-vis development in the South,

(ii) that the potential for improved pasture in Tropical Australia is significant, and that the Northern Territory may meet increasing competition in the allocation of resources from intensive land development in Queensland,

(iii) that the section of the industry in the Northern Territory that is dependent on natural pastures may decline in importance in relation to the Top End.

The role of the extensive cattle raising industry in the Northern Territory in the future may well be conditioned by the demand for store and breeding stock in more favoured areas. There is some possibility that the concept of the

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\(^1\) Report of the Committee of Investigation into Transportation Costs in Northern Australia (the Loder Report) Commonwealth of Australia, 1965, p.134-5. Following the recommendations of the Loder Report, a subsidy has been given on the cost of importing superphosphate to Darwin. The landed price at Darwin is pegged to the quoted price at Townsville. This means, of course, that the return of 8 per cent on private capital on sown pasture development should be adjusted to gain a strict efficiency valuation of the expansion of the industry in the Top End.
remote North as a reservoir of store stock could finally come to fruition, but recent trends indicate a marked swing to breeding and fattening and in 1966-67 only 17.6 per cent of the turn-off of the Northern Territory was consigned for immediate slaughter. Looking at the second alternative, it would appear that, from a national point of view, the breeding animals at present in the study region could be put to more productive use in the South or the areas with potential for development with improved pasture in Tropical Australia. Current projections suggest that the supply of forage for beef cattle up to 1980 will outstrip the capacity of the national herd to utilise it. But, as Waring comments

This is not to say that by reducing the climatic risk to which stock are exposed national welfare may not be increased by substituting forage in one area for forage in another, with a consequent redistribution of the livestock population.

In this case the Beef Roads Programme may provide an egress for the cattle of the arid parts of the Northern Territory to happier climes, rather than access to markets for their progeny. In reality, such a pessimistic view must be qualified by the observation that fixity in structural capital and the attitudes of pastoralists will probably determine that production in these areas will be maintained and may even expand significantly, though the relative importance of the industry in the arid zone is almost certain to decline.

The optimum allocation of resources would include the consideration of location, and a national adjustment in the beef industry to a new general equilibrium in production would produce the maximum output for the lowest real cost. As has been seen in the analyses of spatial equilibrium

within the Northern Territory, adherence to a theoretical optimum is often conditioned by a host of institutional and environmental variables, and this is no less true at the national and interstate levels. However, it seems fair to conclude that the general trend throughout the industry is towards the expansion of production on areas of favourable land quality, and a concurrent increase in the importance of technical advances which have made it possible to re-evaluate the pastoral potential of humid Tropical Australia. If Government policy on road construction is therefore in contradiction of the long-term outlook, it is unlikely to be justifiable on strict efficiency grounds. In fact, as has been mentioned in various asides to the main argument in this thesis, several subsidiary motives lie behind the Beef Roads Programme. These include the desire to promote the mining, fishing, and tourist industries, and national objectives such as defence and the raising of living standards among the aboriginal population. In addition the wider view must incorporate the satisfaction of developing the North and opening up some of the last areas of wilderness that remain. It may well be that the title 'Beef Road' was chosen in preference to the more prosaic 'Developmental Road' because it stresses the emotive rather than the economic appeal of Northern Development.
CHAPTER 8

ACCESSIBILITY, TRANSPORTATION, AND LAND DEVELOPMENT

So far these are nothing but assumptions on your part. I'll grant you that they conform to the laws of logic. But are they in accordance with human law? In case you think I'm crazy, let me explain. I agree that man is a creative animal, doomed to strive consciously toward a goal, engaged in full-time engineering, as it were, building himself roads that lead 'somewhere - never mind where'. And perhaps if he feels like straying now and then, it's just because he is doomed to build this road; even the man of action, however stupid he may be, must realise from time to time that his road always goes somewhere and that the main thing is not where it goes but keeping the well-meaning babe at his engineering chores, thus saving him from the deadly snares of idleness, which as is well known, is the mother of all vice. There's no disputing that man likes creating and building roads.

Dostoyevsky, Notes from Underground

INTRODUCTION

Two main objectives remain to be accomplished: the results of the empirical work must be synthesised, and general conclusions on the role of transportation in land development must be sifted from findings that relate to the study industry alone. This final discussion falls naturally into three parts; the consideration of the relationship between accessibility and exchange, the examination of the impact of accessibility on land productivity, and the identification of the important components of locational advantage. The latter provides a framework for the evaluation of investment in transport. Both specific and general inferences will be related to the models of accessibility and location rent response that have been developed throughout the thesis; particular emphasis is given to the problems and methodological issues that arise
in attributing production increases to expenditure on road projects, and stress is placed on the need to take a wide view of the interaction between transportation and land-use.

A. ACCESSIBILITY AND EXCHANGE

The concept of spatial price equilibrium underlies the work reported in this thesis on the efficiency of the system of exchange. This is based on the proposition that a good will move from a location where its value is lower to a location where its value is higher until differences in values are not larger than transportation costs. In von Thünen's Isolated State model, trade was restricted to the transfer of commodities between farmers and the entrepreneurs of a single central Town, where market prices were just sufficient to cover the cost of transportation from the most distant unit which would repay the charges on the resources that were employed, and the cultivated area was just large enough to feed the population of the Town. At the land-use margin the economic rent of land was zero. For holdings of a uniform size in intermediate locations rents arose from variations in the level of local prices for commodities and inputs. It has been suggested that farm net returns may be compared at the scale of the most distant unit, to give an index of comparative advantage which may be termed situation rent. In reality, the presence of alternative marketing opportunities ensures that situation rents are also determined by the rationality of producers' consignment decisions. Where it is reasonable to assume that the commodity entering trade is homogeneous at the point of production and suffers no deterioration in transit, the actual decisions can be compared to a solution generated by a normative model to see whether farmers attempt to minimise transport costs or maximise net received prices. Assessments of the efficiency of allocation by this means provide a valuable insights into the roles played by distance and price in the exchange system and allow further inferences to be drawn on the importance of accessibility in the deployment of resources. However, as has been described in Parts 2 and 3 of the thesis, it is also necessary to
examine the system in more detail and consider such factors as the institutional structure of marketing and the interaction between production and consignment decisions; further complications arise as new demands appear and mobility increases. The aim of this section is, therefore, to draw together these elements and examine the exchange system in the Northern Territory to point up the links between investment in transportation and immediate gains in situation rents.

Chapter 1 documented the changes in marketing opportunities that took place between the early occupation of pastoral leases in the Northern Territory and the period chosen for study in this thesis. Although plans were laid for meat processing plants and trunk rail lines, the actual outlets for cattle were limited to the Wyndham meatworks, trade from the port of Darwin, and the distant demands of fatteners and plants in Queensland and South Australia. Transportation within the region remained virtually unchanged for decades, with the notable exception of the completion of the Oodnadatta to Alice Springs railway in 1929. Thus in 1950 the pattern of exchange reflected years of experience of deterioration losses under on-the-hoof movements and low net receipts for stock at relatively unreliable markets. Conditions began to improve in the early 1950s with increased spending on the stock-route network and the greater stability of prices following the implementation of the Australian-United Kingdom Meat Agreement. By 1957, the datum point for the first study of allocation, beneficial changes were foreshadowed from the control of disease in stock (by the declaration of the Central Australian Pleuro pneumonia Protected Area), and the commencement of the primary growth phase of the adoption of road transport. However, it is reasonable to assume that this year provides a valid picture of the exchange system in adjustment to the traditional structure of property accessibility, and the results of the empirical work will be interpreted in this light.
The total output of the industry in 1957 was about 147,500 head, of which nearly 123,000 were exported from the Northern Territory. The Pleuro Line separated the South Australia supply area from the remaining spheres of market influence so that observations on the impact of transport costs and net received prices on allocation have to be restricted to producer response in the north of the study region. Here, opportunities were restricted to the sale of fat stock to the Wyndham and east coast Queensland processing plants, the live cattle trade to the Philippines, and the transfer of stores within the Territory and across into contiguous areas of Queensland. From a comparison between the actual pattern of exchange and a normative solution generated by the Transportation Problem, it was apparent that total transport payments were close to the minimum, but only under the constraint that all demand schedules were met in full. Actual supply area boundaries were relatively discrete, which suggests that market allegiance was inflexible. The extent of the influence of each centre was not determined by the equalisation of either rate payments or net received prices for fat stock at the juxtaposition of supply area boundaries. These points demonstrated the need to consider marketing in its wider setting and cast doubt on the efficacy of prices as an agent for allocating commodities at the firm level. As a corollary the conclusion was drawn that the concept of spatial equilibrium in exchange must be broadened to include institutional rigidities and the possibility of product substitution as distance from markets increases.

The first section of Chapter 5 extended the analysis and looked at the consignment pattern from the viewpoint of exchange efficiency. The role of immedacy of payment and the length of the purchasing season in the decisions of operators in the Victoria River District on the sale of fats to Wyndham was noted. In this case it appears that some producers ignored opportunities to reap relatively good returns from sales to the plant because of its buying policies. However, the northwestern extension of the
Queensland supply area was also influenced by the fact that this market offered an opening for store cattle since, under transport by droving, deterioration losses on fatstock became significant for trips over three hundred miles. Zonal tabulations for sales to Queensland in 1957 showed that no fats were contributed from properties more than five hundred and fifty miles from the Mt Isa railhead, and there was a highly significant correlation ($r = -0.43$) between the percentage of slaughter cattle in the output of the fifty-one units in the three northern Districts and their distance by stock-route from their most favoured market. This shows the importance of distance and transport technology as determinants of enterprise structure in the traditional production pattern.

Over the study period these two elements of accessibility changed dramatically. The entry of two new processing plants in 1963 reduced the average trip distance for consignments from northern stations from 287 miles in 1957 to 246 miles in 1966. In addition the works extended the range of choice of producers between fat and store turn-off, and between alternative centres of demand. Whereas store cattle made up sixty-three per cent of total exports in 1957, the proportion had fallen to about thirty per cent in 1966. Mobility also increased as a result of the adoption of road transport and an analysis of movements in the latter year suggests that about 11,250 culled bulls and females were dispatched to the Katherine and Darwin meatworks that would have had no opportunity value without the change of mode. Further trading gains arose from the sale of 11,000 fattened cows and heifers on the Queensland and South Australian markets, while an annual average of around 5,250 animals may be salvaged from drought losses in the Alice Springs District. The provision of the two meatworks and the switch to consignment by road train therefore permitted important changes in the exchange system. Both elements share a common origin in the general rise in the demand for boner-quality beef that followed the exploitation of the United States market from 1960 onwards.
Because of the impact of these changes on the industry, special studies were made on the timing and location of the processing plants and the diffusion of the use of road transport. In the first case, it appears that development began in 1963 as a result of the partial exhaustion of more accessible supplies of boner-beef from the herds of the southern States. The service and cold storage requirements of meatworks determined the siting of the two facilities -- in close proximity and at a remove from the main concentrations of cattle in the Barkly Tableland and the Victoria River Districts. Thus, although the plants have had a favourable effect on received prices, their spacing is far from optimal with regard to livestock supplies. Higher operating costs in the Northern Territory reduce the payments that can be made to growers while dependence on the export markets restricts the range of product and the possibility of gaining good returns on high quality fatstock. This points up the need to consider the nature of final demands and processing costs in assessing the possibility of reducing transport costs and raising farmgate prices by optimising plant location and capacity. However, the timing of entry and the duplication of facilities suggests that exchange efficiency could have been promoted by government intervention in this sector at relatively low cost, for each plant was constructed for about $1 million.

Although, as has been seen, road transport permits greater mobility and leads to external economies in production, the process of diffusion was governed by the level of receipts for stock at market centres. It appears that producers based their decision on the choice of mode on net received prices for existing classes of sales (that is those that would have taken place regardless of the form of movement). From an analysis of diffusion over time, it was apparent that market prices influenced adoption through two effects -- the valuation of non-rate (deterioration) costs, and the determination of the margin which producers could forego on additional direct transport payments to gain speed, mobility, and convenience advantages. Again this
demonstrates the interaction between the demand and movement components of accessibility. The deductive approach to the substitution between droving and road transport over space suggested that a comparison of total transfer costs would tend to favour on-the-hoof consignments for very short and very long trips. Empirical studies of usage in the South Australian supply area in 1957 and the Queensland supply area in 1963 indicated that strong spatial regularities were absent, though broad trends were apparent within zones, which supported the deductive notions and the hypothesis that producers seek to minimise total transport costs. The pattern of usage bore little relationship to the quality of road surfaces, though expenditure under the pastoral roads programme, which provided for dry-weather 26 feet wide roads with reinforcement in weak spots, was probably a significant encouragement to adoption. There is no evidence that good surfaces diverted supplies from one supply area to another and a comparison of rate payments on bitumen and dirt roads showed that there was only a one cent per beast-mile margin in favour of the latter. This means that the level of direct savings from this source is small. Studies of possible deterioration losses on different surfaces indicated that they were unlikely to cover the additional capital costs of sealing ($7,000 per mile), and it is certain that sealed beef roads are not necessary for the efficient operation of haulage services.

The 1966 allocation of fatstock shows the influence of increased mobility as compared to the situation in 1957. Thirty-one of the one hundred and forty-seven units that marketed fats during the turn-off season split their sales between centres. Comparison of the actual pattern with a normative linear programming solution pointed up the eastward extension of the South Australian supply area and the occurrence of excessive transport costs in this sector. The main reasons for this state appear to be the attraction of higher prices on the Adelaide market and the operations of buying agents based at Alice Springs. In the northern Districts, the boundaries of the market areas of the four
demand centres were not discrete. A major part of the overlapping was due to the basic similarity between the locational characteristics of the Katherine and Darwin meatworks, while some consignment decisions were directly determined by the integration of properties and the plants. Independent operators on the margins chose between rival centres on the evidence of price differences, personal experience of weight judgement and promptness of payment, and assessments of the importance of additional factors like the rate of condemnation for disease and deterioration in transit. Although it is possible to rationalise many of the individual consignment decisions in the light of detailed knowledge, it seems justifiable to conclude that a significant proportion of consignments were non-optimal. This was particularly evident from the comparison of net received prices at the intersection of supply area boundaries, and it was suggested that tradition-based immobilities prevented the exploitation of opportunities, while some consignments resulted from wasteful competition among the processing plants.

In 1966 sixty-nine per cent of the cattle exported from the Northern Territory (including movements to export meatworks) were fats. The pronounced decline in the trade in store stock from 1957 runs against the general observation that improved transportation will promote regional specialisation, and the traditional links between the Territory and fattening properties in Queensland have become less important. One reason for this situation is that there is comparatively little difference between the two classes of cattle in the northern Districts for the Katherine and Darwin meatworks offer direct competition for unfinished but mature (2½ and 3 year old) beasts. However, there is little evidence that producers in the Alice Springs District are turning to breeding, and the overall switch to breeding and fattening seems to be due to the structure of prices for different types of stock, the need to minimise uncertainty in receipts, and the superior flexibility of breeding and fattening enterprises in times of drought. Correlations
between the indices of station accessibility and the proportion of fats marketed by each unit in 1966 and 1967 show a fairly strong relationship, and this is further confirmation of the beneficial influence of the new meat-works on the pattern of exchange. Field interviews in the Victoria River District emphasised the flexibility that has been gained in marketing and the opportunities that this has given in production.

In summary, the empirical work in this thesis on the determinants of trade and transport costs, has shown that the Northern Territory beef industry became increasingly emancipated from the constraints imposed by distance from markets between 1950 and 1966. Accessibility, in the widest sense, has developed as a result of the opening up of the United States market for boner-beef, and the continued buoyancy of the domestic outlets for better quality meat. Higher prices for the product led to the entry of two successful processing plants in 1963, and were a major factor in the adoption of road transport. At the local scale the role of total transport costs and net product receipts in allocating production is complex, but there is evidence that institutional rigidities and inefficiency in exchange disrupt spatial price equilibrium. This makes it unlikely that localised route improvements will exert much influence on the direction of trade. It follows that such investments will have maximum effect where they reinforce trends towards the development of new types of sales and the adoption of superior transport technology. These will be mobility gains that arise on existing, suppressed, and diverted traffic. In planning a network to take advantage of these forms of benefits it appears that flexibility in location and standards is desirable, and where, as in the case of the Northern Territory, production is extensive and traffic flows are small, a wide ranging network of comparatively low grade roads will best serve the user industry. If priorities have to be set it would seem wise to open up the highest quality land and support ventures such as the entry of new processing plants, and to
ignore the attraction of penetrating the last inaccessible areas that could be utilised. Thus land development should be fostered at the intensive rather than the no-rent margin.

B. ACCESSIBILITY AND LAND PRODUCTIVITY

The concept of spatial equilibrium in production is based on the premise that, in a normative economic system, the monetary marginal product (at local prices) of a production process must not exceed marginal costs (at local prices). This means that operators will seek to expand the scale of their enterprise up to the point of diminishing economic returns. The explicit inclusion of spatial variations in factor costs and commodity returns merely extends the generality of the traditional model of the farm firm by allowing for differences in accessibility. The assessment of the relative importance of location on output and profits forms a major concern of this thesis, since this can give a guide to the probability that economic activity may be generated by improvements in transportation. Von Thünen demonstrated that entrepreneurial responses to variations in comparative locational advantage could be deduced within a closed system in which distance from a central market was the main independent variable affecting the operations of holdings of a uniform size. He showed that differences in local prices would give rise to gradients of intensity of output within single crop zones, under ceteris paribus conditions, and observed that by excluding returns to non-land inputs, the economic value of location could be assessed as a rent. Location rents have two sets of components -- those arising from farmgate price advantages at a given scale of output, which may be aggregated as a rent to situation, and those that are generated as a result of the adjustment of output to those advantages. The latter may be grouped conveniently under the term intensity rent. The actual level of both types of rent can be measured by comparing the net returns of units with those earned by the least favoured enterprise that produces the common agricultural commodity.
Chapter 2 examined the theory of economic rent in some
detail to judge its utility as a model of response in the
real world. It was observed that variations in land quality
would be likely to distort the pattern of adjustment to
accessibility, but measures were suggested to incorporate
or isolate this variable. In the empirical work on the
identification of spatial equilibrium in production in the
Northern Territory beef industry an index of pasture
potential has been used extensively to take account of its
influence on output. More serious objections to the model
arise when its stability over space and time is examined.
Von Thünen assumed that farm size was fixed and that the
natural resources available to each operator were identical
and costless; under these conditions it is easy to prove
that there will be symmetry in intensity of output, factor
use, and net returns per unit of cultivated land and per
enterprise. If the size of holdings is allowed to vary and
competition for the use of land is permitted, location rents
may be distorted or destroyed. Where farms with the same
quality of access to markets control different amounts of
uniform soil, scale per unit of land will differ under
rational management because some costs are degressive or
progressive with acreage. When farmers can bid for the use
of land, enterprise boundaries will be adjusted to bring each
holding to a total least-cost combination of resources --
hence the market for land will absorb all rents; and returns
to capital will be uniform throughout the industry. In this
case scale per unit of land will tend to follow the ideal
rent gradient, but no rents will be earned. It follows
that empirical work designed to test the influence of
accessibility on land productivity must examine output and
returns in terms of areal and enterprise intensity. The
study industry provides a good test case for the applicability
of the concept of location rent to real problems for there
is relative uniformity in holding size and the pattern of
property boundaries has remained stable between 1957 and
1966. In addition, the obvious importance of spatial
variations in market prices and transport costs in determining
the level of marginal returns, and the technical homogeneity
of production strengthen the likelihood of a linkage between accessibility and scale. Thus the conclusions of the studies of spatial equilibrium in production should have a wider generality and could be expected to throw light on the power of improvements in transport to trigger shifts in intensity rents to long-term 'attainable' levels.

Limited survey data for 1949-50 showed that differences in rate payments and farmgate prices for fatstock would have given rise to steep situation rent gradients in the study industry; this suggested that variations in land-use intensity might be linked to accessibility. The use of droving for all movements to railheads and processing plants and the fixity of the allocation pattern up to the start of the study period also made it reasonable to assume that the distribution of production would exhibit the effects of limited marketing opportunities. Hence both elasticity and mobility aspects point to the probability of adjustment being evident at the end of the traditional era in exchange. Production information for the 1957 turn-off season was used to test this inference. The relationship between sales per square mile and indices of accessibility for each holding was explored using simple correlation analysis, and this showed that the link between the variables was weak. The work was carried further by formulating regression models to attempt to predict property sales from an assessment of the natural pasture resources of each unit and the rate payment and farmgate price series. The best function used the index of net received prices, and both independent variables contributed significantly to the power of the equation. All values were log-transformed and the model was interpreted as suggesting that, on average and holding land capacity constant, a rise in marginal returns of one dollar per beast was associated with an increase in sales of ten head per property. However, the parameters in the function explained only thirty-three per cent of the variation in output so that the degree of adjustment was not marked. This result points to the importance of factors not included in the model such as differences in the level of non-land inputs and the quality of station management,
and short-term influences on consignment like climatic fluctuations and the need for immediate finance to cover loans.

Between 1957 and 1966 market prices rose steadily at all centres of demand for Northern Territory cattle and comparison with national indices of prices paid by farmers suggests that margins in the industry widened over the decade. This situation would tend to reduce the relative influence of rate payments on net returns and lead to an increasing measure of response to movements of prices over time which would over-ride spatial variations in farmgate prices (according to deductions that can be made using a closed system Isolated State analogue). In addition to the probable emancipation of the study industry from the elasticity component over the decade, certain effects could be expected to follow from the mobility created by the opening of the Katherine and Darwin meatworks and the adoption of road transport. Among these are a reduction in the importance of distance from markets in the decision on consigning fat or store cattle and the promotion of multi-market sales. In consequence it is reasonable to hypothesise that spatial equilibrium in production became less likely over the study period. The tests made by correlation and regression analysis of the intensity of land-use and property output for the 1966 turn-off season suggest that this inference is valid. The regression models show a consistent tendency for productivity to be associated with increasing transport costs and lower farmgate receipts. This may be partially explained by the peripheral location of the new processing plants with respect to the main concentrations of cattle on the Mitchell grass associations of the Barkly Tableland and the Victoria River District.

Two significant changes occurred in the production pattern between 1957 and 1966. First, the number of enterprises contributing stock to trade rose. The figures for the two years were 118 and 154, and thirteen of the contributors in 1957 made no consignments in 1960, so that there were forty-nine new entrants. The 't' test was used
to determine whether these units had suffered from poor accessibility under the traditional pattern of exchange. The results suggested that there was no significant difference between the indices of rate payments and net receipts in this group and the values in the basic population, though the average land quality of the newer enterprises was significantly lower. Second, the use of road transport made it possible to exploit resources of previously unmarketable stock and, as has been seen in the discussion of spatial exchange equilibrium, this may have led to a rise in sales of over 16,000 head (including drought savings). Despite the identification of these sources of increased production, the examination of the level of turn-off over the study period for the whole industry points to relative stagnation in output -- indeed these changes may mask a comparative decline in productivity, though the influence of climatic variation (particularly the eight-year drought in the Alice Springs District) makes this point difficult to confirm.

Having tested the basic relationship between accessibility and station output it was desirable to formulate more complex models of production scale which included non-land inputs. This task was performed using survey information supplied by the BAE which referred to a sample of seventy-two enterprises for the years of 1962-63 to 1964-65. A regression model was used to determine the main influences on cash income per hundred square miles and this showed that land quality, capital (in the form of expenditure on fencing), and labour were all important in the production function, while the specification of the indices of accessibility as additional independent variables did not increase the explanatory power of the equation. The factors included in the regression analysis explained sixty-eight per cent of the variation in cash income per square mile, and suggested that pasture quality was the basic determinant of intensity of output per unit of land. This result ties in with the conclusion which can be drawn from the examination of sales in 1966. Here the simple correlation coefficient between holding output and total
Feed resources was highly significant ($r = 0.83$) and this single independent variable explained about seventy percent of the variation in sales. From the combined analyses it can be concluded with some confidence that range quality has become more important as a control on scale since 1957 and that there is symmetry between intensity at the land unit and enterprise levels (i.e. property size does not exert a strong influence on output).

Perhaps the most interesting evidence on spatial equilibrium in production that is given in the thesis is provided by the zonal tabulation of the characteristics of the holdings in the BAE survey. Classification of the seventy-two units by imputed road transport rate payments in 1964, into quintiles, did not disclose any regularities. However, the same procedure showed an interesting gradient in both areal and unit returns when the groups were defined by net received price differences. There was a distinct tendency for income to fall in the three northern Districts as farmgate prices for fatstock decreased. This was confirmed by tabulations which cross-classified the figures by land quality sets. A prima facie case existed for interpreting the gradient as exemplifying the generation of situation and intensity rents. The importance of variations in net receipts in determining receipts is unquestioned, but the identification of intensity responses is more difficult and is the main interest of this work. Comparing the actual slopes of net farm income per square mile and returns to capital and management income with hypothetical gradients that would be generated on the population mean (that is the situation rent effect), it was apparent that income fell more steeply than would be expected from the operation of this effect alone. Proof that operators substitute accessibility inputs for other resources at a distance from the market would be given by a decrease in the use of non-land factors of production, but examination of the characteristics of the holdings in each zone did not confirm this. Capital intensity tended to be related to land quality and not to location. Low returns were associated with heavy
use of capital so that accessibility did not condition scale but did affect profits. Hence it is possible to infer that resources might be used more effectively in the industry if producers recognised the need to adjust to variations in local prices.

Since there is little evidence that accessibility exerts any influence on land-use intensity it is highly improbable that localised route improvements -- which, of necessity, can only change comparative locational advantage slightly unless accompanied by mobility gains, will generate an expansion of economic activity. A full evaluation of the impact of a new road must include its additional capital and maintenance costs as a charge on the net farm incomes of user properties. The Beef Roads Programme in the Northern Territory was used as an example of the need to scale expenditure against the net benefits that may accrue to producers from immediate and attainable adjustments in the scale and form of their enterprises. The proposals were credited with the changes that have resulted from the switch from droving to the use of road transport, though road use is not restricted by surfaces well below the standards of the current Programme. The results of the formal benefit-cost analyses showed that the deployment of public capital could not be justified under these assumptions unless the upgraded route dominated all movements from a sub-region and a highly optimistic view was taken of the profitability of land development. Where, as in the case of expenditure in the eastern Victoria River District, the whole network is treated there is virtually no chance that the nation will recoup its investment. Further comment on the efficacy of government planning in this sector in the Northern Territory will be offered in the last section of this chapter. At this stage it is important to note that the analyses showed that common ground exists between the theory of spatial equilibrium in production and the methodology that best serves to evaluate road proposals where
complementarity effects are expected.\footnote{It may be noted once again that the argument of the thesis is not concerned with subsidiary effects on other user industries (like tourism and mining).} Benefit-cost analyses of investments in transportation can be placed on a sound theoretical footing by abandoning the notion of secondary benefits and substituting the concept of attainable gains in intensity rents. This allows a systematic appreciation of the relationship between transport and land-use and the net advantages of proceeding with a given proposal.

Since accessibility seems to have little influence on the intensity of pastoral land development in the Northern Territory, it is of interest to determine the factors which do affect scale; to permit the separation of conclusions which apply to the case study from those that are more widely applicable. The estimates of pasture quality that have been calculated from CSIRO data gave a consistently good performance in a wide range of techniques, and suggest that the industry is intimately tied to the natural environment. This is supported by the obvious influence of climatic variations on annual production. Moreover, it appears that this factor has become more important over the study period in the manner postulated by theorists like Brinkmann, who suggest that Ricardian fertility rent differences widen as local price disparities narrow.

Certain qualities of the study industry tend to reinforce this tendency. First, the small range of opportunities for the use of non-land inputs means that the management factor rarely outweighs response to differences in fertility. Second, the extensive nature of operations on cattle properties determines that capital investment is discontinuous and, under conditions of uncertainty in prices and feed resources, this leads to short-term inelasticity in supply and the utilisation of land according to its rank in the quality scale. Finally, it appears that tax sheltering is an important by-product of beef production in
some cases. Where this is so, stations with good pastures will tend to be developed to a greater extent because they have a larger capacity to absorb capital at an overall profit. In addition to these factors, which explain much of the pattern of development in the Territory, it is necessary to mention that speculation, conspicuous consumption, and non-monetary objectives may also play a part in the improvement of holdings.

Although the Northern Territory beef industry has many special features, the conclusion which has been reached on the likelihood of spatial equilibrium in production also seems applicable to modern commercial agriculture at the regional scale. The general decrease in transport rate payments in relation to market price levels for most commodities and the increasing mobility which has followed continued innovation in transport technology have both tended to emancipate land-use from the constraints imposed by poor accessibility. In addition, new techniques in production have led to the disruption of price determined equilibrium at the firm level. Many improvements in farm operation demand discontinuous or lumpy investments in machinery that will pay at any set of prices that permit the enterprise to stay in business. Hence, the production function in modern agriculture does not lend itself to marginal adjustments in local prices and it becomes increasingly improbable that intensity rents will be generated as a result of variations in comparative locational advantages. This means that the fragmentary evidence that is available for the 1957 turn-off season linking accessibility and output in the study industry may represent a rare example, at this scale, of the relationship explored by von Thünen in his classic the Isolated State.

C. ACCESSIBILITY AND PUBLIC POLICY

This final section draws together some of the findings of this study and points up their implications for public policy on transportation and land development. Some brief comments are offered on future trends in the exchange system
and the steps that the Commonwealth Government could take to foster the expansion of the Northern Territory beef industry. The political aspects of the recommendations are beyond the scope of this study, but it is recognised that many of the measures would not be adopted under contemporary views of the role of the state in Australia. Nevertheless the discussion is designed to raise a number of fundamental issues in the deployment of infrastructural spending which may be of greater moment in underdeveloped economies where resources are scarce and investment is largely controlled by the government.

Chapter 1 introduced a model of the structure of accessibility which serves as a planning check-list for expenditure designed to stimulate or facilitate land development. Six components were identified; the influence of exogenous demand through market prices at existing processing and consuming centres; the impact of transport rate payments on marginal returns under the existing mode of movement; the efficiency of the exchange system; the relative dislocation caused by the imposition of barriers to trade; the range of demand for different types and qualities of the commodity at the regional scale; and the limitations imposed by transport technology. The past and future roles of these elements in the accessibility of properties in the Northern Territory will be reviewed in turn. As a point of reference for the discussion, it is valuable to consider how far the $30 million made available for the current Beef Roads Programme since 1961 could have been spent more effectively, given hindsight and centralised planning.

The importance of the level of final demand for a commodity on the magnitude and distribution of total transport costs is graphically illustrated by the study industry. The opening of the United States market for boner-beef was the main cause of the renewed interest in the Territory among processors and led to the construction of the Katherine and Darwin meatworks. The rise in prices at all centres over the study period was the major influence
in the adoption of road transport and all evaluations of the benefits of modal change must be qualified by the observation that the assessments only hold for the existing structure of market returns. Thus the role of the remaining elements in holding accessibility may be directly determined by commodity demand. This fact is well known but some of its ramifications are often ignored in planning. As seen in Chapter 1 there were numerous schemes to link the Northern Territory with southern Australia by a transcontinental rail line between 1911 and 1950. Such projects would have tapped a remote market for producers at tremendous expense and it is unlikely that the product would have found ready buyers. Commenting on the papers presented at the 1954 seminar held by the Australian Institute of Political Science, Blunden remarks:

"It was taken for granted transport was the first requirement for solution of the problem [of development] when, in fact, it might well be that firm orders for one million tons of beef from the U.S.A. or China might be the real key to progress."

In view of this, the commencement of the Beef Roads Programme in 1961 when the United States trade was expanding was apposite. However it is important to recognise that current investment in processing facilities, haulage plant, roads, and property improvement may become redundant if this outlet fails. Although current trading agreements make this unlikely, it is realistic to take the risk into account for a chance occurrence like an outbreak of foot-and-mouth disease would lead to the imposition of a United States embargo. At present the main problem in the trade appears to be over-supply, and it is interesting to note that the Territory meatworks were not exempted from quota restrictions in the 1969 season. Here is a


disturbing case of cross-purpose administration since these plants have a very limited access to the domestic market and to include them in the same category as abattoirs in southern Australia which export a small proportion of their kill is to partially negate the objectives of the road programme. This illustration is useful in pointing up the need for consistency and systematic thinking in policy. Looking to the future, it is possible to deduce exchange and production responses to different sources of final demand. If the United States trade continues to absorb most of the regional output it seems likely that the present trend away from enterprise specialisation will be maintained and the new holdings on the improved pastures of the Top End will probably fatten their own young-stock. In contrast a strong demand for good quality chilled beef from Japan might stimulate the stations in the Top End and the farmers on the Ord to specialise in fattening, while the arid interior would turn to breeding. Finally, a dependence on the domestic market might convert the Alice Springs District into a fattening area for northern stores. In each case forward planning would attempt to hasten the change to maximise gains from trade and, quite obviously, the different situations would require separate policies on route investment.

Rate payments under existing modes of movement can be controlled and reduced by a wide range of measures. In the case of road transport the construction of higher standard surfaces is an indirect means of lowering costs and consignors may not benefit from the investment unless the gains are transferred to the user-industry. Studies by the BAE show that road quality is not the main determinant of hauliers' costs. Variable costs differ for individual vehicle makes but show a general decrease per beast-mile as unit capacity rises. Fixed costs become less onerous as the number of loaded miles travelled per year increases. Hence significant savings could be made by encouraging the use of large road trains and guaranteeing custom to efficient operators, though such provisions would require constant review to prevent monopoly pricing. Fieldwork in 1967
and 1968 disclosed that about fifty-four per cent of the total capacity of units operating in the Territory were held by three companies and there appears to be a marked tendency towards bigger haulage organisations. The three main firms were spaced well apart and had bases in Alice Springs, Mt Isa, and Katherine so that competition may result in a rational division of traffic. However, government intervention in the early stages of adoption could have prevented excessive competition by restricting the use of semi-trailers and small capacity trains. In the future, regulations on road train lengths and axle loadings, and the enforcement of legislation on drivers' rest periods could lead to a rise in rate payments. A major policy objective should be to minimise this tendency by encouraging the adoption of innovations like the double-decker unit. Subsidies to hauliers might also be considered and could have been introduced in preference to over-spending on road construction, though this conflicts with a development policy based on efficiency criteria.

The concept of exchange efficiency highlights the possibility of saving transport costs and increasing net returns by re-allocating flows, and promoting more advanced marketing techniques. The former task would be difficult to fulfil because of the multiplicity of sales and the individual nature of consignments but real gains could be made by ensuring that price knowledge was widely diffused. In some cases price stabilisation might be beneficial and the uncertainty of the store trade with Queensland in the 1950s has been quoted as an example. At present inefficiencies arise from the reluctance of northern producers to accept weight-and-grade assessments of the value of fatstock and these could be remedied by adding the responsibility of judgement to the government meat inspectors. The Northern Territory also suffers from a lack of open markets to provide a datum for prices. The principal firm of stock and station agents in Alice Springs organises stud bull and store sales, and similar events in
the Top End might considerably assist in the stocking and development of holdings in the improved pasture zone. Such measures could be undertaken by a body such as the NTAAIB at low cost, and might develop out of annual gatherings such as the Katherine Show.

Mobility is curtailed in the Northern Territory by the presence of barriers imposed to assist in the eradication of pleuropneumonia and the prevention of the spread of tick infestation and redwater fever. These restrictions have interrupted inter-District trading and depressed the returns of producers who might otherwise have sold stock to buyers in Adelaide. The erection of duplicate road transport receiving yards at Alice Springs did allow northern operators to exploit this market, though the blood test procedures added costs and inconvenience. The turn-off of stock through Alice Springs from outside the Central Australian Pleuropneumonia Protected Area between 1959 and 1968 varied between a few hundred and nearly eight thousand in 1963, so that it is possible to over-estimate the difficulties associated with moving stock southwards. The continued decline in the incidence of the disease has allowed the relaxation of requirements and in 1967 over ten thousand head of cattle entered the Alice Springs District from the north to build up herds depleted by the drought. Although it is difficult to fault the policy of giving different statuses to particular areas from a veterinary viewpoint, it is possible that a more economic solution to the need to eradicate pleuropneumonia might have been reached by the wholesale slaughtering of infected herds. By 1966 the disease was endemic on only two northern stations -- Lagune (Northern Territory) and Carlton Hills (Western Australia) -- and the elimination of these herds might have allowed the abolition of the restrictions. Here the government could recoup payments to the owners for compensation from savings in inspection and inoculation, and a levy on consignments to the higher price markets that would be opened up to northern producers.
The range of demand for Territory stock and the structure of local prices changed markedly when the Katherine and Darwin meatworks commenced operations. It has already been suggested that an abattoir run as a public utility might have been profitable at the end of the 1950s, while this might have avoided duplication and excessive competition by private enterprise. The failure of the Commonwealth Government to appreciate the possibility of reducing transport costs and raising receipts by this means points up the necessity of viewing accessibility as an entity. A processing plant would have cost about $1 million (the price of about fifty miles of sealed road), and any deficits on processing could have been met by savings on road construction and maintenance. However, the inadequacy of planning in this sector is widespread and Hirschman states the case against current practices in the following terms:

It ... takes an unusually enterprising and risk-accepting government to engage in novel manufacturing activities instead of going on with its port and highway projects. Highways never fail, and, as they are usually not maintained, they can be built over and over again, thus turning out to be ideal outlets for governmental funds, involving no risk and a bare minimum of mental effort in general.

Looking to the future it is valuable to examine briefly the possibilities that exist for reducing transport costs by adding new facilities. The obvious locations for further plants are Mt Isa and Alice Springs, but considerable difficulties would attend commercial operations at these centres due to their distance from the coast and the higher cost of processing in northern Australia. This can be illustrated by comparing the structure of transport costs between Alice Springs and Adelaide. The current charge for the movement of livestock is $211.92 per bogie van (holding 18 head) or $11.77 per beast. A quotation supplied by South Australian Railways in 1968 suggested that refrigerated containers for meat would cost about $35.00 per ton, or

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$7.81 per beast (assuming an average dressed weight of 500 lb). Thus the total rate saving would only cover additional operating costs of about $4.00 per head, which can be compared to the estimate given by the manager of the Katherine works that they suffer an $11.00 per carcase disadvantage as compared to plants on the eastern seaboard.

In the case of a works at Alice Springs there would be direct competition with buyers in Adelaide so that it is unlikely that it could pay prices that were high enough to capture local production. In 1969 a small abattoir was built by the NTA and this is capable of being extended to process stock for export, but on current assessment it would not pay to complete the plan, even though there could be additional advantages from the avoidance of bruising and weight losses on trains and the ability to kill drought affected stock that would not travel well. Much the same conclusion can be reached on a facility in Mt Isa, and fieldwork disclosed that a local butcher had completed a feasibility study which did not favour the project. In this case the difficulty of disposing of by-products and fear of competition from integrated large-scale meat companies were further reasons mentioned which weighed against the investment. The construction of a facility near Borroloola would be a more hopeful prospect provided the McArthur River mineral reserves are exploited. A sensitivity analysis of the 1966 fatstock exchange pattern using the Transportation Problem suggested that, with a final demand of about 16,400 head, a plant at this location would reduce total rate payments by approximately $128,000 as compared to an optimal solution for the five existing markets. This is far greater than the estimate of $44,500 for the savings that will accrue from the completion of the Beef Roads Programme. However, construction would be conditional on the opening of a deep-water port and the provision of service, which makes development unlikely in the short-term.

Finally, it is necessary to consider measures that can be taken to further mobility through improvements in
transport technology. The Beef Roads Programme was initially conceived, as such a measure in the belief that road standards would stimulate the adoption of the new mode. It is the demonstrable absence of a direct link between formation type and usage that is the main reason for suggesting that the proposals have wasted public money. This is not to question the fact that the switch from droving to road transport has resulted in significant and lasting gains to the beef industry. Given the fact that road transport requires a minimum standard of surfacing, it is relevant to examine the ways in which road finance might have been allocated more efficiently. The Programme selected projects from judgements on the hierarchical order of the existing network, so that all the roads were merely re-alignments of old arterial routes. Since the extent of the mobility gains that can arise from the use of road transport is circumscribed by the connectivity of the route net it might be expected that, given minimum standards on the basic structure, maximum benefits from further investment will follow the linking of isolated segments. The Beef Roads Programme included the expenditure of $22.2 million on 995 miles of sealed roads. If these routes had been upgraded to gravel beef road standard (Class B) at an average cost of $15,500 per mile, finance would have been available to treat a further 477 miles. This would have been nearly sufficient to construct roads from Yuendumu to the Western Australian border (294 miles) and Plenty River to the Queensland border (217 miles) to give direct connections between Alice Springs and Nicholson, and Alice Springs and Mt Isa (given complementary investment by the States). These routes would reduce road distances between the centres by approximately 340 and 230 miles, and would give access to the South Australian market to the Kimberleys, the Victoria River District and the Barkly-Gulf Region. The immediate benefits that would arise on suppressed and diverted traffic in this case might be substantial though producers in the Alice Springs District could suffer disbenefits from the lowering of market prices.
Road transport requires the construction of permanent ways and this leads to a characteristic discrepancy between user and social costs, for traffic rarely bears the full charge on the capital spent on roads in rural areas. As has been seen in the benefit-cost analyses of projects in the Northern Territory these costs could often not be recouped from net production gains. An interesting possibility for equitable pricing and wider mobility in the future is offered by the use of hovercraft to transport cattle. This cross-country mode has obvious advantages in connectivity and flexibility of operations. Feiger\(^1\) has calculated that, in the case of moving 7,500 head from Lawn Hill (in the Queensland Barkly-Gulf Region) to the railheads at Kajabbi or Cloncurry, the total social cost of road transport would be double that incurred in using an N4 hovercraft, given the absence of technical difficulties. However the actual rate payments by pastoralists would be $100,000 higher than if trucks were used. These could be equalised by a subsidy to hovercraft operators to allow them to quote competitive rates. The Commonwealth Government would realise a net gain by avoiding expenditure on beef roads.

In summary, accessibility can be improved by a wide range of measures and optimal planning procedures would consider all the opportunities in a systematic manner. Some suggestions have been offered for the Northern Territory to demonstrate the kinds of openings that may arise in the development of an agricultural industry. These suggestions would need to be evaluated in far greater detail before implementation, but it is apparent that there are many ways of improving transport and exchange outside the construction of roads. This conclusion may also hold for many other comparable development situations so that the study may have a wider applicability. It seems that man may indeed always be bent on completing his 'engineering

chores' because this gives an obvious outlet to his desire to change and improve the economic environment for production. From the results of this study it is apparent that a more flexible and opportunist approach to transport may lead to a better use of resources. Viewing the relationship between accessibility and exchange it is apparent that the maximum pay-off from investment is often earned by supporting emerging commodity demands and stimulating technical innovation in transportation. Thus projects should be designed to foster mobility and reap immediate gains from existing, suppressed, and diverted trade. It seems unlikely that the attainable benefits that may be generated from the adjustment of scale in agriculture following a localised improvement will be significant under modern commercial conditions except in special cases. These will occur when all the resources for production are present and only transport is lacking, and when the factors employed have no opportunity value without the project. Even here it is important to assess whether the capital that is employed could have been used to better effect elsewhere in the economy. In all cases it is contended that the concepts of accessibility and location rent adjustment provide the necessary framework for a systematic evaluation of the role of transportation in land development.
APPENDIX 1

THE DERIVATION OF HOLDING AREAS AND THE INDEX OF LAND QUALITY

1. The definition of the basic holding population

Several problems were met in determining a consistent set of production units for the identification of the origin of stock movements and the calculation of intensities of output, by area. The following sources have been used to arrive at the set of 179 that is shown on Map 2.1.

(i) The 'Details of Current Pastoral Leases' supplied by the Department of the Interior (1965).

(ii) Pastoral Map of the Northern Territory, compiled by the NTA, 1955.

(iii) Pastoral Map of the Northern Territory, compiled by the NTA, 1965.

The list supplied in Table A.1, follows (i) in most respects, which gives details of the tenure and rental payments of 193 units. Deviations from this source have been made under the criteria given below:

(a) The lease areas given in (i) have been checked against the 1965 mapped areas, and stock reserves within individual lease boundaries have been added on the grounds that they form part of the effective grazing land available to operators (stock-routes, for example, are not fenced).

(b) In twelve cases, two leases are operated as a single unit and the areas of both have been amalgamated (e.g., Alroy and Dalmore Downs).

(c) Some leases have been omitted because their exclusive production interest lies in sheep. These are Dalmore Downs, Delny and Gurner. Two other stations--McDonald Downs and Newhaven--have interests in sheep but these are included as normal beef properties.
(d) No records are available of any trading (either as sellers or recipients for any year for which data is available) for some leases and these have been omitted. These are Bonrock, Cox River, Murrurangi and Point Stuart.

(e) Five leases are shown on the 1965 Pastoral Map, which are not included in the basic list. These have been added at the base of Table A.1 (Florina, Ooloe, Wildman River, Annaburroo and Dorisvale).

This procedure gives a population of 179 for 1965.

Certain qualifications must now be made on the use of the names given in Table 1.

(i) Nomenclature.

Many properties in the Northern Territory have alternative names and, quite frequently, different spellings are used, even in official publications. The usage in this thesis is based on the Pastoral Lease List which sometimes prefers an older or lease title name to the one used by property operators (e.g. Talallah Downs is known in the Alice Springs District as 'Mongrel Downs'). Spellings have been simplified wherever possible (when alternatives exist), e.g. Gimbatt for Gimbatt, Anthony Lagoon for Anthony's Lagoon.

(ii) Internal subdivision.

The use of the list given in Table A.1. has required the loss of some information on the origin and destination of stock movements. In some cases, a lessee may divide a lease into two distinct properties under separate managers and movements are documented from the station homesteads (e.g. Auvergne lease, which is divided into Auvergne and Neryy stations). Because of difficulties associated with determining internal boundaries and some ambiguities in permit information, these leases have been treated as a single economic units. There are a wide range of land-holding arrangements within leases with a gradation from complete
subdivision to groupings of out-stations around a particular homestead. Thus Waterloo is regarded by the lessees as consisting of Waterloo and Limbunya stations, whilst a neighbouring lease, Mistake Creek, held by the same company is operated in two units but under a different system. Here a full-status manager controls the part of the lease known as Kirkimbi, while Mistake Creek homestead is regarded as the base for a sub-station under the control of the manager of Nicholson (Western Australia). In most cases, however, the modified lease pattern does reflect accurately the economic structure of the industry. One further point may be noted. In the BAE survey of enterprise structure in 1962-1963 to 1964-65 the derivation of the sample was based on the availability of records. In two instances, the survey accepted internal subdivisions as separate enterprises. These are Nevery (part of Auvergne lease), and Limbunya (part of Waterloo lease). The locations of the homesteads of these holdings are shown on Map 2.1, and these supply origins have been used in the calculation of transport cost and net received price values for the empirical work which utilises the BAE data.

(iii) Changes over time.

Between 1955 and 1965 the pattern of leasing altered considerably and many grazing licences were converted to permanent title. Superficially this would preclude the use of the 1965 population in the analysis of movement data for 1957. In fact, many of the re-arranged boundaries affect units that did not contribute output until the early sixties. Local knowledge also suggests that the effective grazing areas of many units have not changed substantially though the form of title has altered. In all cases it has proved possible to relate origin and destination data for 1957 to a meaningful boundary in the 1965 population, though in a few cases this has involved some approximation. Examples of this procedure are the matching of Buffalo Springs and Coolibah, and Harper Springs and Mt Skinner. Where leases have been amalgamated (e.g. Lyndavale and Eldunda, now Eldunda) origin and destination data for 1957 have been adapted accordingly.
The modification of the Pastoral Map is a continuous process and since 1966 a number of new leases have been formed by resumptions from the larger units. Examples are Kinuna (from Creswell Downs) and Benmara, Mittiebah and Mt Drummond (from Alexandria). These changes do not affect any of the analytical work in the thesis. Alexandria forms a special case in the listing in Table A.1. In 1955 this property covered 11,262 square miles, making it, in all probability, the largest privately operated land-holding in the world. Discussions with the manager in 1968 indicated that the resumption of the three new leases had made practically no difference to the area used by the company. Accordingly, the economic unit throughout the study period has been regarded as consisting of the 6,292 square miles under effective occupation.

2. The calculation of the index of land quality

The index of variations in pasture quality that is plotted in Map 2.1, has been assessed from a variety of sources published by CSIRO. The area within each lease boundary that is occupied by different pasture types was measured on the series of maps supplied with CSIRO reports, by simple cell counts on superimposed grids. For the greater part of the Northern Territory, pasture associations have been mapped at 1:1,000,000. The surveys and cartographic data utilised can be listed as follows:


(2) 'Survey of the Barkly Region, Northern Territory and Queensland', Land Research Series, No. 3, CSIRO, Melbourne, 1954, edited by Christian, C.S. [map: showing Land Use Groups of the Barkly Region, 1:1,000,000].


(5) Unpublished text and map from the survey of the cord-Victoria region (map at 1:1,000,000).

(6) 'Pasture Lands of the Northern Territory, Australia', Land Research Series, No.5, CSIRO, Melbourne, 1960, by Perry, R.A. [map: Pasture Lands of the Northern Territory, Australia, 1:2,000,000].

The classification of pasture types is not consistent in the series of surveys and Perry's 1960 map has been used to interpolate between different interpretations of the vegetational structure. In addition, this map has been used to supply measurements of pasture areas for properties not covered by the maps at 1:1,000,000 or less.

Following Perry, with some emendations, seventeen pasture types were distinguished. Having estimated the area occupied by different associations within each boundary, an index of the average land quality of each holding has been reached by attributing a maximum, theoretical stocking rate to each type, and expressing the sum of these products as a function of total area. Thus a property with areas of four pasture associations ($a_1$, $a_2$, $a_3$, $a_4$), which have theoretical carrying capacities of $S_1$, $S_2$, $S_3$, $S_4$, has an index of land quality ($I$), where

$$I = \frac{\sum a_i S_i}{n}$$

The values for each holding are given in Table A.1. The theoretical herd capacity ($T$) of each property is simply the product of this value and station area, i.e.,
The main problem with this approach is met in the determination of the maximum theoretical stocking rate. Unfortunately, little information is available on the actual density of stocking on given stands of natural pasture. The density of stocking is conditioned by the availability of permanent water but it is not known whether three or five miles is the general grazing range of feral cattle. The figures used in the calculations given in Table 2.2 have been taken from published CSIRO sources which assume, in general that stock do not utilise pasture more than three miles from a water. A discussion of the determination of each coefficient is given below.

(i) **Barley Mitchell Grass.**

This form of grassland covers a wide area on the Barkly Tableland. Christian and Stewart (1954) estimated that the stocking rate at that time was twelve to fifteen per square mile. This was on the assumption that stock can graze within a five-mile radius of water. Similar country occurs in the Alice Springs District, where Perry (1962) suggests that the stocking rate ranged from ten to twenty per square mile, with the proviso that this falls markedly in periods of drought. In the Victoria River District, the same author (1969) quotes a moderate to high carrying capacity of fifteen to twenty per square mile. Further in his 1960 summary, he suggests that twelve to fifteen represents a reasonable average for the whole of the Northern Territory, and that if all pasture were within 3 miles of a watering point, the stocking rate could be nearly trebled.

On this evidence, an average maximum carrying capacity of this type would seem to be about thirty-five beasts per square mile (this of course, would demand a very substantial investment in watering points).

(ii) **Barley Mitchell Grass and Other Perennials.**

As a type, this grassland is restricted to the Victoria River District where Perry (1969) estimated its present carrying capacity as fifteen to twenty. In his 1960 work he quotes ten to twenty, whilst provision of waters to bring all the pasture within three miles of a bore or dam would increase the stocking rate to thirty to fifty.
An index value of forty beasts to the square mile has been assumed.

(iii) **Inferior Mitchell Grass and Other Perennial Grasses.**

This type is taken to include the 'Inferior Mitchell Grass' and 'Northern Inferior Mitchell Grass' areas of the Barkly Region and the 'Bluegrass Plains' of the Victoria-Ord survey. In the former the carrying potential is given as ten per square mile. In the latter the present capacity is given also as ten. Following a personal communication with Perry, it was decided to add the 'Drybag' country to this category, which was thought by Christian and Stewart to have a potential of about four. Subsequent work, Perry (1960) suggests that this can be included as an inferior Mitchell grass type, - the whole group having a capacity of eight to ten at present. These figures would 'proportionately increase' if waters were six miles apart. This category does not include certain classes of pasture which were put under the same heading in the 1960 summary.

An average value of twenty-five has been assumed on the basis that the average of 706 cattle (at nine per square mile) which are held within five miles of a water could equally well be held within three miles of a watering point.

(iv) **Broken Mitchell Grass Country.**

Christian and Stewart estimated that this type of grassland had a maximum potential of a little over four per square mile. This type exists only on the northern edge of the Barkly Tableland, where Perry (1960) represented it as a mixture of Barkly Mitchell and inferior Mitchell grassland with three awn spear grass and soft spinifex types.

A reasonable estimate of the average capacity would seem to be four per square mile.

(v) **Arid Short Grass Plains.**

This type is restricted to the Victoria-Ord area, where it is thought to have originated as a Mitchell grass pasture. Severe depletion has reduced carrying capacity to five to ten per square mile. It is not shown on the map accompanying Perry's 1960 Territory summary.

The average capacity has been assumed to be in the region of 7.5 per square mile.
(vi) **Short Grasses and Forbs.**

In Perry’s 1962 work on the lands of the Alice Springs Area, this type is termed ‘short grass – forb pastures on flat or undulating country’ and is stated to have an average year-long stocking rate of about seven cattle per square mile. The type is very variable with a range from five to ten, and Perry (1960) estimates that the intensification of watering points could ‘at least double the present carrying capacity’. However, the same author’s 1962 paper stresses the need for good management and remarks that pasture utilisation might be optimised by intensifying watering points ‘without increasing the stocking route’. (p.267). It would seem that it is particularly difficult to estimate the physical potentials of pastures in this region because of the incidence of drought.

An average value of fifteen has been adopted provisionally. This may be over optimistic when the need to destock pastures during droughts is considered.

(vii) **Short Grasses and Forbs on Floodplains and Outwash Plains.**

These pastures are similar to (vi) but include some high quality areas scattered throughout the young alluvial soils. Perry (1962) comments that many have been heavily and selectively grazed and puts the mean stocking rate at seven with a range of five to twenty. He estimates that the rate could be doubled by providing watering points in increased density, and suggests that the potential of this pasture is greater than that of (vi).

An average value of twenty has been assumed, but again this may be too high.

There are possibilities for using this land-use type for more intensive feed production employing irrigation and introduced grasses. These are not considered here.

(viii) **Short Grasses and Forbs on Lowlands mixed with Hilly Country.**

The 1960 summary states that the stocking rate of this type varies from zero to ten per square mile and notes that although potential is variable, ‘in many parts the provision of more waters could double or treble the present carrying capacity’. In the 1962 survey of the Alice Springs area the same author renames this country ‘Alternating Hills and Lowlands’ and quotes an overall stocking rate of five per square mile. In the Victoria-Ord paper the type is
represented by 'Hilly Country with Useful Lowlands' with a carrying capacity of zero to ten depending on topography and proximity to better country."

A mean value of ten per square mile has been assumed.

(ix) Northern Bluebush.

Perry (1960) quotes Christian and Stewart as claiming that the present carrying capacity of these areas is from sixty to one hundred cattle per square mile, and remarks that more waters would slightly increase these rates. In fact they assume that between one third and one half of the area will be accessible to stock for the fattening period at a rate of eighty beasts to the square mile. If this period is only six months of the year, the year-long carrying capacity for the whole of the mapped area would be about sixteen per square mile.

On these assumptions a value of twenty per square mile has been assumed. It might be noted here that the economic value of this pasture type is disproportionately greater because of the quality of its feed as a stock fattener.

(x) Bladder Saltbush and Southern Bluebush.

A year-long stocking rate of five or less is assumed in the Alice Springs survey with the remark that in good years it helps to produce fats. In the 1960 summary, Perry suggests a stocking rate of two to five, but doubts whether intensification by providing more waters would be 'economic'.

An index value of five per square mile would seem reasonable.

(xi) Three-awned Spear Grass.

This pasture type has a very low carrying capacity in the dry season, but may produce good feed in the early part of the Wet, (Perry 1960). In the Victoria-Ord area the 'Three-awn Plains' have similar characteristics.

A value of one beast per square mile has been assumed.

(xii) Tippera Tall Grass Plains.

The group of this name is quoted as having a carrying capacity of five per square mile 'under extensive management conditions', with a potential of fifteen to twenty per square mile under more intensive conditions, in the Victoria-Ord survey. In the pasture lands summary, this type is described
under an earlier name as 'Kangaroo Grass - Perennial Sorghum' pasture, with a carrying capacity of less than ten at present and a possible potential of sixty to six hundred per square mile. The figures for the higher ranges under intensive management refer to experiments at the Katherine Research Station. It seems unlikely that cattle could ever be produced for a commercial market at the very high stocking rates; moreover, it is probable that this land-use type will be first to be developed for sown Townsville Stylo. Estimates have been made of its productivity under pasture improvement. In the absence of any substantial evidence about its true potential as a natural pasture type, it seems reasonable to adopt a value of about 17.5, which tallies with estimates of pastoralists in the eastern part of the Victoria River District who aim to intensify natural pasture utilisation.

(xiii) Tippera Tall Grass on Low Hilly Country.

This type is restricted to the Victoria River District. In the 1960 summary an average actual stocking rate of between zero to ten beasts per square mile (mean four per square mile) is given. In the Victoria-Ord survey the mean is five per square mile. It would seem that the intensification of watering points could raise these rates and a value of eight is assumed. Relatively little of the area covered by this type could be developed with Townsville Stylo.

(xiv) Upland Tall Grass Plains.

In Perry's 'Pasture Lands of the Northern Territory' (1960) this type is classified as 'Annual Sorghum and Other Tall Grasses', with an actual stocking rate of four per square mile, and the possibility of 'greatly increased productivity'. In the Victoria-Ord survey the carrying capacity is stated to be under five beasts per square mile. In the Top End the 1960 summary map shows an area of Kangaroo Grass mixed with Rugged Country and this has been added to this category. In addition this map misrepresented some areas as being 'rugged and inaccessible', when they were usable. These areas in the three Brock's Creek Land Systems have been reclassified from the maps of the Survey of the Katherine-Darwin Region (1953).

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1 See for example, Norman, M.J.T., and Arndt, W., 'Performance of Beef Cattle on Native and Sown Pasture at Katherine, N.T.', Division of Land Research and Regional Survey Technical Paper, No.4, CSIRO, Melbourne, 1959.
The value of this composite group is taken to be 7.5 beasts per square mile.

A large part of the area covered by this group has some potential for Townsville Stylo.

(xv) **Lowland Tall Grass Plains.**

This type covers country which is flooded for most of the wet season. Perry (1960) estimates the average stocking rate of this 'Reeds - Wild Rice' pasture as under five per square mile, following Christian and Stewart (1953). This area has no potential for Townsville Stylo but may be developed for mechanised rice production.

The index value is assumed to be five beasts to the square mile.

(xvi) **Kangaroo Grass.**

This type occurs on the middle and upper sections of the rivers of the Katherine-Darwin Region, and consists of pasture which is flooded for three to four months. The present and future use of this group is very similar to that of (xv).

The index value is taken as four per square mile.

(xvii) **Coastal Country.**

This consists of salt flats which may produce useful, if often inaccessible feed. An index value of one per square mile is assumed, though there is little evidence available on the utilisation of this type.

Certain comments must be appended to these descriptions. First, it will be apparent that the assumption of an actual value for a given pasture type is somewhat arbitrary. Since most of the coefficients have been determined by reference to maximum actual stocking rates, they probably tend to over-estimate the value of the better associations. However, because the main use of the index is in supplying an estimate of differences between properties, rather than the number of stock that could be carried on each holding, this is not a serious fault. Second, the carrying capacities of grasslands cannot be totally disassociated from current technology, even under the open range system. Thus the assumption of a coefficient of 17.5 beasts per square mile for Tippera Tall Grass Plains country is only valid under
current conditions, when supplements and intensive stocking are applied. The feed value of an area is the main criteria for classification, so, in this case, the high estimate is justifiable, but it must be remembered that no index could reflect accurately the whole range of agro-economic variables in land quality.

A third point follows from this. The estimates assume that water is freely available at a density of under one water per twenty-eight square miles (i.e. spaced at three mile intervals). In reality the quality of land is also determined by the presence or absence of natural surface water supplies. This means that the unimproved grazing value of land on the Barkly Tableland Mitchell Grass Plains would be virtually zero in many areas. The index, therefore, measures pasture quality, not land quality in a more general sense. The estimation of the latter would also involve consideration of factors such as the presence of shade trees, poison bushes and competitive grazing from native fauna and feral stock (these include donkeys, horses, wild cattle, buffalos and, rarely, camels). The term 'land quality' has been preferred because the index embraces the greater part of the variation in use capacity that influences economic operations. However, the need to take account of variations in the availability of water should be remembered.

Experience with the index given in Table A.1, suggests that the distribution reflects, fairly accurately, the quality of the basic resources of pastoralists. In certain cases there is reason for dissatisfaction with the final choice of a coefficient (for instance, the value of the Broken Mitchell Grass Country is probably understated, which gives low capacities to holdings on the margin of the Barkly Tableland, such as Beetaloo and Mallapunyah Springs). These faults are not thought to be significant and it may be fairly stated that the method represents a best guess at spatial differences in pastoral resources and land quality.
Table A.1: Holding areas and indices of land quality for the basic population

<table>
<thead>
<tr>
<th>Number</th>
<th>Name of Property</th>
<th>Area (square miles)</th>
<th>Land Quality Index</th>
<th>Theoretical herd Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aileron</td>
<td>1,551</td>
<td>6.28</td>
<td>9,740</td>
</tr>
<tr>
<td>2</td>
<td>Alcoota</td>
<td>943</td>
<td>15.12</td>
<td>14,260</td>
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<tr>
<td>3</td>
<td>Allambi</td>
<td>930</td>
<td>1.91</td>
<td>1,780</td>
</tr>
<tr>
<td>4</td>
<td>Alexandria</td>
<td>6,292</td>
<td>29.11</td>
<td>183,148</td>
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<tr>
<td>5</td>
<td>Alroy and Dalmore Downs</td>
<td>3,482</td>
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<tr>
<td>6</td>
<td>Ambalindum</td>
<td>1,320</td>
<td>4.56</td>
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<tr>
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<td>Ammaroo and Ilbumric</td>
<td>1,666</td>
<td>5.40</td>
<td>9,000</td>
</tr>
<tr>
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<td>Andado</td>
<td>2,057</td>
<td>1.83</td>
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<tr>
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<td>Angas Downs</td>
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<td>Anningie</td>
<td>1,715</td>
<td>8.73</td>
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<td>Anmitova</td>
<td>883</td>
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<td>Argadargada</td>
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<td>Austral Downs and Burramurra</td>
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<td>Auvergne</td>
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<td>10.13</td>
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<td>Newry</td>
<td>-</td>
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<td>-</td>
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<td>Avon Downs</td>
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<td>Brunette Downs</td>
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<td>Population</td>
<td>Value</td>
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<td>Creswell Downs and Walhallow</td>
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<td>7.70</td>
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<td>1.18</td>
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72  Jinka         797   9.34   7,440
73  Kalala        1,519  1.84   2,800
74  Kildurk       1,093  6.75   7,382
75  Kilgour       1,639  2.40   3,938
76  Killarney     1,097  23.37  25,640
77  Koolpinyah    525   6.14   3,222
78  Kulgera       529   11.08  5,860
79  Kurundi       1,862  3.92   7,300
80  Lake Nash     3,365  25.13  84,555
81  Legume        1,187  10.10  11,984
82  Lilla Creek   1,153  2.52   2,900
83  Loves Creek   1,550  5.75   8,920
84  Lucy Creek    1,597  8.77  14,000
85  Macdonald Downs and 
     Bundey River   689   9.98  6,880
86  McLaren Creek 1,371  4.41   6,040
87  Mainoru       1,249  2.55   3,180
88  Mallapunyah Springs 1,574  2.04  3,212
89  Manangoora    547   12.56  6,868
90  Manbulloo     1,489  9.38   13,967
91  Manners Creek 1,713  13.68  23,440
92  Margaret River 309   4.36   1,388
93  Marqua        1,701  9.07  15,425
94  Maryfield     1,594  3.50   5,580
95  Maryvale      1,253  4.25   5,320
96  Mataranka     1,159  9.93  11,510
97  Meneling      270   6.41   1,729
98  Milton Park   1,210  7.51   2,780
99  Mistake Creek 1,683  12.18  20,502
100 Montejinni    1,300  17.19  22,350
101 Moree         913   4.15   3,792
102 Mountain Valley and 
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103 Mount Allen   921   9.73   8,960
104 Mount Bundy   1,336  5.09   6,800
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APPENDIX 2

ACCESSIBILITY AND PRODUCTION SCALE -- ALTERNATIVE MODELS AND INTERPRETATIONS

This brief Appendix presents some of the additional results of the empirical work and examines two issues; the problem of lagged adjustment, and the problem of differential supply area response.

1. Adjustment lags

The analyses of production scale that were described in Chapters 3 and 4 were based on the assumption that links with variations in holding accessibility would be apparent in the short-run. It is apparent that structural rigidities, uncertainty, and the constraints imposed by the breeding cycle of cattle could inhibit response to transport or price improvements; thus a given production pattern could be in phase with an older set of comparative locational advantages. It is possible to take some account of such lags by matching annual sales with different accessibility indices. Table A.2 presents some of the more interesting models of station sales that arose from the work described in Part 2. Where the sign of the coefficient for rate payments or farmgate prices is negative, production scale tends to decrease as property location worsens; and these equations are of particular relevance to the study problem. This occurs in twenty-three cases in Table A.2, which gives results for the basic population of 179 holdings.

The table shows the regression coefficients for the theoretical herd capacity and accessibility indices, their t-values and the multiple correlation coefficients for the functions. Where the t-values are significantly different from zero at the five per cent probability level it is reasonable to assume that the regression coefficients demonstrate a link between pairs of independent and dependent variables. The only accessibility series which
Table A.2: Alternative regression models of industry sales
1957, and 1963 to 1967 (N = 179)

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<td>-0.38</td>
<td>0.80</td>
<td>7.43</td>
<td>-0.14</td>
</tr>
<tr>
<td>Log. 1964</td>
<td>66 price</td>
<td>-0.36</td>
<td>0.81</td>
<td>7.50</td>
<td>-0.14</td>
</tr>
<tr>
<td>Log. 1965</td>
<td>57 rate</td>
<td>0.25</td>
<td>0.61</td>
<td>5.17</td>
<td>-0.14</td>
</tr>
<tr>
<td>Log. 1965</td>
<td>57 price</td>
<td>0.42</td>
<td>0.63</td>
<td>5.48</td>
<td>-0.21</td>
</tr>
<tr>
<td>Log. 1965</td>
<td>64 price</td>
<td>0.51</td>
<td>0.63</td>
<td>5.43</td>
<td>-0.22</td>
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<td>Log. 1965</td>
<td>66 price</td>
<td>0.43</td>
<td>0.64</td>
<td>5.51</td>
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</tr>
<tr>
<td>Linear 1966</td>
<td>57 rate</td>
<td>260.07</td>
<td>0.06</td>
<td>15.90</td>
<td>-0.28</td>
</tr>
<tr>
<td>Linear 1966</td>
<td>57 price</td>
<td>185.00</td>
<td>0.06</td>
<td>15.74</td>
<td>-0.01</td>
</tr>
<tr>
<td>Linear 1966</td>
<td>66 price</td>
<td>185.68</td>
<td>0.06</td>
<td>15.86</td>
<td>-0.00</td>
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<tr>
<td>Linear 1966</td>
<td>66 price</td>
<td>-153.62</td>
<td>0.08</td>
<td>19.90</td>
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<tr>
<td>Linear 1966</td>
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<td>-486.98</td>
<td>0.08</td>
<td>19.69</td>
<td>0.32</td>
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<tr>
<td>Linear 1966</td>
<td>66 price</td>
<td>-266.09</td>
<td>0.08</td>
<td>19.55</td>
<td>0.05</td>
</tr>
<tr>
<td>Log. 1963-67</td>
<td>57 rate</td>
<td>1.23</td>
<td>0.54</td>
<td>8.59</td>
<td>-0.02</td>
</tr>
<tr>
<td>Log. 1963-67</td>
<td>57 price</td>
<td>1.41</td>
<td>0.55</td>
<td>8.78</td>
<td>-0.05</td>
</tr>
<tr>
<td>Log. 1963-67</td>
<td>66 price</td>
<td>1.41</td>
<td>0.55</td>
<td>8.75</td>
<td>-0.04</td>
</tr>
<tr>
<td>Linear 1963-67</td>
<td>57 rate</td>
<td>190.95</td>
<td>0.06</td>
<td>19.43</td>
<td>-0.19</td>
</tr>
<tr>
<td>Linear 1963-67</td>
<td>66 price</td>
<td>10.79</td>
<td>0.06</td>
<td>19.19</td>
<td>0.04</td>
</tr>
</tbody>
</table>

\(c\) = regression coefficient  
\(t\) = t-value of coefficient  
\(t\)' is significant at the one per cent level at 2.60  
\(t\)' is significant at the five per cent level at 2.35

Source: dependent variables, NTAAIB stock permit data; independent variables see Chapters 3 and 4.
fulfil this condition are the dairy rate payment and farmgate price differential indices in the logarithmic models of sales in 1957. However, the other results may indicate that location exerted a slight influence on output. Examination of the coefficients for lagged functions suggest that there is little evidence to support the view that supply response patterns are inherited. Further, it appears that the substitution of indices makes little difference to the multiple correlation coefficients of the equations.

Two additional points may be noted. First, the logarithmic transformations seem to give greater weight to variations in accessibility. Here, a given percentage increase in farmgate prices is associated with a constant increase in output at all scales. In this case, the rent gradients would form convex downward slopes from market terminals and production scale would be asymptotic to the no-rent margin. Second, it appears that the linear functions have superior total explanatory power. This is due to the dominant role of land quality in the industry and, by extension, this suggests that the Ricardian rent function takes a simple form. Thus there is likely to be a distinct cut-off point (for a given set of prices) beyond which it will not pay to exploit land of a lower use-capacity.

These inferences must be qualified in the light of the coarseness of the data, but they provide interesting pointers to possible extensions of the methodology employed in this thesis.

2. Differential supply area response

The empirical results that are given in the body of the thesis refer to the total number of available observations from the basic population and the modified BAE sample. It seems reasonable to suggest that production response to differences in accessibility might be more apparent within supply areas, for in this case, institutional, uncertainty and elasticity influences would be constant for the groups. It is possible to separate the Alice Springs District from the remainder of the Northern Territory and equate it with
the South Australian supply area; while observations for
the remaining Districts can be aggregated. Further groupings
are not meaningful because of the presence of split
allocations, and fluctuating market boundaries in the north
of the Northern Territory. The findings for the two data
sets will now be discussed in turn.

Producers in the northern Districts shared a dependence
on the Queensland store trade up to 1963, due to the lack of
local processing facilities and the declaration of the
Central Australian Pleuropneumonia Protected Area. The
subsequent entry of the Katherine and Darwin meatworks
changed marketing opportunities substantially and led to a
general rise in prices. Table A.3 shows the characteristics
of selected regression models for the stations in these
Districts. Again, the t-values of the regression coefficients
for the accessibility indices show that the reliability of
this element of the functions is low. The results suggest
that there may have been a tendency for rate payment and
farmgate price differences to condition scale. However, it
is clearly possible to reject the view that disaggregation
will lead to a marked increase in the explanatory power of
the models. The most significant result is found in the
logarithmic equation relating the 1966 farmgate price
series to average holding sales between 1963 and 1967.
Here, the t-value and the multiple correlation coefficient
may be compared with those of the functions for 1957 prices
(log.) and 1964 prices (linear). This check shows that
the relationship is not particularly strong.

Sub-sample results are also available for the regression
model of cash income per square that was presented in
Chapter 5. Using the same notation, the function for the
Northern Districts takes the form,

\[
\begin{align*}
\log X_1 &= 0.50 + 0.17 \log X_2 + 0.79 \log X_4 + 0.11 \\
& \hspace{1cm} \log X_{10} + 0.15 \log X_{11} - 0.26 \log X_{12} \\
R &= 0.81 \quad R^2 = 0.66 \quad [N = 41]
\end{align*}
\]
Table A.3: Regression models of industry sales for northern and Alice Springs District property sets, 1957, 1966 and 1963-67

a. Northern Districts (N = 102)

<table>
<thead>
<tr>
<th>Equation</th>
<th>Sales form</th>
<th>Access variable</th>
<th>Equation parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Constant</td>
</tr>
<tr>
<td>Log.</td>
<td>1957</td>
<td>57 rate</td>
<td>-1.31</td>
</tr>
<tr>
<td>Log.</td>
<td>&quot;</td>
<td>57 price</td>
<td>1.18</td>
</tr>
<tr>
<td>Linear</td>
<td>&quot;</td>
<td>57 rate</td>
<td>41.02</td>
</tr>
<tr>
<td>Log.</td>
<td>1966</td>
<td>57 rate</td>
<td>0.76</td>
</tr>
<tr>
<td>Log.</td>
<td>&quot;</td>
<td>64 price</td>
<td>1.30</td>
</tr>
<tr>
<td>Log.</td>
<td>&quot;</td>
<td>66 price</td>
<td>-0.97</td>
</tr>
<tr>
<td>Log.</td>
<td>1963-67</td>
<td>57 price</td>
<td>2.37</td>
</tr>
<tr>
<td>Log.</td>
<td>(Mean)</td>
<td>66 price</td>
<td>2.47</td>
</tr>
<tr>
<td>Linear</td>
<td>&quot;</td>
<td>64 price</td>
<td>-387.77</td>
</tr>
</tbody>
</table>

b. Alice Springs District (N = 77)

<table>
<thead>
<tr>
<th>Equation</th>
<th>Sales form</th>
<th>Access variable</th>
<th>Equation parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log.</td>
<td>1957</td>
<td>57 rate</td>
<td>1.59</td>
</tr>
<tr>
<td>Log.</td>
<td>&quot;</td>
<td>57 price</td>
<td>1.85</td>
</tr>
<tr>
<td>Linear</td>
<td>&quot;</td>
<td>57 rate</td>
<td>509.75</td>
</tr>
<tr>
<td>Linear</td>
<td>&quot;</td>
<td>57 price</td>
<td>516.20</td>
</tr>
<tr>
<td>Log.</td>
<td>1966</td>
<td>66 price</td>
<td>0.32</td>
</tr>
<tr>
<td>Linear</td>
<td>&quot;</td>
<td>66 price</td>
<td>24.88</td>
</tr>
<tr>
<td>Log.</td>
<td>1963-67</td>
<td>57 price</td>
<td>2.11</td>
</tr>
<tr>
<td>Log.</td>
<td>(Mean)</td>
<td>57 price</td>
<td>2.11</td>
</tr>
<tr>
<td>Log.</td>
<td>&quot;</td>
<td>66 rate</td>
<td>1.86</td>
</tr>
<tr>
<td>Log.</td>
<td>&quot;</td>
<td>64 price</td>
<td>1.85</td>
</tr>
<tr>
<td>Linear</td>
<td>&quot;</td>
<td>66 price</td>
<td>1.82</td>
</tr>
<tr>
<td>Linear</td>
<td>&quot;</td>
<td>57 rate</td>
<td>181.23</td>
</tr>
<tr>
<td>Linear</td>
<td>&quot;</td>
<td>57 price</td>
<td>182.11</td>
</tr>
<tr>
<td>Linear</td>
<td>66 rate</td>
<td></td>
<td>131.55</td>
</tr>
<tr>
<td>Linear</td>
<td>&quot;</td>
<td>64 price</td>
<td>131.39</td>
</tr>
<tr>
<td>Linear</td>
<td>&quot;</td>
<td>66 price</td>
<td>129.01</td>
</tr>
</tbody>
</table>

't' is significant at the one per cent level at 2.62; 2.64
't' is significant at the five per cent level at 2.36; 2.38

Source: As Table A.2.
The $t$-values for the regression coefficients are $2.14; 6.14; 1.26; 1.23; \text{ and } -0.60$ respectively. Here only the coefficient for fencing inputs is reliable, and in most other respects the form of the equation approximates that of the whole sample. However, it is interesting to note that the farmgate price differential exhibits a negative sign. This means that revenue intensity tends to fall as property access to high price markets worsens. This may indicate that price effects are relatively more important in the north, and that rate payments for road transport exert less influence on scale. If this is so, it confirms the value of the new processing plants to the industry and strengthens the conclusions which have already been drawn on the low level of response that is likely to follow road investment.

The production pattern in the Alice Springs District presents a particularly interesting case from a theoretical viewpoint. The Alice Springs railhead is centrally located and the usable country extends outward at a radius of between 100 and 250 miles. South of the terminal, there are a number of smaller rail sidings (Deep Well, Rodinga, Rumbalara and Finke), which attract some cattle, but there appears to be an increasing tendency for traffic to move to either Alice Springs or Finke. However, additional outlets are easily taken into account in rate cost and farmgate price calculations, so that the District can be equated in many locational characteristics to the Isolated State model. Further, the pleuro-line partially shields producers from competition on the South Australian market, where prices were consistently high over the study period. Examination of the models presented in Table A.3 shows that there was a pronounced tendency for scale to fall off towards the periphery in 1957. Since Alice Springs forms the basing point for the farmgate differential indices, the price and rate costs values are virtually identical in each case. Map 3.2 gives visual confirmation that there was an intensity gradient in this year, and detailed examination of

Stock permit data suggested that a considerable trade had developed between holdings on the edge of the occupied country and those near the terminals (it is not possible to identify cattle types but it fairly obvious that the outer properties sent stores to the centre).

In the following years the eight-year drought (1958-65) greatly reduced stocking intensities and gross output, which makes it difficult to draw reliable inferences on the impact of improved accessibility on the production pattern. The models in Table A.3 suggest that the centripetal tendency weakened and this may be observed in the distribution of consignments shown on Map 4.1. There is therefore a prima facie case for concluding that the importance of variations in transport payments in scale decisions declined over the decade from 1957 to 1966. This would support the findings drawn from the studies of the whole industry. In fact, some qualification is needed here. Map 2.1 shows that good land is unevenly distributed within the District and there is a fairly marked central concentration. The correlation coefficients for the accessibility indices and the index of land quality for the seventy-seven holdings confirm this (they average -0.10). It is therefore possible to suggest that part of the explanation for the 1957 result lies in multicollinearity. If this is so, it seems likely that the old pattern will be partly reconstituted when better seasons permit a regular response to variations in land resources. There is a general issue behind this finding. Towns and routes will be located, where possible, near to areas of good land1 -- indeed the Northern Territory is atypical in that there is an overall tendency for terminals to be eccentric to the better pastoral country. This means that

1 This problem is discussed by Garrison, W.L., in Allocation of Road and Street Costs - The Benefits of Rural Roads to Rural Property, Washington State Council for Highway Research, Seattle, 1956. Garrison's study is concerned with an attempt to estimate highway user benefits from land value data. It discusses a methodological approach to the complementarity problem which provided the initial stimulus for the work described in this thesis.
the wider findings on the role of accessibility can be
accepted without any necessity to take account of systematic
bias from this source.

The revenue intensity function for the thirty-one
holdings in the Alice Springs District that were included
in the modified BAE sample takes the form,

\[(ii) \log X_1 = 0.66 + 0.57 \log X_2 + 0.16 \log X_4 + 0.14
\]

\[\log X_{10} - 1.21 \log X_{11} + 0.93 \log X_{12}\]

\[R = 0.78 \quad R^2 = 0.61\]

The t-values for the regression coefficients are 3.11;
0.85; 1.36; -0.01; 0.01. The multiple correlation
coefficient for this equation is just significant at the
one per cent level. The t-value for the land quality index
indicates that it is the only variable that makes a
statistically verifiable contribution to the function.
There is an apparent tendency for rate payments to exert
some influence on output while prices do not, but the
similarity between the two series points to the dangers
that are inherent in making fine interpretations of the
data.
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Kansky, K.J., 'Structure of Transportation Networks: relationships between network geometry and regional characteristics', *University of Chicago, Department of Geography Research Papers*, 84 (1963).


