CITRUS SIAM ADOPTION IN A SOUTH SUMATRAN RUBBER SMALLHOLDING VILLAGE: AN INTERDEPENDENCE APPROACH

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Declaration

Except where otherwise indicated

this thesis is my own work.

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Abstract

In investigating the adoption process of a crop called "citrus siam" in a South Sumatran rubber-smallholding village, Belatung, the importance of externality of other villagers in a villager's decision making was noticed. Neo-classical economics generally uses a model in which individuals are treated as atomistic, self-interested and independent beings, and attempts have rarely been made to incorporate an individual's relative socio-economic position into a utility function framework. Previous attempts, which may be placed under the broad haeding of "interdependence approach", are so far simplistic, and still in their infancy.

On the other hand, the sociological and anthropological literature has paid greater attention to these aspects. Approaches developed for analysis of a person's socio-economic position can provide useful concepts for economists to develop realistic economic models of human behaviour. Techniques of sociological network analysis appear to be particularly useful for economists to utilise in their work.

In this thesis, firstly, the interdependence approach literature and basic literature of adoption process are reviewed. Secondly, villagers' interactions with each other are carefully described with sociological network analysis techniques. On this basis, thirdly, a model of expected utility which explicitly incorporates both a person's absolute and relative income levels is developed for the analysis of the "Cancian Dip" or "upper-middle class conservatism" hypothesis. Finally, with data collected from the village, Belatung, hypotheses and propositions of the model are statistically tested.

The interdependence approach, though theoretically a little more complicated, is empirically proved to be significantly more powerful in explaining the citrus siam adoption process in Belatung.

Glossary of Indonesian Terms

adat	System of traditional custom of Malay, Indonesia
bagi dua	Sharecropping where harvest is divided into two halves, same as paruhan
bagi tiga	Sharecropping where harvest is divided into one third for landowner and two thirds for sharecropper
BAPPEDA	Badan Perencanaan Pembangunan Daerah (Regional Development Programme Body)
bedeng	literally railway embankment, but actually a house divided into four sections each of which is for one family of a National Railway worker.
BIMAS	Bimbingan Massal
bupati	literally regent who governs subdistrict in province, presently appointed Governor of province.
camat	head of a district in kabupaten.
cengkeh	cloves
depo (depe, depa)	about 170 cm, which is the length of two arms stretched out. Indigenous unit of measurement.
desa	smallest administrative unit, village
Dinas Perdagangan	Trade Agency of Ministry of Trade and Commerce
Dinas Perkebunan	Estate Crop Agency of Ministry of Agriculture
Dinas Pertanian dan Tanaman Pangan	Agency for Agriculture and Food Crops of Ministry of Agriculture (Food Crops Agency)
duku	Nephelium lappaceum
dukun	traditional medical healer
dusun	literally hamlet, but in South Sumatra corresponds to desa, smallest administrative unit.
haji	pilgrim to Mecca.
jeruk siam (jeruk siem)	citrus siam (Citrus Nobilis Microcarpa Hoslk)
jeruk manis	sweet oranges (Citrus aurantium or Citrus sinensis Osbeck.)
kabupaten	subdistrict of province, regency, where bupati governs
kapak	cotton
kecamatan	subdistrict of kabupaten, where camat governs
kedai kopi	coffee shop, grocery shop in Malay
kepala desa	village head.
kerbau	water buffalo.
kerio	head of a natural village, dusun, in South Sumatra, which now corresponds to an administrative village, desa.
khotib (khatib)	preacher, mosque official, religious teacher
lada	pepper
ladang	upland, a plot of land. See also padi ladang.
lebak	lower land along rivers, floodbed. More than once a year, these plots are flooded. It is divided into three levels, from higher levels, lebak tinggi (lebak pematang), lebak tengah (lebak tengahan) and lebak rendah (lebak dalam). For detailed discussion of geographical terms, see Takaya (1980).

Lebaran	religious feast celebrated at the end of the fast
Lebaran haji	religious feast celebrated on the 10th day of Du'lhijjah (an islamic calendar month) for haji.
LIPI	Lembaga Ilmu Penelitian Indonesia (Indonesian Institute of Sciences).
marga	administrative unit under kecamatan
nakok	rubber tapper (sharecropper)
numpang	a type of land lease system where a lessee, penumpang, is not required to pay any charges.
padi ladang	Brush and grass on ladang are cut with parang (large knife) during the dry season. Dried brush and grass are burnt in November, and immediately after this, holes are punched out with a six-foot long tugal, and 10 to 20 grains of rice seed are dibbled in each hole. Harvest is between April and June.
pangeran	prince in the Sultanate system
parang	large jungle knife
paruhan	sharecropping where harvest is divided into two halves, same as bagi dua
pasirah	a village head during the colonial period. The administrative village then covered a wider area, which now correspond with a marga. After the independence, a head of marga.
pematang	raised area along a river, literally small dike in rice field or raised path.
pemborong	contractor, builder and trader of harvests who organise hired labourers.
P.J.K.A.	Perusahan Jabatan Kereta Api (National Railway)
rambutan	Lansium domesticum
Rupiah (Rp.)	US$1=Rp.1000, A$1=Rp.800 (1982-3)
sawah	irrigated rice field
sekolah rakyat (SR)	primary school before 1945
sekolah dasar (SD)	primary school after independence
sekolah menengah pertama (SMP)	junior high school
sekolah menengah atas (SMA)	senior high school
sekolah menengah ekonomi pertama (SMEP)	junior economic high school
sekolah menengah ekonomi atas (SMEA)	senior economic high school
talang	(1) remote hamlet of a village (2) peneplain and terrace area, its soil is red and classified as red yellow podsol, very poor soil, deficient in nutrients, considered as having no potential for agricultural use.
tanjung	cape, tongue of land along a river
toko kopi	coffee shop in Indonesian
tugal	long wooden stick
ume	In today's Malay culture, ume or uma stands for upland fields where slash and burn cultivation is practiced, is an antonym of sawah. In this area, however, ume means a garden or a plot of land in general due to the lack of sawah. Thus ume and kebun(kebon) seem to be used interchangeably by villagers.
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CHAPTER 1

Introduction

Independence is for the very few;
it is a privilege of the strong.

Nietzsche, Beyond Good and Evil, 1886

Independence?
That's middle class blasphemy.
We are all dependent on one another,
every soul of us on earth.

George Bernard Shaw, Pygmalion, 1913

All envy is proportionate to desire;
we are uneasy at the attainment of another,
according as we think our own happiness would be advanced
by the addition of that which he withholds from us.

Samuel Johnson, The Rambler, 1750-52

1.1 Research Objectives

No man is, in practice, a purely economic man who is independent of other men, though a man tends to claim proudly that he is in principle an independent man who is not influenced by others. Modern economics has been established on the foundation of this principle rather than on actual practice, but with this foundation it has well approximated various economic situations so far. Modern economics has even endeavoured on occasion to explain various sociological situations and other situations, which had been generally thought in the area of other disciplines. Thus, the term "Economic Imperialism" has been ironically coined.[1]

[1]Radnitzky and Bernholz 1985, and Hirshleifer 1985.

However, as the world economic situation has become more complex and modern economics has failed to advance suitable practical remedies, a number of criticisms against its foundations have been voiced by outside groups. At the same time, as modern economists have looked into more micro-level economic situations, they have started to realise the inappropriateness of the foundation themselves. Modern economists, however, have not been unaware of such difficulties, and the pioneers of modern economics always mentioned these in their classic works. They were just "assumed-away" for the sake of simplifying theories, or worse for protecting established theories in the knowledge that the incorporation of the concept of "interdependence" vitiated these.

At present, the movement towards incorporating the concept of "interdependence" into modern economics is gaining momentum, although it lacks a common integrated approach.

These problems have been well understood by economists and economic anthropologists dealing with non-western economies who have engaged in field research. For example, the adoption of agricultural innovations in developing agriculture has been tackled by economists with various ad-hoc frameworks until recently. This phenomenon has been often better explained by rural sociologists than economists. It is only recently that a solid theoretical framework for the economic analysis of the agricultural adoption process has been proposed.

This study has two objectives.

Its first and major objective is the presentation of a theoretical framework for economic studies of adoption process of new technologies in agriculture, which is based on the concept of interdependence.

Its second objective is to test the interdependence approach model with empirical data. It is useful to focus on a situation where many of the "external" factors in the environment facing potential adopters are similar. It was decided to study the adoption process in the village of Belatung in South Sumatra, Indonesia, for this purpose. This village has traditionally been a rubber-smallholding village; however, in recent years, many villagers have adopted a new crop, locally known as "citrus siam".

1.2 Background of the Case Study

With the realisation that the "oil boom" may be nearing its end, the Indonesian government's national priorities have shifted to non-oil and non-natural gas industries. Indonesia's rubber industry, in particular, has been regarded by the government as a most important industry with good potential for growth. However, the lack of effective estate/smallholding cash crop extension services and problems with research have delayed the execution of any swift change of the national priorities to supporting these industries as opposed to the traditionally important agricultural food crop sector. In recent years, many rubber smallholders have switched from rubber to other cash crops whose gestation periods are much shorter than rubber, or whose profitability is much better than rubber in the short term. Depending on regional conditions, rubber smallholders have been trying coffee, cloves and many other tree crops or fruit crops.

In South Sumatra where rubber smallholdings dominate rubber production, and which is one of the major rubber producing areas of Indonesia, this change of rubber smallholders has been widely observed. Especially, citrus siam has been widely tried by rubber smallholders as an alternative crop, and has been very successful.

Citrus production has long been adopted by Indonesian farmers from Bali to Sumatra, but has not been widely commercialised due to insufficient domestic consumption. In these days, although relevant national statistics are lacking, a significant increase in demand for citrus can be seen due to the Indonesian people's changing dietary pattern. In city areas, citrus fruits are consumed by a large proportion of people directly or indirectly in the forms of fresh juice, tinned juice, granules or powder. The reaction on the supply side has been so rapid that the Ministry of Agriculture has warned that rice farmers should not intercrop rice and citrus for the purpose of mere short term profit.[2] Rice farmers in Java have started producing citrus on mounds between rice, and getting significant profits out of this.

Citrus production is thus becoming very popular, but is vulnerable to disease. The export of saplings/grafts of citrus to outer islands is prohibited for fear of transferring

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[2]See the article of Kompas on 15 August 1983 (Kompas 1983c).

diseases experienced in Java. Nevertheless, farmers of outer islands or Javanese transmigrants have still been trying to transport them from Java. However, farmers in the down-stream areas[3] of South Sumatra have also been producing a kind of citrus, citrus siam, since the 1950's, and during the federal period and before the 1965 coup, it seems they even exported it to Singapore through Palembang. Because of the centralisation under the New Order regime, its export from Palembang to Singapore was banned, and due to the wide-spread citrus virus disease in the area, production decreased greatly.

The revival of its production in South Sumatra started in the early 1970's, but in the mid- and up-stream areas in the province to avoid disease. Farmers in the new areas seem to have acquired the techniques to produce citrus siam by observation or by learning from their fellow farmers or relatives who produced citrus siam during the previous boom. During the previous boom, these new areas were marginal production areas mainly because of high transportation costs.

Thus, rubber smallholders in the new areas, formerly the marginal areas for citrus, have gradually switched to citrus siam production from rubber production which has been suffering from decreasing profitability due both to decreasing productivity of the old rubber stands and to relatively poor prices in the area.

This growing popularity of citrus siam was not interrupted by the sudden increase of profitability of coffee in 1976. Although it was grown widely in the up-stream areas, coffee was not suitable in the lower region. During the surge of coffee prices, farmers in the mid- and down-stream areas have actually adopted citrus siam. The surge of coffee prices did not last for long, but by the early 1980's the popularity of citrus siam had gained more momentum.

In these circumstances, extension services for citrus siam production have been strongly demanded by farmers. The Food Crop Agency (Dinas Pertanian dan Tanaman Pangan) is in charge of this crop and has the great potential to diffuse the information

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[3]The province of South Sumatra has traditionally been divided into three in relation to its rivers. From the east, down-stream areas, mid-stream areas, and up-stream areas.

effectively through the agency's Kontak Tani (contact farmer) system,[4] which has been operating in sawah rice growing areas.

However, as mentioned above, the up- and mid-stream areas in South Sumatra have traditionally been under rubber smallholdings, and the Agency's contact farmer system is not yet established there although this is intended.

For the establishment of the contact farmer system, the selection of the contact farmer in a village is naturally a key aspect. Usually, the agency asks a village head to recommend one farmer for the job. The village head seems to select himself or a powerful farmer next to him in his own group. The selection may be viewed as very political one, and tends to end up in the "top-down" approach. This "top-down" approach has sometimes been found to have a disturbing effect on diffusing information.[5] The contact farmer selected may monopolise information from the authority or he may not convey villagers' opinion to the authority for his own benefit. He may be isolated in terms of information flows in the village. Although he may be an important person in the village, he may be too "different" from other villagers for them to receive his influence from. In this case, the information from the authority may diffuse, but the authority is unlikely to obtain feedback about farmers' reactions or problems through him. Much depends on the village structure, and on individual characteristics of the person selected.

Economics has little to say about the characteristics of individuals as agents of technology diffusion. It can suggest that a rich farmer is generally quick to adopt, but has nothing to contribute about information flows, or about whether the richest farmer can effectively influence others. This is because conventional analysis assumes atomistic, astructural, discrete, individual and independent roles for farmers. The nature of comparative statics analysis provides for only a monotonic relationship, for example, between a farmer's wealth and his adoption behaviour, saying that non-monotonic relations can ultimately be reduced to a set of monotonic relations if they are identifiable. However, in actuality, there may be some explanatory variables which influence the dependent variable in opposite ways depending on its range, and cannot be decomposed.

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[4]For a discussion of the contact farmer system, see Benor and Harrison (1977).

[5]Agarwal (1983)

In sociological studies of adoption/diffusion processes, Cancian (1967, 1979) has strongly argued for a curvilinear or rather non-monotonic relationship between socio-economic status measured in terms of wealth or income levels and farmers' innovativeness. Rogers, in his distinguished works on adoption/diffusion (Rogers 1983), treated Cancian's findings ("Cancian Dip") as a warning against a blind usage of monotonic assumptions.

The "top-down" approach backed by the findings of economic studies based on monotonicity has been pointed out as not being conducive to or satisfactory for the explanation of the process of adoption/diffusion. At the other extreme, the "grass-root participation" approach seems also to have problems. The selection of change agents within a village such as contact farmers, should be carefully conducted paying great attention to the relationship between adoption behaviour and characteristics of people who are likely to become the source of information.[6]

In the recent economics literature, a framework useful for the analysis of social structure and information has gradually been developed, namely, the interdependence approach (interdependence utility function approach).[7] However, in many respects, this approach is as yet at an early stage of development.

In this study, an attempt is made to develop an empirically testable model based on this interdependence approach and drawing on the network analysis developed in the sociology of social structure. Some hypotheses which relate the citrus siam adoption process in a rubber-smallholding village in South Sumatra to the villagers' individual and structural characteristics will be derived and statistically tested. Non-monotonic relationships between adoption behaviour and its explanatory variables will be carefully explored.

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[6]Agarwal 1983, Rogers 1983, and Benor and Harrison 1977.

[7]Hirsch 1977, Hayakawa and Venieris 1977, Boskin and Sheshinski 1978, Becker 1974, Layard 1980 and Scitovsky 1976.

1.3 Thesis Structure

This study is presented in the following way.

In the rest of Chapter 1, the literature of theoretical adoption/diffusion process models is first reviewed. Economic and sociological studies of contextual effects on individual behaviour for the purpose of integrating these two disciplines and the adoption/diffusion process models are further discussed. Dynamic aspects associated with the integration are also reviewed. Research methods adopted for this study are then set up according to the results in literature reviews.

Chapter 2 is devoted to the description of the village, Belatung, in South Sumatra, Indonesia, in terms of basic general characteristics and its economy, especially agricultural economy.

In Chapter 3, the village's socio-economic structure captured by network analysis is described, and villagers' reference groups are derived and related to the structure of interdependence among villagers.

In Chapter 4, the citrus siam adoption processes in South Sumatra and in a village, Belatung, are described in detail in relation to other major crops. Villagers' times of adoption are then related to the structure of interdependence.

In Chapter 5, the interdependence utility function is formulated and a measure of a villager's attitude towards risk is derived from the interdependence utility function. This measure is related to adoption behaviour, i.e., the scale and time of adoption. Relations between the adoption behaviour and variables associated with the interdependence utility function are derived and hypothesised.

Chapter 6 supplies empirical statistical examinations of hypotheses derived in Chapter 5.

Finally, in Chapter 7, the process and results in this study are summarised, and the advantages of the interdependence approach are discussed subject to the limitations imposed by the facts (1) that contextual effects were measured with particular methods which are likely to have influenced the results, and (2) that the adoption process of citrus siam was studied in only one village. Some research and policy recommendations are also discussed.

1.4 Review of Literature

Several existing models of the intra-farm diffusion process, economic and sociological studies of the contextual effects, and dynamic aspects of the adoption/diffusion process associated with the contextual effects studies, are reviewed here.

1.4.1 Theoretical Models of the Intra-farm Diffusion Process

A study of the diffusion process of an agricultural innovation in a certain area can be decomposed to three components. The first component is a farmer's time of adoption[8] of the innovation concerned, and the second is the farmer's scale of adoption over time. The intra-farm diffusion process can be described with these two components. Further, if an agricultural innovation in a small village is studied, the adoption process in terms of the extent of the innovation adopted in the whole village can be derived from these two components, provided that a survey is properly conducted.[9] This is the third component of the diffusion process and called the inter-farm diffusion process.

Few models have been formulated until now for analysis of the intra-farm process.

1.4.1.1 Mansfield Model

Mansfield (1961, 1968) developed imitation models for both inter-firm and intra-firm diffusion processes.

Mansfield (1968) made the following assumptions. Firstly, the proportion of new adopters to non-adopters is a function of the profitability of the new technology (assumed constant) and the level of uncertainty associated with the new technology. Secondly, the level of uncertainty is a function of the initial level of uncertainty and the ratio of total adopters to all potential adopters in a system. Thirdly, the level of uncertainty is, further, linearly related to the ratio of total adopters to all potential adopters. Finally, the ratio of the level of uncertainty to the initial level of uncertainty is inversely related

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[8]Lindner, Pardey and Jarrett (1982) called this the adoption lag (A.L.) and separated it into (1) the discovery stage lag (D.S.L.) and (2) the evaluation stage lag (E.S.L.). The D.S.L. is the period from availability to awareness and the E.S.L. refers to the period from awareness to first use of the innovation.

[9]A well constructed random survey can approximately capture the adoption process of the whole village, while a census survey is, of course, the most accurate method despite various associated costs.

to the ratio of adopters to all potential adopters. These assumptions reflect the decision makers' imitative attitude, and are very intuitive..

Mansfield fitted logistic curves to data of intra-firm diffusion processes of diesel locomotives in United States between 1925 and 1959. He explained about 70 percent of the variance of the derived speed of adoption by some characteristics of firms.[10]

1.4.1.2 Stoneman Model

Stoneman (1981) showed that Mansfield's model cannot explain the stylised fact of the sigmoidal curve of the diffusion process, when Bayesian learning[11] is applied to the revision of the level of uncertainty associated with the new technology. He developed an adaptive portfolio model involving Bayesian learning. In this model, the Freundian utility function, which consists of the mean and variance of total return from two technologies and adjustment costs, is maximised to derive the optimal allocation rate of the new technology as a function of means and variances of two technologies.[12] The optimal allocation rate is adaptively revised according to means and variances of two technologies, which are revised in the Bayesian manner. He showed (1) the more profitable the technology, the higher the level of usage and (2) the more risk averse the firm, the lower the level of usage.

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[10]The speed of adoption is defined as a coefficient of time in the logistic function. Characteristics used to explain the variance are (1) profitability of a diesel locomotive, (2) time lag from the first diesel locomotive adopter, (3) operation size, and (4) liquidity (Mansfield 1968, p.185).

[11]See Anderson, Dillon and Hardaker (1977) for the concept of the "Bayesian learning" and its application to agricultural decision analysis.

[12]The Freundian utility function has the following form:

$$u(X_i) = a\ E(X_i) - \frac{1}{2} b\ Var(X_i) - C$$

where X_i is the i-th individual's income and E(*) and Var(*) are respectively an expectation operator and variance operator. C is the disutility of adjustment costs.

1.4.1.3 Feder Model

Feder (1980) and Feder and O'Mara (1981) developed an expected utility maximisation portfolio model. They assumed that: instead of Bayesian learning, the change of variance of yield of the new crop (technology) depends negatively on time and on the total acreage of the new crop. Here, time captures the exogenous improvement of information about the innovation, such as that derived from a more efficient distribution system of information from outside sources, and the total acreage represents farmers' cumulative experience with the innovation, the communal "learning by doing".

Simulations with this model produced sigmoidal curves and some implications concerning the income distributive effects of innovations. In the simulation, the lower limit of landholding size of adopters[13] gradually diminishes as the variance of yield of a new technology decreases. This decrease is assumed to be a function of two independent variables, time, and the total area of new technology. They related this lower limit landholding size to the land-holding distribution of the study area. Consequently this model can generate a sigmoidal curve of the number of adopters over time. It should be noted that the economic structure of an area, for example a village, can be described not only by landholding distribution, but also by many other economic factors, such as distributions of income and items of human capital (e.g. educational attainment).

1.4.1.4 Lindner Model

Lindner, Fischer and Pardey (1979) constructed a simple model based on Bayes Theorem to derive a farmer's time of adoption, assuming that the amount of information a farmer collects each unit of time is constant. The model suggests that; (1) the time of adoption is earlier when the innovation is more profitable, (2) the time of adoption is related to a farmer's initial degree of pessimism about relative profitability of the innovation (farmer's initial expected difference between average yields from the new and old technologies), (3) the time of adoption is earlier if the initial degree of conviction is stronger, i.e., the inverse of variance of difference between yields from the new and old

[13] "Critical landholding size". Farmers with landholdings smaller than this will not adopt the innovation, while larger farmers will adopt it at least on a portion of their land.

technologies initially expected by a farmer is greater, and finally (4) the time of adoption is inversely related to the farmer's degree of confidence about the quality of information, which is represented by a ratio of the number of observations to the real variance of difference in yields from two technologies.

Lindner and Fischer (1982) improved portfolio models by introducing the concept of "quality of information". This concept represents the quality of information collected for revisions of decision makers' belief of new technology, i.e., the distribution of returns from the new technology. Information about the new technology from adopters to a potential adopter is classified as "indirect information", while information from farmers' own experiences with the new technology is classified as "direct information". They explained the possibility of "rational rejection" of a profitable new technology by a potential adopter. A farmer's rational rejection can happen if he is restricted to sources of information which he greatly discounts. Even though he collects unlimited quantities of information from them, its quality does not reach the level required to adopt the innovation.

1.4.1.5 Gladwin Model

Gladwin (1976a, b, 1979, 1980) developed a completely different model of a farmer's adoption behaviour. Her model's distinct feature is that she regards the decision of adoption vs. non-adoption (rejection) as a product of a hierarchical decision process in which a series of decision criteria is used in Yes-No judgments. This hierarchical theory of choice, initially developed by Tversky (1972), states that people generally do not make complicated calculations of the overall utility changes associated with alternatives. It is argued that an individual's decision process is represented by a hierarchical decision-tree, with decision criteria at each node (branching point) of the tree.

Her model's advantage, according to Ongkili (1985), lies in 'the scope generated for comparing and testing the influence of additional or alternative factors that are perceived to limit adoption'. Ongkili states also that this point is important in the light of the tendency among economists to focus on only a limited number of adoption constraints when investigating the problem of low adoption levels of new technology. For instance, empirical studies which have concentrated attention on the risk factor as an inhibitor of

adoption (Moscardi 1979, Dillon and Scandizzo 1978) fail to test the relative importance of risk compared to other limiting factors such as non-profitability, lack of knowledge, lack of capital or credit (Ongkili 1985). Hence, her model is helpful to locate decision criteria in a particular adoption process in a particular area.

Another advantageous feature of Gladwin's model is that it avoids the cumbersome process of eliciting decision-makers' utility functions for tests of risk attitudes, or even the use of socio-economic data for the same purpose.

Her model also has problems, however. Firstly, for the construction of a hierarchical decision tree, researchers have to have very close interaction with decision-makers especially for identifying which criterion is superior to others. This is a most demanding requirement for researchers. Secondly, her model does not allow (1) any trade-off among decision criteria and (2) any feed-back process. Her model rejects one of the major principles of neo-classical production and consumption theory, and fails to consider dynamics of the adoption-diffusion process. The lack of consideration of feed-back, in which a potential adopter may loosen his decision criteria according to his last decision-making itinerary represented by the decision tree is the major demerit of her model. Accumulation of the feed-back process naturally leads to consideration of the trade-off among decision criteria. Hence, Gladwin's model with the feed-back process incorporated can be regarded as an equilibrium model, and it may converge onto the same analytical results that neo-classical models produce.

These models reviewed here are regarded as the most important ones dealing with the core of the adoption/diffusion process. The necessity of modelling the farmers' collection and evaluation of information available to them from others as well as from their own experiences, has emerged.

The Lindner model has utilised the concepts of quality of "direct information" and "indirect information". These concepts now turn out to be crucial for the development of a theoretical model of the adoption/diffusion process. If a simple aggregation by time, total products, or number of adopters is not allowed, information flows must be directly

considered, and by some means the relationships between information sources and recipients have to be conceptualised. In other words, one person's effect on another person's decision making, in terms of information quality or information evaluations has to be considered. A structure of these relationships or effects among all potential sources and recipients of information about agricultural innovation has to be elicited by some means.

Studies of the effect of the structure of the relationships of components of a system on behaviour of these components have been called studies of "contextual effects". They have been developed mainly in sociology, but implicitly in economics, too. The development in economics has been more formal (mathematical) and rigid, but the assistance of the sociological studies is required for its operationalisation in economics.

1.4.2 Contextual Effects and Individual Effects

The basic assumption of the neo-classical economics that a decision-maker is completely independent of other decision-makers' characteristics and behaviour in his decision-making is a paradigm at the present stage of the development of economics. There is another paradigmatic assumption, in the sociological literature that the impact of the decision-maker's society on his decision-making cannot be ignored. This paradigm is a more general one than the former in the sense that the former paradigm is a special case of this paradigm. This has rarely been treated in economic literature although it has long been recognised but "assumed-away" by neo-classical economists. In other words, the effects of his social context can in itself be as significant as the effects of his individual characteristics in the determination of his individual behaviour. These effects of social context have been called "contextual effects" in sociological literature, and the assessments of contextual effects have been represented by a linear model in which measures of individual behaviour are regressed on combinations of individual characteristics and their group-level averages or dummy variables which indicate memberships of certain groups (Boyd and Iversen 1979, Blalock 1984).

Erbring and Young (1979) argued:

> If social context is to affect individual behavior, such effects must be transmitted through processes that are somehow contingent upon the social structure in which the individual is embedded. Thus a specification of group-

level effects on individual outcomes requires, first of all, a careful examination of possible linkage mechanisms through which the hypothesized "contextual effects" might operate. In particular, it shall be argued that contextual effects must be conceptualised as a consequence of processes of interactions among individuals in a social network.

Such interactions are generally classified into two categories: (1) face-to-face contacts between pairs of individual decision-makers and (2) symbolic categorical relations shared among all individual decision-makers in a given group.[14] In network analysis, an approach based on the first type of interaction is called the relational approach, and one based on the second type is called the structural approach. The relational approach focuses on social processes of contagion underlying such group phenomena as assimilation and contrast. The structural approach, on the other hand, focuses on socio-psychological processes of comparison underlying such "reference group" phenomena as competition, emulation, identification, facilitation and inhibition. Without reference to interactions in either form, the notion of contextual effects tends to become theoretically vacuous.

In economic studies, contextual effects are increasingly recognised as the basic concept for various subjects as indicated below. Whichever type of interaction may be of interest in relation to these contextual effects, it has to be recognised that individual decision-makers belong to the context of a social system as well as to distinct personal categories. Decision-makers are related to other decision-makers in the social system. They receive information from others, and evaluate it according to their own positions in the social system as well as to their own personal characteristics. Decision-makers must thus be regarded as "contextuals"[15] instead of as "individuals".

In the next sub-section, economic studies in which the contextual effects are incorporated either explicitly or implicitly are reviewed in the search of an integrated framework to treat the contextual effects which explain the adoption/diffusion of innovations.

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[14]Symbolic categorical relations include (1) symbolic interactions based on the equivalence of two persons' patterns of interactions with all others (structural equivalence) and (2) relations based on the equivalence of two persons' individual socio-economic characteristics with no respect to their actual interactions (categorical equivalence).

[15]Hamaguchi (1982)

The treatment of contextual effects and social interactions in sociological studies, especially in network analysis are also reviewed.

1.4.3 Economic Studies of Contextual Effects

In this section, firstly, the existing adoption/diffusion models' implicit treatment of social interaction which involve contextual effects is reviewed. Secondly, Becker's explicit treatment of social interactions is evaluated. Thirdly, utility function models which include relative income levels in the utility function are examined. Finally, interdependent preference models are inspected.

1.4.3.1 Social Interactions in Economic Models of the Diffusion Process

Since Griliches and certain sociologists debated the effects of social interactions in reference to studies of hybrid corn diffusion in the United States,[16] the concept of such interactions has been implicitly included in diffusion models of innovations. However, the concept has often been included in terms of the "total area"[17] or "total product"[18] of the innovation in the surrounding region of the farms under study, and sometimes simply in terms of "time".[19]

The underlying assumption of this social interaction concept is that the quality of information about an innovation improves over time through the various search activities of decision-makers, and is proportionate to the number of their chances to observe the innovation. This assumption is plausible for an overall regional scale study of a diffusion process, but hardly appropriate for a small scale detailed study such as that of the diffusion of a new agricultural technology in one village. This is because the quality and quantity of the information a farmer collects cannot be increased and improved in an exogenously determined way, but rather through socio-economic interactions among villagers. It may be true, of course, that socio-economic interactions increase with time, total area, etc, so that the use of these proxies captures social interactions in a stochastic and not deterministic sense. In a small scale study, the stochastic representation of socio-

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[16]Griliches (1957, 1960, 1962), Brandner and Straus (1959) and Havens and Rogers (1961).

[17]Feder and O'Mara (1981).

[18]Mansfield (1961, 1968).

[19]Davies (1979), Feder and O'Mara (1981).

economic interactions by their proxies may thus be very erratic, and it may well be better to investigate directly the socio-economic interactions themselves.

1.4.3.2 Becker's Social Interaction Model

Becker studied social aspects of the household, such as fertility, marriage, divorce and education of children, and further studied social organisations.[20] In one basic study, he treated social interactions[21] in a utility function model which includes the characteristics of other persons that affect a person's output of consumables. In Becker's study, for example, a person's utility function consists of his "distinction" in his occupation, and some market goods or services. His distinction involves the opinions about him (as he perceives it) held by other persons in the same occupation, and is determined by both his "social environment" and his effort to change. The "social environment" is the aggregated situation of the opinions about him before he makes an effort to change them. As the result of the inclusion of the "social environment" variable into a person's utility function as an endogenous variable, and the assumption that his expenditure on consumables and his effort to change his environment are perfect substitutes in his utility function, socio-economic transactions, i.e., "social interactions" in Becker's terms, have to occur immediately between him and other persons in his occupation.

Such immediate socio-economic transactions involving other persons' income levels in a person's utility function mean that an envious person has to immediately force others to transfer parts of their incomes to him. Criminal activities can therefore be explained in this framework.[22] With such a model, envy[23] cannot simply be interpreted as incentive to make an effort to increase a person's utility through an increase of his own controllable

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[20]Becker (1981, 1983).

[21]Becker (1974, 1976a).

[22]Becker (1976b).

[23]Being "envious" is defined differently in various studies. Varian (1974) states that if an agent prefers another agent's bundle to his own at a given allocation, the first agent "envies" the second. Rawls (1971) defines "envy" as "the propensity to view with hostility the greater good of others, even though their being more fortunate than we are does not detract from our advantage" (p.532). Becker states that "an envious or malicious person presumably would feel better off if some other persons become worse off in certain respects" (1974, p.1088). The definition used here follows Becker's.

consumables in a way that does not harm others. Becker's straightforward inclusion of other persons' characteristics as endogenous variables into the utility function leads to a narrow interpretation of the effect of a person's envy on others, i.e., that envy always harms others.

Becker's model thus explains how social interaction between two persons takes place, on the assumption that the degree of a person's evaluation of others' opinion about him can be measured in some form. In order for this model to be operational in explaining the difference of interactions with many other persons, the degree of evaluation of information from each other person should be measured and compared, and be directly incorporated into a utility function by some means.

Becker's utility function approach towards social interactions can easily accommodate a finite number of decision-makers. However, Becker does not internalise the "social environment" in his model. The formation of this social environment is not endogenous in the model. For example, how, and by what means his "distinction" in his occupation is determined is not investigated. This problem seems to be treated as a totally sociological concern. But at least it can be argued that the "social environment" in terms of the decision-maker's distinction is determined by his socio-economic characteristics relative to others' corresponding ones. A simplistic example of this mechanism is his relative income or wealth level(s) to others, or his rank of wealth level in the relative income utility function models which are reviewed in the following section.

1.4.3.3 Relative Income Utility Models

Pigou (1962) noted that " ... the satisfaction which a man derives from the possession of a given income depends not only on the absolute amount of income, but also on the relation subsisting between it and the incomes of other people". Duesenberry (1949) stated that "Our theory ... depends upon the validity of a single hypothesis, viz.: that the utility index is a function of relative rather than absolute consumption expenditure", and developed his relative income hypothesis. And Galbraith (1958) more dramatically argued that "people are poverty stricken when their income ... falls markedly behind that of the community". Recently, Hirsch (1976) introduced the concept of the "positional goods". Thus, economists have known the existence and

importance of the contextual effects on individuals, but rarely constructed a formal model of the contextual effects following such statements.

Only recently, formal models of contextual effects in the above framework have started emerging. Boskin and Sheshinski (1978) considered the optimal redistributive taxation system using a utility function which includes a person's relative income level as well as his absolute income level, and solved Mirrlees' problem of the regressivity of marginal tax-rates (Ng 1983).[24]

Layard (1980), without referring to the Boskin-Sheshinski model, developed a utility function model which includes the relative income level as well as the absolute income level. This model was stimulated by the study of relative deprivation by Runciman (1966). The concept of "relative deprivation" indicates that a person's satisfaction decreases if others' satisfaction, or characteristics from which satisfaction is derived, increases or is expected to increase. In Layard's study, two features of human nature are considered: (1) the desire for social status and (2) the expectation of income and social status. These features, together with the present income level, are incorporated into a utility function for the analysis of public policy, such as that involving taxation and education, especially examination systems.

In his formulation of the utility function which incorporate the relative income level, Layard noted with interest that Runciman's study indicated the following:

> For the evidence is that people are mainly bothered about the income of people close to them in the income distribution and do not suffer greatly from the riches of the rich (or the poor), unless they happen to be nearly rich (or poor) themselves. Thus one cannot really assume that status is determined by a person's income relative to mean income.

In place of the relative income level, Layard introduced a person's percentile rank-order in the earnings distribution into the utility function as a continuous variable, and conducted his analysis. This presents a major problem. Although he had recognised a person's differentiated suffering on account of different persons' income levels, he did not

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[24]Mirrlees (1971) derived an optimal tax scheme which has a progressive tax-rate but a regressive marginal tax-rate. Various forms of utility functions and social welfare functions are used in later studies (Atkinson 1973, Helpman 1974), but still the regressive marginal tax-rate is present.

account for this by merely transferring the relative income into a rank order. Thus it seems that Layard misunderstood what Runciman meant. What Runciman really implied in his book is the importance of the reference group to which a person belongs. A person's relative income level should be derived in reference to the income levels of members of his reference group. The concept of social rank does not represent this at all. For example, if Person B whose social rank is just one rank above Person A swaps his social rank with Person C whose social rank is two ranks above Person A, Person A is not affected at all, because his social rank is unchanged. If Person B belongs to Person A's reference group and Person C does not, a change in Person A's utility can be expected. In order to introduce this aspect, a person's reference group should have been first identified, and then the person's relative, rather, subjectively relative, income level should have been calculated by, for example, corresponding different weights to the reference group's members' income levels as well as non-members' income levels.

Katz (1983) also incorporated a person's social rank in terms of ascending order of wealth ranks, and analysed the person's risk attitude assuming that he is risk-averse with respect to both absolute wealth level and social rank.[25] He found that a utility function incorporating social rank corresponds with the Friedman-Savage utility function (Friedman and Savage 1948), in which one's attitude towards risk changes from risk-averse to risk-taking or vice versa as one's absolute wealth level increases, depending on the wealth distribution within the system. This result immediately encounters the

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[25]Let U_i be Person i's utility function which consists of his absolute wealth level, X_i, and his social rank, R_i. Katz's assumptions are:

$$-\frac{\partial^2 U_i}{\partial X_i^2} \Big/ \frac{\partial U_i}{\partial X_i} > 0 \quad and \quad -\frac{\partial^2 U_i}{\partial R_i^2} \Big/ \frac{\partial U_i}{\partial R_i} > 0,$$

in addition to

$$\frac{\partial U_i}{\partial X_i} > 0, \quad \frac{\partial U_i}{\partial R_i} > 0 \; and \; \frac{\partial^2 U_i}{\partial X_i^2}\frac{\partial^2 U_i}{\partial R_i^2} - \left(\frac{\partial^2 U_i}{\partial X_i \partial R_i}\right)^2 > 0,$$

and he derived:

$$-\frac{d^2 U_i}{dX_i^2} \Big/ \frac{dU_i}{dX_i} \gtrless 0.$$

problem of a rich person's insurance behaviour and a poor person's gambling (the gambling-insurance paradox), as well as the problem discussed above with respect to Layard's utility function. There is no room in this model for the adjustment over time which has been introduced to overcome the gambling-insurance paradox.[26]

1.4.3.4 Interdependent Preferences Models

If, in the relative income utility model, different weights are given to different persons' income levels to derive a person's relative income level, the utility function with this definition of the relative income level can be regarded as a utility function which represents interdependent preferences. A person's preference is regarded as dependent on other persons' socio-economic characteristics. The degree of a person's dependence varies among his counterpart persons. Therefore, relative income utility models are accommodated as special cases amongst interdependent preference utility models.

Interdependent preferences have been studied by few scholars. Duesenberry (1949) applied interdependent preferences to an analysis of the choice between consumption and saving, and to an analysis of demand growth. Leibenstein (1950) introduced the concepts of "bandwagon effect", "snob effect", and "Veblen effect". Johnson (1952) used interdependent preferences in an analysis of the effects of income distribution on aggregate consumption. Pollak (1976) incorporated interdependent preferences into demand analysis with a linear demand system. Hayakawa and Venieris (1977) and Kapteyn et al. (1978, 1980) and Van Praag et al. (1979) introduced a sociological concept of "reference groups (space)" into their study of consumer interdependence.

However, only Duesenberry's study is directly suggestive for the analysis of the innovation diffusion process. He assumed that the distribution of income was rectangular, i.e., that income receivers were evenly distributed over a range of incomes from zero to the maximum income level, and derived a curve which monotonically converges to a ceiling level. This curve resembles the upper part of a sigmoid which generally describes

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[26]Markowitz (1952), Zeckhauser and Keeler (1970), and Binswanger (1980). The Friedman-Savage utility function can explain the coexistence of insurance against the remote possibility of large loss, with gambling for the remote possibility of a large gain. However, this can imply quite unreasonable behaviour at other levels of wealth, such as a rich man in the convex area of the function not insuring himself against possibilities of the major loss.

diffusion processes. If it is assumed that the income distribution is a form of normal distribution, it is intuitively suggested that the curve derived may well become a sigmoid. But Duesenberry did not do this, and no one else has done so until now.

In order for these interdependent preference models to be operative, measures which can indicate a person's effect on another person's utility should be determined, and incorporated into the first person's utility function or demand function. Pollak used constant interdependence coefficients to indicate and represent this effect, and incorporated them in a linear demand system.

Even though Leontief's input-output analysis, a widely used tool in economics, appears to be capable of providing a method for such measurement of these coefficients, it has rarely been conducted in economic studies.

Kapteyn et al. (1978, 1980) and Van Praag et al. (1979) introduced "reference weights", and measured them according to persons' similarities or difference in six socio-economic characteristics, i.e, education, working-environment, job-type, degree of urbanisation, age and geography. These reference weights may represent persons' symbolic categorical relations,[27] but there is no assurance that they actually imply that the persons interact with each other and pass information to and from each other.[28] This method seems to be the easiest way to argue if or how strongly any two persons are related. But without assurance of their actual interactions, this approach may produce misleading results.

Leontief's input-output analysis is a widely accepted tool so far to measure monetary interdependence among economic agents in a system on the basis of their actual interactions.

Structural path analysis of input-output matrices or social accounting matrices (SAM) has been developed by Lantner (1974) and Gazon (1976, 1979). These authors formulated the concepts of economic influence and structural path analysis to capture the transmission of influence within a structure. More specifically, whereas the reduced

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[27]Refer to two categories of interactions in Section 1.4.2 on page 14.

[28]Refer Rogers and Bhowmick 1971.

form[29] provides the solution of a model by expressing endogenous variables as functions of exogenous variables, structural path analysis attempts, in addition, to clarify and explain this solution through the study of the transmission of influence within the matrix of economic transactions, starting with changes in exogenous variables and proceeding to their ultimate effects on endogenous variables (Defourny and Thorbecke 1984, p.119). These latter authors interpreted an average expenditure propensity and a multiplier as the respective intensities of direct and global influence.

By using an input-output matrix of monetary transactions among decision-makers, their monetary interdependence can thus be investigated (Michaely 1983). However, the monetary transactions do not necessarily transmit information to and from decision-makers. For the detection of informational interdependence, and more general interdependence, more general interactions among decision-makers in the input-output matrix have to be examined. Sociologists have realised the usefulness of the input-output analysis to capture interdependence among decision-makers in a system, and developed network analysis. Network analysis methodologies are reviewed in Section 1.4.4.

1.4.3.5 Information Quality and Interdependence

The concept of "information quality" was introduced by Lindner and Fischer (1982), as reviewed in Section 1.4.1.4, where information about an innovation is classified into two categories, (1) "direct information" from a decision-maker's own experience with the innovation and (2) "indirect information" from other adopters of the innovation. These authors argue that the "indirect information" is less important than "direct information".

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[29] An input-output matrix model is usually set up as follows:

$$X = A\,X + Y$$

where X is a vector of gross products of sectors (i=1,2,...,n), Y is a vector of final products (demands) of goods (i=1,2,...,n), and A is a matrix of input-output coefficients. The reduced form of this model is:

$$X = (I - A)^{-1}\,Y$$

where I is the identity matrix.

It is also apparent that some clear differences exist between the levels of importance of sets of indirect information from two distantly located adopters. The concept of "distance" is thus introduced in some empirical diffusion process studies. Lindner, Pardey and Jarrett (1982) studied the adoption process of trace element fertiliser in South Australia, and Ongkili and Quilkey (1983) studied rice farmers in Sabah, East Malaysia.[30] In these studies, a set of variables which represent the "distance" between an adopter and various sources of information about innovations was found to be very significant in explaining the time of adoption. The overall explanatory power of the regression remained low, however.

In these empirical studies, formal institutional sources such as extension service stations and geographically closest adopters are utilised as sources of information about innovations. This is a restriction which does not seem appropriate for a small village level study. Lindner, Pardey and Jarrett's study treated an area where farmers were widely spread geographically, so that the distance could be measured in kilometers. On the other hand, Ongkili and Quilkey's study treated rice farmers located very closely to one another in Sabah villages. The distance variables were more significant in the former than in the latter study.

This disparity between the two studies is thought to be due to the restrictive selection of the information sources. More broadly, sources of indirect information about an innovation can be classified into two categories:

1. System-external sources,
2. System-internal sources.

The "system" comprises all potential adopters in the study area. The system-external sources are not components of the system, but are closely related to the potential adopters as sources of information about the innovation concerned. They comprise, for example, extension services working through local offices and farm visits, experiment stations, agricultural radio programmes, agricultural magazines, and so on. The system-

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[30]Ongkili and Quilkey (1983) introduced "psychic distance" variables and "institutional" variables as well as physical distances to information sources.

internal sources are the components of the system. Thus all the potential adopters are sources of information about the innovation by directly talking to each other, or by allowing their farms to be observed.

In a study of a geographically sparsely spread system covering a wide area, the system-internal sources of information may well be much less important than the system-external sources, unless there is an efficient communication system between potential adopters. In a large sample study, the system-internal sources are often aggregated or represented by a particular source for the purpose of operationability. Hence the aggregated or represented system-internal sources lose their accountability.

In smaller area studies, on the other hand, the components of the system are closely located and very regularly exchange information about innovations as well as about other activities. System-external sources for each component of the system may often be identical. The system-internal sources may therefore be much more important. Thus in a small village, all farmers are by and large information sources for all farmers, and they can be located somewhere in the "information flow map".

However, the manner of an individual farmer's evaluation of the quality of information varies widely among farmers, depending on counterpart farmers. The informational structure is hence defined as a set of all connected potential adopters in accordance with how they evaluate each other. The simplest example is that of an information flow map, where decision-makers are connected if information flows between them. This concept of the village informational structure is justified if a decision-maker does not differentially evaluate the information he receives, i.e., if he accepts received information as it is, regardless of the person from whom he receives it. More plausible types of informational structure can be imagined, however, and they are reviewed in Section 1.4.4.

1.4.3.6 Risk and Attitudes towards Risk

After a decision-maker receives information from others and evaluates it in accordance with his relationships with others, he then revises his allocation of resources using the information received, taking into account his attitude towards risk. This process may be simultaneous. If the decision-maker is more risk-averse, he needs more narrowly distributed yield data and/or a higher average yield. Lindner and Fischer (1982) clearly showed, in their Bayesian model, that the necessary amount of yield data for a decision-maker to adopt a new technology increases as he becomes more risk-averse. Feder (1980) also showed this property in his expected utility maximising portfolio model.

In empirical studies of the adoption process, attitude towards risk has been used as a primary explanatory variable for adoption behaviour, although this is also assumed to be determined by various socio-economic characteristics.

In the literature, it has been generally agreed that risk-aversion is an important determinant of adoption behaviour. Lack of adoption or slow adoption is expected if uncertainty associated with the innovation is high, and/or if a farmer's risk aversion is high.

Because of the difficulty in directly measuring risk or risk-attitude, there have been several indirect methods in which these variables are incorporated as determinants of adoption behaviour. Feder et al. (1981) reviewed these indirect methods as well as direct methods, and pointed out their merits and demerits.

The presence of a crop which is reasonably stable in risky situation was regarded as a determinant of adoption of another crop (new crop) (Gerhart 1975). This approach is potentially misleading, because the adoption of the former crop is also to be explained. The adoption of multiple crops of villagers should be considered in a simultaneous equation system, or the whole cropping pattern should be explained in a single equation, where the cropping pattern is considered as a single crop. Thus, it is considered that crops other than one whose adoption is to be explained or the cropping pattern of farmers should not be included as an explanatory variable of the crop being adopted, although it may show a significant correlation with the adoption of the innovative crop.

The incorporation of location-specific dummy variables thought to represent risk or

risk attitude has been used in a number of studies, but these location-specific dummy variables may also represent other factors such as soil fertility and rainfall. The magnitude of risks associated with the environment can be directly derived by collecting relevant data in the field. If the study aims to explain a village-level adoption process, however, these environmental risks can be neglected on the basis that they are almost identical among all villagers in the village. Of course, there may be a variation in such environmental risk between areas of the village, and it will then be important to take this into account.

There is another argument for the inclusion of risk as a determinant of adoption behaviour from the information viewpoint. Farmers' ability to collect and evaluate information relevant to agricultural innovations influences their perception of risk. Data have been collected concerning contacts with extension services, demonstrations, and other media services. However, the explanatory power of these factors depends on the performance of the extension services etc. As Feder et al. (1981, pp.16-17) pointed out: "If the extension services has failed in the past, the most dominant factor may be the information gained by observing the procedures and performance of neighbours, friends, and relatives who have experimented with the innovation." Farmers' information channels should thus not be limited to official sources.

It is considered more fruitful, however, to shift the focus to villagers' attitudes towards risk from studying these environmental risks. Attitudes towards risk may be obtained through gambling experiments or other types of experiments (Binswanger 1980, Young 1979). However, such experiments tend to use the hypothetical conditions which may be totally irrelevant to agricultural decisions, or the risk attitude measure is determined in the manner in which the measure may absorb all the variations from the predictions of the specified models. Their statistical significance levels as determinants of adoption behaviour were found to be mixed.

Thus, effort to consider risks and risk attitudes should be retained in the study with careful consideration of farmers' environmental conditions and informal channels of information. The context in which all potential adopters are embedded should hence be carefully considered in a model of adoption behaviour.

If the village's socio-economic structure is viewed as having an informational structure where all the villagers are connected by information flows, the interdependence utility function approach (which has already been recognised as a good approach to analysis of socio-economic institutional aspects) may be able to combine the considerations on risk attitude and the village's socio-economic structure. A method which relates a person's attitude towards risk with the form of his utility function has been established.[31] For analysis of economic factors in adoption/diffusion processes, however, a workable model of this type has not yet emerged.

1.4.4 Sociological Studies of Contextual Effects

Network analysis has been recognised as a good conceptual framework for studies of social structure based on structural-functionalism as opposed to categorical analysis.[32]

In network analysis, a decision-maker's norm may be derived from his relations with others and his structural location in the system, as opposed to the given, cross-sectionally identical utility function of decision-makers in the neo-classical framework. The decision-maker may thus be seen as belonging to a system of other decision-makers whose relations or interactions are captured through the use of networks, as well as to categories based on his socio-economic characteristics. Again, membership in certain categories can be interpreted from the viewpoint of his structural location and relationship with other members of the system. Any interaction which transmits information about innovations between any two members of the system may then be viewed from these two members' characteristics and their relationships in the specific system. A particular decision-maker's evaluation of information from a system-internal source, i.e., from another member, is affected by his relationship with that source, and interpreted according to their structural relationship in the system.

The network analysis of contextual effects on an individual's behaviour can be

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[31] Although there are various better measures of risk attitude, the starting point is the Arrow-Pratt risk aversion index. The benefit of various new measures seems to be marginal. See for example Ross(1981) and Zeckhauser and Keeler (1970).

[32] The relationship between network analysis and structural-functionalism was only recently discussed by McCord (1980) and Wellman (1983) although network analysis itself has been utilised by sociologists, anthropologists and others since as early as 1949 (Festinger 1949).

classified into two approaches: (1) the relational approach and (2) the structural approach, depending on the type of socio-economic interactions focussed.[33] In this subsection, innovation diffusion studies in these two approaches are reviewed, and further, in relation to a person's attitude towards risk discussed in Section 1.4.3.6, Cancian's study of "upper-middle class conservatism" is reviewed.

1.4.4.1 Relational Approach

Sociological research on the diffusion of innovations has advanced significantly since the medical innovation study of Coleman et al. (1957) involving the relational approach of network analysis,[34] and its most notable recent contribution is the study of the family planning diffusion process in Korean villages by Rogers and Kincaid (1981). The relational approach of network analysis has been developed in order to elicit the informational structure of social systems by emphasising face-to-face interactions which directly transmit information, and the approach has produced numerous concepts describing a social structure and the position and characteristics of individuals and groups in this structure. Some of these concepts are discussed below.

Sociological research has shown that "social integration"[35] is positively associated with the earlier adoption of innovations which accord with social norms. It has also shown that social integration imposes "innovation homogeneity"[36] within subgroups of the social system, just as it forces prominent persons to adopt innovations consistent with social norms. Potential adopters who are socially integrated into a system of other potential adopters are (1) likely to be early adopters of an innovation which is in accord with the social norms and (2) likely to adopt an innovation at a time when other potential adopters directly connected to them by relations or interactions which are

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[33] Refer also Section 1.4.2 on page 14.

[34] Rogers (1983), Chapter 8.

[35] Angell (1968) classified social integration into three categories: (1) normative, (2) functional and (3) communicative integration. In the framework of relational approach of network analysis of social system, the term "social integration" means the degree of interactions among elements of the system or the degree of interactions which are initiated by an element or directed to the element. The former can be regarded as representing the system's degree of social integration and the latter as representing the element's degree of social integration within the system. In this sense, the term "social integration" here corresponds with the communicative integration.

[36] Pressure to adopt the innovation from adopters to non-adopters within the same group.

relevant to the innovation adopt the innovation. In addition, those who are on the periphery of the system are (1) likely to be late adopters of an innovation which conforms with the social norms,[37] while being early adopters of an innovation which does not conform with the social norms, and (2) likely to adopt innovations at a time predicted by their personal preferences rather than by their relations with other potential adopters.

This conception of the relationship between social structure and the adoption of innovation[38] has been operationalised through the use of two similar network variables which have slightly different meanings.[39] The concept of "centrality" refers to the extent that a decision-maker is involved in all relations among all decision-makers in the system, representing the dimension of the function of social integration in terms of his ability to communicate with other potential adopters. The concept of "prestige" refers to the extent that the decision-maker is the object of interaction initiated by other decision-makers who are themselves the object of interaction, representing the dimension of the function of social integration in terms of influence over other potential adopters. For example, in a network, a person with whom more persons interact has more prestige, and is more influential over others. As Coleman et al. (1957, 1966) pointed out and Knoke and Burt (1982) later elaborated, neither one of these two concepts can account for the apparent dissemination of medical innovations.

In empirical studies, the two variables are usually more or less highly correlated with each other depending on the social context concerned, and neither one can be singled out as the most appropriate index of social integration.

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[37]The innovation's economic profitability may be considered depending on whether the social norm includes considerations on economic profitability.

[38]This has been called the "centre-periphery" conception.

[39]There are numerous statistics which measure the degrees of these two concepts. For detailed definitions, see Knoke and Burt (1982), Knoke and Kuklinski (1982), Freeman (1979), and Freeman et al. (1979).

1.4.4.2 Structural Approach

Considering the difficulty of interpreting the function of social integration in the framework of the relational approach, Burt (1980a, b) proposed a concept of "structural equivalence",[40] and further a structural approach (structural equivalence approach, positional approach) in which symbolic interactions among persons are focussed. He assumed that there are various statuses in a system, replacing the two statuses of the "centre-periphery" conception, centre and periphery, and related the concepts of "prestige" and "centrality". These various statuses are shared by several persons, to the extent of the closeness of these persons in terms of "social distance".

The social distance between any two persons is measured as the degree to which they mutually do and do not interact with third persons. In other words, it is the difference between two persons' patterns of interactions and non-interactions. While the relational approach only focuses on their actual interactions, the structural approach simultaneously and equivalently considers both interactions and non-interactions.[41]

"Social distance" is a concept similar to the one used by economists Blin and Cohen (1977) in tackling the aggregation problem of industries in an input-output matrix.[42] In an input-output matrix, if two industries have an equivalent pattern of inputs and an

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[40]For detailed discussion of the concept of "structural equivalence", see Lorrain and White (1971) and Burt (1980c).

[41]Social distance between two persons, i and j, is defined as follows:

$$s_{ij}^2 = \sum_{k=1}^{n} (z_{ik} - z_{jk})^2 + (z_{ki} - z_{kj})^2$$

where z_{ik} indicates the existence of interactions between i and k initiated by i.

[42]This concept is also similar to the concept of "similarity index" in numerical taxonomy (Sneath and Sokal 1973, Dunn and Everitt 1982). For economic aggregation problems, see Fisher 1969.

equivalent output pattern,[43] they can be aggregated into one industry. As the degree of the equivalence of input/output patterns decreases, the possibility of the aggregation of these two industries decreases. Rather than merely suggesting the possibility of aggregation, however, Burt (1982, 1983) also proposed, on the basis of studies of "invisible colleges" and "interlocking directorates", that the equivalence of input/output patterns indicates the degree of influence between two decision-makers. In order to directly examine the equivalence of two persons in the context of the social system they belong to, their social distance is standardised. This standardised measure is called a structural equivalence proximity.

Burt, further, constructed a person's utility function with structural equivalence proximities as interdependence coefficients. This utility function comprises two parts.[44] The first part is an ordinary utility function which evaluates a person's utility level according to his level of adoption of an innovation regardless of other persons' conditions.

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[43]Let Z_{ij} be the amount of inputs to the i-th industry from the j-th industry, then X_{ij} be the ratio of Z_{ij} to the total amount of inputs to the i-th industry, $\sum_{j=1}^{n} Z_{ij}$, Y_{ij} be the ratio of Z_{ij} to the total amount of outputs from the j-th, $\sum_{i=1}^{n} Z_{ij}$. The input pattern of the i-th industry can be represented by either a vector of

$$Z_{i.} = (Z_{i1}, Z_{i2},..., Z_{in}) \text{ or } X_i = (X_{i1}, X_{i2},..., X_{in}).$$

Similarly the output pattern of the j-th industry can be represented by either a vector of

$$Z_{.j} = (Z_{1j}, Z_{2j},..., Z_{nj}) \text{ or } Y_j = (Y_{1j}, Y_{2j},..., Y_{nj}).$$

The equivalence of the i-th and j-th industries is measured by the same index as Burt used.

$$s_{ij} = \sum_{k=1}^{n} (Z_{ik} - Z_{jk})^2 + (Z_{ki} - Z_{kj})^2$$

or

$$s_{ij} = \sum_{k=1}^{n} (X_{ik} - X_{jk})^2 + (Y_{ki} - Y_{kj})^2$$

[44]Burt's interdependence utility function is:

$$U_i = \mu X_i^{\alpha} (l_{ii} + \frac{\alpha}{\alpha + 1} \sum_{k \neq i} \frac{l_{ki} X_i}{X_k}).$$

where l_{ii} is i's structural equivalence proximity to himself, i.e., independence coefficient, l_{ki} is k's structural equivalence proximity to i, i.e., interdependence coefficient of i on k, and X_i and X_k are i and k's adoption levels (dichotomous).

The second part "discounts" the person's utility according to others' adoption levels of the innovation. In this discounting function, structural equivalence proximities are incorporated as interdependence coefficients. The degree of interdependence in terms of discounting the person's own utility is proportionate to the ratios of his adoption level of the innovation to others' levels of adoption. These ratios are weighted by corresponding interdependence coefficients and summed up. Hence, the person's utility is decreased when another person's level of adoption increases, with yet other persons' adoptions remaining equal. Also, if the person's interdependence with Person B is greater than that with Person C, the magnitude of change in his utility when Person B's adoption level changes is greater than when Person C's adoption level changes, provided that these two persons have the identical initial adoption levels. In other words, the ratio of his marginal utility with respect to Person B's adoption level, and also that with respect to Person C's level is determined by his interdependence (coefficient) with these others.[45]

Burt derived some propositions which conform to the findings of the relational approach to diffusion detailed above. The main propositions are as follows: (1) a person will adopt an innovation after persons whom he perceives to be structurally equivalent to him[46] have adopted it, in relation to his structural equivalent proximity to these persons, (2) a person will adopt an innovation for more personal, rather than social, reasons to the extent that he does not have other persons to whom he is close in terms of the structural equivalence proximity. This means that he will adopt according to his interdependence coefficient, regardless of whether he is at the centre or periphery of a social system.[47]

While Burt used networks of various kinds of socio-economic interactions to derive the magnitude of symbolic interactions between any two persons in the form of both

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[45]More precisely, this ratio:

$$\frac{\partial U_i}{\partial X_k} : \frac{\partial U_i}{\partial X_j} = \frac{l_{ki}}{X_k^2} : \frac{l_{ji}}{X_j^2}$$

is also dependent on their adoption levels.

[46]Structurally equivalent persons who share the same status in terms of flows of information within the network system.

[47]In Burt's terminology, they are structurally unique.

social distances and structural equivalence indices, such symbolic interaction may also be derived by "categorical analysis". Here the focus is on the similarity or difference of individual socio-economic characteristics between two persons (categorical equivalence, for example, Kapteyn et al. 1978, 1980, Van Praag et al. 1979).[48] If two persons are found to have an identical range of socio-economic characteristics, they are assumed to have strong symbolic interaction of a certain kind. If they are found to have a different range of socio-economic characteristics, they are assumed to have strong symbolic interaction of another kind.

Categorical analysis cannot elicit the system of symbolic interactions which transmits information about innovations. This is because it treats each individual member of the system as an astructural, independent and atomistic unit, concentrating on the socio-economic characteristics of discrete individual members. Individual members are classified into categories, and expected to behave similarly if they belong to the same category. The overall context of the system is ignored. Influence of one member on another in the context is ignored. If Person B and Person C are the only persons who are in the same category in a system, and in another system, Person D and Person E are in the same category together with many other persons, it is easily imagined that the symbolic interaction between the former two persons and that between the latter two persons are quite different. Also only influences from outside the category are evaluated, on the basis that all villagers are located around an "average" villager within this category. Difference from the average villager is treated as a randomly distributed deviation, which is eventually attributed to some kind of "error".

Another reason is that: as Rogers and Bhowmick (1971) stated, neither the homophily (similarity) nor heterophily (difference) between socio-economic characteristics determines whether or not information flows between two villagers.[49]

The adoption of innovation in a village may thus be studied through the use of

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[48]See also Sections 1.4.2, p.14, and 1.4.3.4, p.21.

[49]For more detailed discussion, See Rogers and Shoemaker (1971), Chapter 6, pp.210-215.

network analysis, in which the village informational structure is captured by using networks. The "centre-periphery" and "structural equivalence" conceptions may thus be used to relate this structure to the adoption of the innovation. Such an approach to studying adoption would suggest that some limitation is perceived to the applicability of conventional neo-classical economic methods. Indeed, according to the framework just suggested, only villagers at the periphery of the system, or structurally unique villagers [50] in Burt's term, adopt innovations according to their own independent economic preferences. The applicability of conventional economic studies would seem to be restricted to these villagers.

1.4.4.3 Cancian Dip

In relation to the discussion of a person's risk attitude in the economics literature, Cancian's notable hypotheses about the relationship between a person's innovativeness and his risk attitude is discussed here.

The previously assumed monotonic relationship between villagers' socio-economic status and their innovativeness has been questioned by Cancian (1967, 1976, 1979, 1980 and 1981).[51] If villagers are classified into quartiles according to their income levels, villagers of the lower-middle quartile are, Cancian argues, more innovative than those of the upper-middle quartile, while those of the top quartile are most innovative and those of the bottom quartile least innovative. This phenomenon has been called "Cancian Dip" or "upper-middle class conservatism" by diffusion researchers. Cancian Dip is also, Cancian argues, more distinct at the earlier stages of the diffusion process. As the process proceeds, it disappears, because the upper-middle quartile villagers catch up and pass the lower-middle quartile villagers.

Cancian proposes that when uncertainty is high in the early stages of diffusion, lower-middle quartile villagers will be more innovative than upper-middle quartile villagers in a social system, because they have less to lose. Later, when the innovation has

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[50] Villagers who are completely independent in their decision making.

[51] Socio-economic status is generally represented by two variables in Cancian's study (1979), income level and farm size. The innovativeness is represented by various variables such as time of adoption of an innovation, number of applicable innovations used, and percentage of an innovative crop.

diffused more widely and is perceived as less uncertain, the greater socio-economic resources of the upper-middle quartile villagers enable them to adopt at a faster rate than the lower-middle quartile villagers, and thus to catch them up and surpass them in terms of innovativeness.

Thus, the Cancian Dip hypothesis corresponds to Arrow-Pratt's decreasing absolute risk-aversion hypothesis,[52] but goes further in postulating that there is a dip which disappears over time.

The "Cancian Dip" hypothesis is difficult to test statistically with empirical data. Cancian (1979) tested it in 49 data sets, each of which represented a farming system at an approximately 25 percent adoption level of some new technology. 23 of these sets supported the existence of the dip (the first part of the hypothesis) while 26 did not. The second part of the hypothesis was supported by 25 sets. If these data sets are divided into developing countries and developed countries, it can be found that the hypothesis is supported more in developing countries than developed countries. Further, it can be found that the hypothesis is supported more in areas where subsistence or staple crops are mainly produced than in areas of market-oriented agriculture.[53]

The empirical findings of the decreasing absolute risk-aversion hypothesis can be applied in a straightforward manner in developed countries or market-oriented agriculture. It can thus still be taken that there is a monotonic relationship between socio-economic status (measured in terms of income levels or farm size) and innovativeness. It should be noted, however, that the existing empirical support for the decreasing absolute risk-aversion hypothesis does not imply the rejection of the Cancian Dip hypothesis; the decreasing absolute risk-aversion hypothesis is actually a necessary condition for the Cancian Dip hypothesis. It would be useful to test rigorously for the

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[52]Pratt (1964) and Arrow (1965) first proposed this hypothesis. As a person's wealth level increases, his absolute risk-aversion decreases, and hence he becomes more innovative. Empirical studies are provided by Officer and Halter (1968), Bond and Wonder (1980) in Australia, Dillon and Scandizzo (1978) in Brazil, Binswanger (1980) in India, O'Mara (1971) in Mexico, Herath (1980) in Sri Lanka, and Hamal and Anderson (1982) in Nepal.

[53]Rogers (1983) divided these data sets into developing and developed countries. The criterion of his classification is not clear, and the numbers of the data sets which support the hypothesis in each classification could not be reproduced. However, a classification according to a common-sense criterion based on the descriptions of data sets in Cancian (1979) could produce almost identical numbers.

presence of the Cancian Dip in the data sets which have been used to test the hypothesis of decreasing absolute risk aversion.

Although overwhelming evidence for the Cancian Dip has not been found, the automatic assumption of monotonicity between socio-economic status and innovativeness in subsistence agriculture or in developing countries, especially at earlier stages of the adoption/diffusion process is no longer warranted.

In conclusion, it may be said that a synthesis of the insights gained from economic studies of interdependent preferences, and sociological studies of structural equivalence may provide a promising approach to the study of the adoption/diffusion process of an innovation. It seems possible that the incorporation of structural equivalence into a person's utility function in terms of interdependence coefficients could provide a rigorous theoretical framework for the analysis of such processes. It may be a better framework to view the structural aspect of a system and its relationship with the adoption/diffusion process.

1.4.5 Dynamic Aspects of Diffusion Process Models

1.4.5.1 Learning Process

In a transitional society whose tradition is being replaced by new developments, people are "cautious in adapting to a changing environment because tradition and experience suggest that caution is often a wise tactic in the game of economic survival".[54] Members make a series of short-term plans with cautiousness, responding to feedbacks from markets and the behaviour of others, because the task of completely estimating others' behaviour far exceeds any individual's computational capability.

Theoretical tools for such an adaptive strategy are developed in Day and Groves (1975). Day and Singh (1977) used the concept of "cautious optimisation" in a regional agricultural diffusion study. These authors showed that the increasing diffusion of an innovation is caused by the relaxation of self-imposed constraints, due to

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[54]Day and Singh (1977), p.10

"learning-by-doing" effects, and to the relaxation of financial constraints owing to surpluses generated by the previous adoption of the innovation. The concepts of learning-by-doing and "learning-by-looking"[55] are basic concepts within the framework of such an adaptive strategy.

In non-Bayesian models such as the Mansfield and Feder models, uncertainty associated with an innovation[56] is regarded as a decreasing function of the total area or total product of the innovation in the surrounding area of a potential adopter, and sometimes as a function of time in the simplest form. On the other hand, in Bayesian models such as the Stoneman and Lindner models, uncertainty associated with an innovation perceived by a potential adopter is regularly revised according to Bayes Theorem.[57] A potential adopter is assumed to collect a fixed amount of data about the innovation's performances in terms of yields, and to use this for the revision of the prior distribution of yields. According to the posterior distribution of yields, he decides whether to adopt the innovation. If he does not adopt it at this point, the revision process of the yield distribution continues. This appears to be a more behaviouristic and more acceptable way of capturing the persons' learning processes than the assumption that uncertainty associated with an innovation is simply dependent upon time and the total area of the innovation adopted.

In actuality, the amount of yield data collected by a person of an innovation depends on how much effort he makes in searching for it, on what sort of environment he is in in terms of gathering these data, and on how the overall adoption process in the surrounding area proceeds. At earlier stages, the amount of data is small however much effort he makes, and it is natural to assume that at later stages it becomes much greater, simply because of the sigmoidally accumulating number of adopters and products of the innovation.

It may be argued, however, that in a small village the amount of data a villager

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[55]Lindner and Fischer (1982)

[56]Uncertainty associated with an innovation is represented by expected or actual variance of yields of the innovation in all existing models.

[57]See Anderson, Dillon and Hardaker (1977) for its application to agricultural decision analysis.

collects does not matter much. All villagers are, by and large, sources for all other villagers, as discussed in Section 1.4.3.5. Information continuously flows in through the daily interactions. What really matters with respect to the revision of a villager's subjective distribution of yields is the quality of the information he collects, and the way in which he evaluates the information. The evaluation of information can be included in a theoretical model by introducing the concept of "interdependence coefficients" already discussed. A villager is assumed to adapt his resource allocation period by period according to the changes in his environment, in terms of the economic conditions as well as the situation of other decision makers.

1.4.5.2 Network Stability

The incorporation of network analysis into diffusion process studies presents difficulties, even though it may be considered a better approach than categorical analysis.[58] The length of a diffusion process varies from very short, as for example, with the 17 months in the antibiotics prescription study by Coleman et al. (1957, 1966), to very long, as for example, with the 34 years of the locomotive study by Mansfield (1968). If the length of the process is reasonably short, the structure of the system of potential adopters may not change much. But if the length is long, the system structure may well change so substantially that it is clearly necessary to incorporate the mechanism of structural change into the network analysis model. If there is to be some predictive value in network analysis, the complete instability of networks cannot be admitted. On the other hand, their complete stability cannot be imagined. Thus, networks are assumed to be changing, with some stable and some unstable but predictable or observable elements. Similar difficulties of course apply to categorical analysis such as studies by Kapteyn et al. (1978, 1980) and Van Praag et al. (1979).

Rogers and Kincaid (1981) summarised a variety of research results about network stability into four propositions:-

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[58]Refer Sections 1.4.2, p.14, 1.4.3.4, p.21, and 1.4.4.2, p.33.

1. Spatially proximate links[59] are more stable.

2. Links representing ascribed, rather than achieved, interpersonal relationship are more stable.[60]

3. Homophilous links are more stable than heterophilous links.[61]

4. Reciprocated links[62] are more stable.

In many tropical developing countries such as Indonesia, villagers live very close together. Even though there may be some residential quarters in a village significantly different from others in certain aspects, the dispersion of these quarters is very stable over time because of kinship relationships and the lack of a housing market. The kinship structure (ascribed relationships) of a small village is usually a very dominant factor in the general social structure, and continues to remain very stable unless considerable migration takes place. In general, heterophily among villagers, causing instability of the network system, is generated by the adoption of technological or ideological innovations. Similarly, the flows of information about innovations can be regarded as non-reciprocal links. They may be initiated by adopters of the innovation to others, and the first two kinds of links can be regarded as the basis for considering the stability and the second two kinds of links may be produced and changed by the accumulation of changes in the first two kinds of links as adoption/diffusion process develops.

However, if one accepts the generality of sigmoidal diffusion curves, the effect of innovation adoption on network stability is more moderate at early and later stages of diffusion, than at middle stages. Hence, if the network system at the earlier stages is studied, it can be assumed that the network system has not yet changed much as result of adoption.

For these reasons, the network approach based on a single temporal network can

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[59]Link means interactions or relationships between two persons in a system.

[60]Ascribed relationships are, like kinship relationships, determined by persons' births, and achieved relationships are, like membership in the same company, determined by persons' statuses achieved by their own effort.

[61]Homophilous links are links between two persons with similar socio-economic characteristics, and heterophilous links are those between two persons with different socio-economic characteristics.

[62]Links which are initiated by two persons concerned at the same time.

still be meaningful, in a small village study of agricultural innovations. If the network which captures relations and interactions originated from the diffusion of the innovation is additionally considered, the approach will be further reinforced.

The network stability question is usefully regarded from the point of view of the concept of "change of taste" in utility function analysis. This "change of taste" problem has been a critical point for the utility function analysis to be applied to dynamic processes, and has confined it within the range of comparative statics.[63] As seen in the interdependence utility function model, a person's taste can be represented by interdependence coefficients in his interdependence utility function, and these are determined by the network system to which he belongs. In other words, his utility depends on his environment as well as on his own individual characteristics. Therefore, if the stability of the network can be assumed, this problem of "change of taste" can also be avoided in the interdependent preference approach.

1.4.5.3 Dynamic External Economic Conditions

Economic changes induce the diffusion of existing as well as new technologies. Numerous supply-response studies are based on the effects of economic changes on the diffusion of existing technologies.[64] However, a supply-response type approach is not entirely suitable for studies of the adoption process. This especially applies to intra-farm diffusion, unless a threshold which determines a villager's time of adoption is endogenously treated in terms of the profitability of the relevant technologies. The supply-response type approach may be suitable for diffusion studies if many villagers have already adopted the technology on a large scale, and if the expected or actual profitabilities of the relevant technologies are changing considerably over-time. At the earlier stages of diffusion these conditions are not satisfied, however, and the supply-response type approach cannot appropriately explain these stages.

In existing theoretical models of diffusion process of an innovation, the profitability

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[63]Refer Stigler and Becker 1977, and Rosenberg 1985.

[64]Behrman (1968) provides a detailed example of an agricultural supply-response study. Yotopoulos and Nugent (1976) presents general demerits of supply-response models. Ghatak and Ingersent (1984) presents some recent development of the models.

of the innovation is always assumed to be fixed over time. If a model deals with a very short period, this assumption is quite plausible. But usually diffusion processes of innovations are quite long enough for their profitabilities to vary significantly.

In fixed profitability models, a potential adopter may be assumed to collect only physical yield data to revise his subjective distribution of the innovation's profitability. However, in variable profitability models, a potential adopter must also be assumed to collect price data of inputs and outputs as well as physical yields, so that he can calculate his net income from all sources, i.e., his total profit.

In the latter case, all necessary information about innovations, which will involve studying other farmers' performances is represented by the total profit level. One model thus takes into account both the characteristics of innovations, on which existing theoretical intra-farm diffusion models have focussed, and the profitability factors which supply-response studies have treated.

1.4.6 Towards the Interdependence Approach - Discussion

The development of theoretical models of the intra-farm diffusion process and studies of contextual effects in both economics and sociology have been reviewed, and the author has endeavoured to seek the useful convergence of models for studies of the agricultural innovation adoption process. Following this review, it is suggested that the incorporation of the structural approach of network analysis into an economic model, using the interdependence utility function, is an appealing way to tackle the adoption/diffusion process. The problems associated with such incorporation are now discussed.

The particular specification of a utility function by Burt (1980a,b)[65] has certain problems.

Firstly, the only endogenous variable is a person's gain from adoption, dichotomously given. In order for the function to be integrated as either a relative income or interdependent preferences utility function, a person's income level should be the endogenous variable.

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[65]See Footnote on page 31.

Secondly, even if a person's income level is incorporated into his utility function, Burt's utility function cannot be interpreted as a relative income utility function in its simplest form. The following form of the subjectively perceived average income level, $\tilde{X}_i$, (harmonic average) is used for the comparison of the person's absolute income level with that of others':

$$\frac{1}{\tilde{X}_i} = \sum_{k=1}^{n} \frac{l_{ki}}{X_k}$$

where l_{ki} is the interdependence coefficient of i with respect to k and X_k is k's income level. This formulation of the average income level evaluates a unit change in income of a higher income person as being of less significance than a unit change in income of a lower income person. It partly corresponds with Runciman's statement as noted by Layard (1980).[66] The above form involves a complicated interpretation of the interdependence coefficients, however. It is therefore useful to use the simplest form of a weighted average such as:

$$\tilde{X}_i = \sum_{k=1}^{n} l_{ki} X_k$$

giving the simplest interpretation to the interdependence coefficients.

Thirdly, Burt's form of a utility function has a characteristic which is intuitively unacceptable. The marginal utility with respect to a person's income level is:

$$\frac{\partial U^i}{\partial X_i} = \alpha\mu X_i^{\alpha-1} \frac{X_i}{\tilde{X}_i}$$

so that if the person's relative income level, $X_i/\tilde{X}_i$, increases, his marginal utility of a unit increase in income is also increased. This contradicts the decreasing marginal utility theory, that a poor man's dollar is more valuable than a rich man's dollar, and what is felt to be the actual situation that a dollar for a man who perceives himself as poor in his society is much more valuable than when he becomes richer in th society. In other words, an objectively or subjectively poor man's dollar is more valuable than an objectively or

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[66] See Section 1.4.3.3.

subjectively rich man's dollar. Burt's form of utility function must therefore be rectified to conform to this recognition.

Fourthly, comparing Burt's form of a utility function with that of Becker, the treatment of other persons' income levels appears to be a problem. Burt did not assume other persons' income levels to be either exogenous or endogenous in a particular person's utility function. He just demonstrated how one's utility changes when others change their income levels in an adoption process. Becker treated these income levels as endogenous, controllable by giving or taking certain amounts of income to or from other persons as a means for reaching an equilibrium. Becker's treatment may be plausible for relationships within a household, but causes problems if applied to situations where relationships between households are considered. It is of course true that in a general context, monetary and non-monetary transactions which involve various sums of money or valuables are frequently observed among households. However, in many villages in developing countries, such monetary or non-monetary transactions among households within villages are often rigidly regulated by religious and traditional customs.[67]

Further, and in relation to this fourth aspect, the problem can be looked at from a different point of view. The primary concern of this study is the explanation of a person's adoption behaviour, rather than his initiation of interactions with other persons. If the latter are also included as endogenous variables these have to be considered on the basis of the similarity or difference between the person and his counterpart's socio-economic characteristics. The actual external interactions which transmit contextual effects in the important manner already discussed (Section 1.4.4.2) are thus neglected. Therefore, such interactions or, more specifically, others' income levels are better treated as exogenous variables. It is probably more appropriate to assume that a person is "harmlessly envious" to others,[68] because he does not try to control others' income levels.

Fifthly, the treatment of others' income levels as exogenous variables leads to another problem which is related to a person's attitude towards risk, and its measure. If a

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[67]For example, in Islamic areas, one tenth of one's income should be donated to mosques for saving poor people in the areas.

[68]For the definition of "envy" or "being envious", see Footnote on page 16.

person's attitude towards risk is related to the utility or disutility from changes in his own income level together with changes in others' income levels, then a measure suitable for this purpose must be formulated. This is done in the theoretical model in Chapter 5.

It must be also recognised that the choice of a suitable interdependence coefficient poses another major problem in formulating the interdependence utility function in a way that is useful for analytical purposes.

In existing relative income utility function models, the concept of "reference groups" is missing, although its importance has been noticed (Section 1.4.3.3). The problem now is how such reference groups may be identified. In reviewing the network analysis of contextual effects, it was found that the concept of "structural equivalence" in the structural approach appears to be superior both to the relational approach and to the "categorical equivalence" concept in the structural approach (categorical analysis). However, it must be admitted that none of these concepts have been rigorously examined empirically in sociology and other relevant disciplines.[69] It is therefore in this study refrained from concluding that particular interdependence coefficients are superior to other possible measures. Hence, the enhanced definition of "structural equivalence" developed by Burt (1980c), in which indirect interactions of the second-order[70] are included, is accordingly used. By including indirect interactions, information flows which are transmitted through such indirect interactions are more emphasised.

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[69]Exceptions are Burt's studies of "invisible colleges" and "interlocking directorates" (1982, 1983).

[70]Interactions between two persons which involve a third person as a mediator. This adjustment was also used by Rogers and Kincaid (1981) in their relational approach study of family planning diffusion processes in Korean villages. It seems that proponents of these two approaches have realised demerits in using only direct interactions.

CHAPTER 2

Belatung Village Scene

2.1 Introduction

The rubber smallholding village of Belatung in South Sumatra, Indonesia, was selected as a case study of villagers' adoption behaviour. South Sumatra is a province producing both oil/natural gas and rubber, and is affected by the Indonesian Government's current effort to give more emphasis to agricultural industries including rubber. Recently a branch of Research Institute of Estate Crops (Balai Penelitian Perkebunan Sembawa) was opened on the outskirts of Palembang to conduct research on new technologies and effective methods of diffusing them, cooperating in the latter with the Extension Agency of Estate Crops (Dinas Perkebunan) of the Ministry of Agriculture. Despite the official emphasis on rubber, however, the smallholders of Belatung are shifting their interest towards other more profitable crops such as the perennial tree crop, citrus siam.

In this chapter, the socio-economy of Belatung is described, to help to understand the background to the citrus siam adoption behaviour of villagers.

2.2 General Information

2.2.1 Physical Environment

2.2.1.1 Area

Belatung is one of the villages in Marga Lebuk Batang, Kecamatan Peninjauan, Kabupaten Ogan Komering Ulu of South Sumatra Province (Figures 2-1 and 2-2). This village is located about 20 kilometers from Baturaja, the capital of Kabupaten Ogan Komering Ulu, and 195 kilometers from Palembang, the capital of South Sumatra Province. Baturaja is located in an important position in terms of transportation of both

goods and people. The railway from Palembang to Tanjung Karang (capital of Lampung province) passes through it, as does the Sumatra Highway. Belatung is also on the railway line from Baturaja to Palembang, being the second station after Baturaja. The early morning train from Baturaja to Palembang, mid-day express from Tanjung Karang to Palembang, mid-day train from Palembang to Baturaja, and two mid-night expresses, one from Tanjung Karang and another from Palembang, pass through Belatung each day. There are also some irregular freight trains from a cement factory in Baturaja to its main processing factory in Palembang (PT Semen Baturaja).

Belatung officially covers 1325 ha, and is bounded by Bandar Agung to the North, Karta Mulya to the East, Transmigration Sungai Gilas to the South and Lebuk Batang Lama to the West (Figure 2-2). The village residential area is situated along the Ogan river (Figure 2-3).

Within its total area, Belatung has 100 ha of sawah, 530 ha of "dry land", and 610 ha of smallholding estate crop area (Tanah Perkebunan Rakyat). The sawah area has long been abandoned, however. According to the village head, a government survey team estimated the costs of improvement of the sawah area in early 1970s. Since the costs of building water gates and embankment were estimated as being too high, the village's proposal that this area should be improved seems to have been rejected.[1] Nowadays the official area of sawah only seems to be quoted as a means of obtaining fertiliser from the BIMAS project.

The official category of dry land (Tanah kering pertanian) seems to include the land classes of ladang, pematang and lebak. These are quite different in terms of geomorphology and agricultural utilisation. Ladang covers the peneplain and terrace areas, while pematang indicates the land along but not flooded by the river. Lebak covers areas seasonally flooded by the river.

Lebak is usually further classified into three levels, from low to high, namely lebak dalam (lebak rendah), lebak tengah (lebak tengahan) and lebak tinggi (lebak pematang). However, because of the speed of river water flow in this area, the river edges are quite

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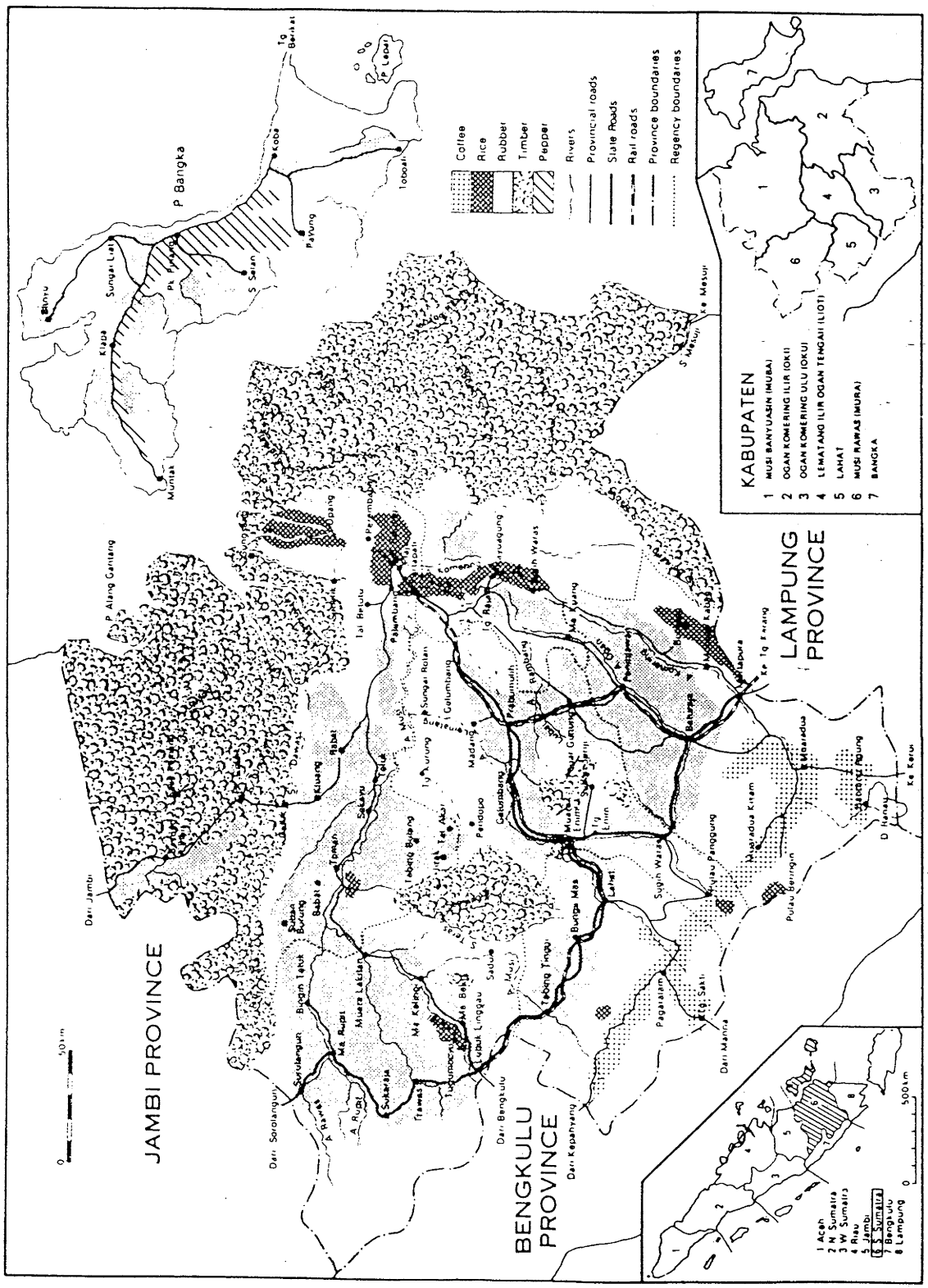
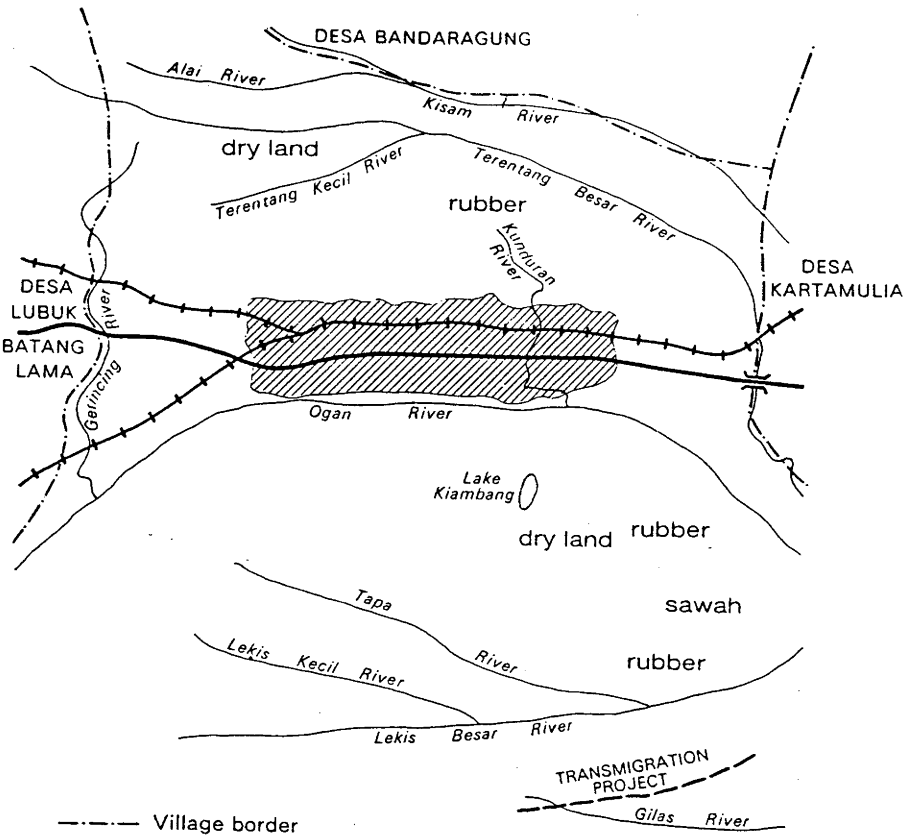
[1]There has been no official answer from the government.

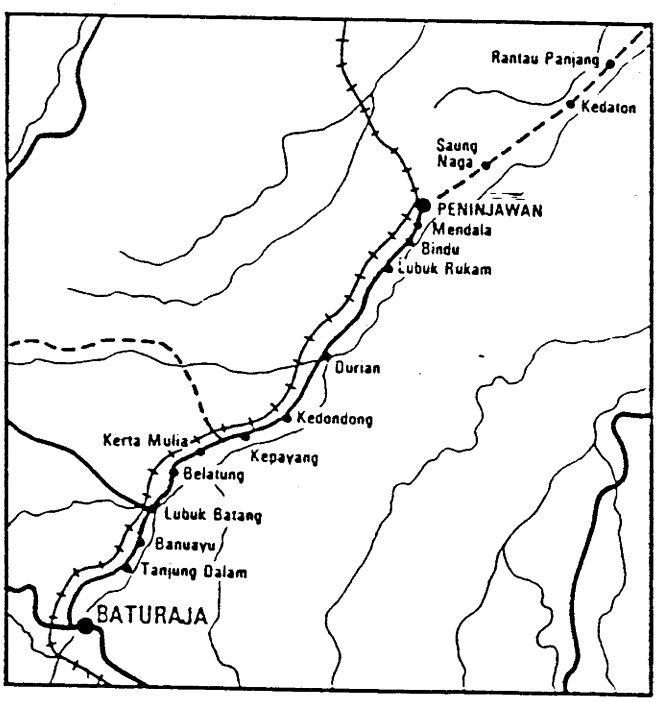
Figure 2-1: Map of South Sumatra, Indonesia



Source: Barlow and Muharminto (1980)

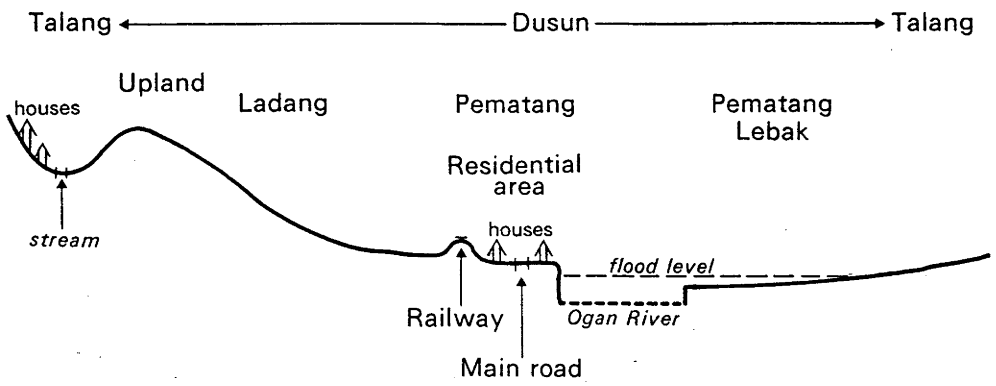
Figure 2-2: Maps of Belatung





Source:
(a) Fieldwork
(b) Barlow and Muharminto (1980)

Figure 2-3: Schematic Cross-section of Village Landscape



Land	Crops
Upland	
(talang)	Rubber
(ladang)	Rubber, pineapple, citrus, rambutan, rice (padi ladang), vegetables
Lowland	
(pematang)	rubber, rice, vegetables, citrus
(lebak)	rice (padi lebak), vegetables, citrus, durian, coffee

Source: Fieldwork

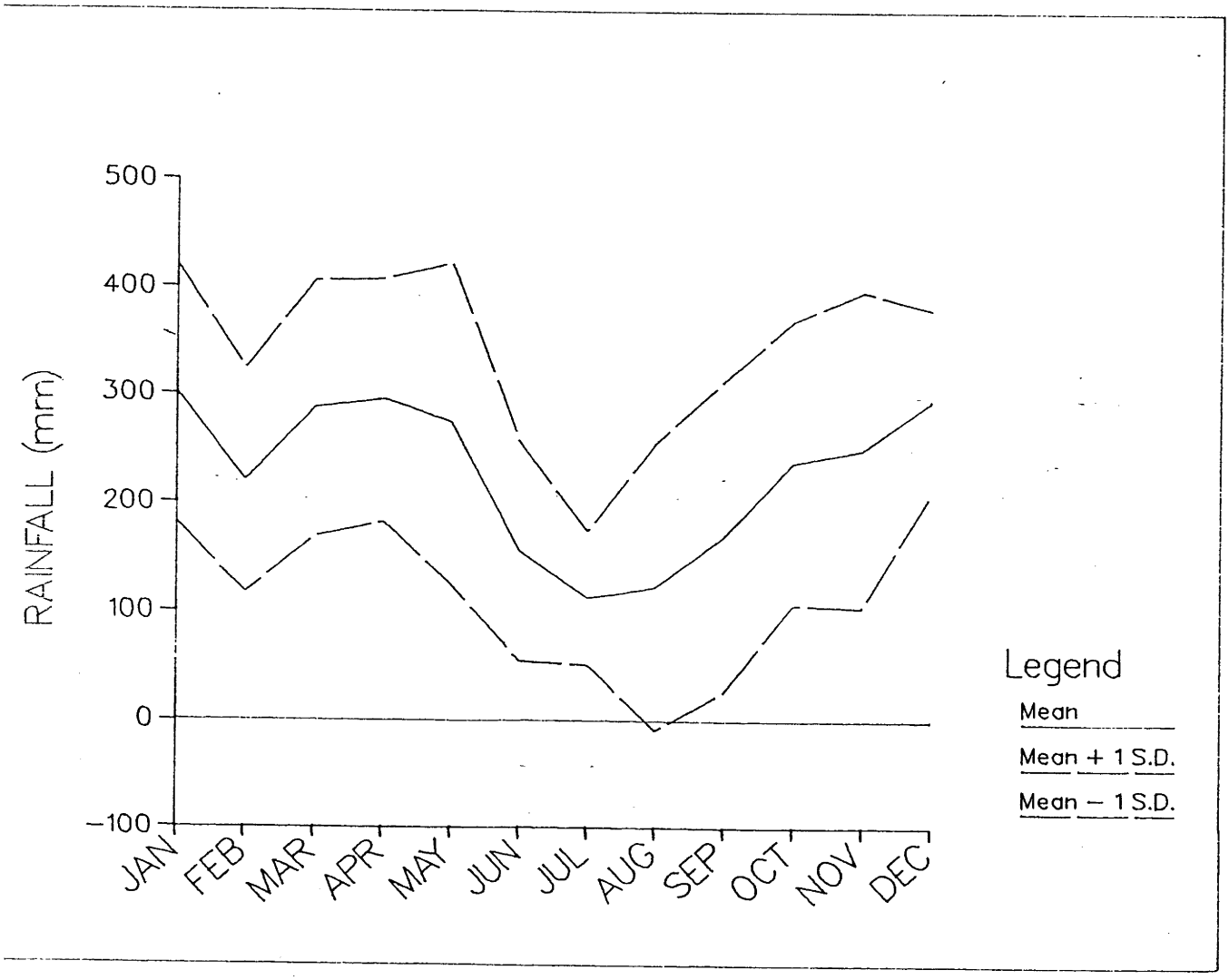
sharp and no area corresponds exactly to lebak dalam and lebak tengah. The Belatung villagers accordingly distinguish only lebak and ladang. The sawah land may correspond to the lower levels of lebak lands, but the characteristics of this area were not be examined because of the difficulties of reaching it.

Takaya (1980) studied the agricultural landscape along the Komering river, which is the neighbouring main stream to the Ogan. People there classify their lands into the six categories, going from higher to lower levels. These are talang, pematang, lebak pematang, lebak tengahan, lebak dalam and rawa-rawa. Talang is upland away from the main river, but not necessarily suffering from lack of water. This term is sometimes used by villagers to characterise a hamlet located away from the village's main residential area, even though there are only one or two houses there. Pematang is land along the river but not submerged by floods. The three categories of lebak land are seasonally flooded. Rawa-rawa is a perennially inundated part of the backswamp.

2.2.1.2 Meteorological Conditions

Tropical forest climate prevails in South Sumatra. Baturaja is located at an altitude of 49 m and more than 200 km away from the coast. It is cooler and less humid than the area around Palembang. The maximum temperature is about 32 degrees C, and the minimum 20 degrees C, with only small fluctuations in this temperature range. The annual total rainfall, in Baturaja, is on average 2693 mm, with a standard deviation of 480 mm between 1970 and 1982. During the last 13 years, there have been three years, 1972, 1975 and 1977, when the annual rainfall was less than 2213 mm (the average minus one standard deviation). The local people divide a year into two seasons, musim hujan (rainy season, November to mid-May) and musim kering (dry season, mid-May to October). More than 250 mm of rain falls in a month of an average rainy season, but monthly rainfall drops to 100 to 150 mm in dry seasons. As shown in Figure 2-4, there is a fairly high probability of no rain in August.

Figure 2-4: Monthly Rainfall Pattern 1970-1982, Baturaja



Source: Dinas Pertanian dan Tanaman Pangan Baturaja (1970-83)

2.2.2 Historical Background

In this sub-section, the agricultural situation around Baturaja is historically described according to some official documents of the history of South Sumatra (Ma'moen Abdullah 1978, 1979, 1980), and village elders' stories.

2.2.2.1 Dutch Occupation Period (1920 - 1941)

The Netherland's colonial administration was established in the so called "up-stream area" (daerah ulu) in the 1920's. Previous to that Dutch control extended to the "low-stream areas" (daerah ilir) only. The present province of South Sumatra was divided into three Afdelings governed by Asisten Residens and these were divided into some Onderafdelings governed by Kontroleurs.

At the Onderafdeling level, the local indigenous administrative structure was used to support the colonial administration. An Onderafdeling was divided into several Distriks governed by a Demang, which corresponded locally to a Marga governed by a pasirah and supported by kerios, (heads of dusuns). Pasirahs were usually elected from the pangeran family of the region. However, the titles of the pangeran, gelar depati and raden, which had been used for the positions of the old Sultanate, were officially abolished.

The railway between Palembang and Lampung was opened in about 1930. According to the village elders' story, Belatung had been the residence of the pasirah and pangeran in the area before the opening of the railway, but after the opening the capital of the Kabupaten moved to Baturaja, and the capital of the marga moved to the neighbouring Lebuk Batang Baru (See Figure 2-2-b).

Rubber estates in this area seem to have been started in the 1920's. In 1923, the price of rubber peaked at 120 gulden per pikul, and Erfpachtsperceel lands (long term lease lands) were opened as rubber estates. An estate called Erfpachtsperceel Maria Louisa was opened in Belatung and its surrounding area. Presumably the rubber smallholdings started spreading from this estate. The villagers' estimate of the age of their old rubber trees is around 50 to 60 years old as Whitford (1931) indicates that the initial establishment of rubber estates took place during the 1920's.

Rice production for subsistence seems to have been supervised by the Dutch colonial

administration. According to the village elders, the presently abandoned sawah land was often inspected by the Kontroleur of the Onderafdeling based in Baturaja.

2.2.2.2 Japanese Occupation Period (1941 - 1945)

The Japanese occupation military administration forced villagers to produce food crops such as rice and cassava. This emphasis on food crops was completely different from the Dutch colonial administration's emphasis on cash crops. According to village elders, their rubber smallholdings close to the residential area were cut down and burnt so that cassava could be cultivated. They were also forced to produce rice on sawah lands. Certain proportions of harvests had to be given to the government through the reorganised village administration. Daily household goods were only available through "distribution shops" (toko gabungan). Lamp oil was totally banned, and villagers used rubber sap for lamps. The only non-food crop which villagers were forced to plant was cotton. It seems to have been planted on ladang lands, and to have been unsuccessful in the area.

This change of emphasis damaged the village economy and its effects persisted even after Independence in 1945. The rubber lands close to the village, which were burnt down, had been the villagers' prime sources of cash. It took them a long time to replant such areas and resume the rubber production.

2.2.2.3 Federal Period to 1969 (1945 - 1969)

Recollections of the villagers are the sole source of information about the economic situation in the village from Independence until 1969. No official record is available. According to the author's interviews with village elders, this period was freer than the present in terms of regulations on economic activities. There was no restriction on what crops could be grown. Although the villagers suffered from lack of cash during the earlier part of the period, they soon resumed rubber production and with the intermediation of Chinese rubber dealers started exporting their harvest to Singapore through Palembang. Palembang was the centre of the South Sumatran economy, which had closer links with Singapore than Jakarta.

The period was also freer in terms of the movement of population, and the number of persons in the village seems to have decreased considerably during the latter half. The

Lampung and Ranau areas (Figure 2-1) were gradually planted to coffee as the production of that crop became increasingly more profitable over other cash crops, especially rubber.

Between 1965 and 1969, the village economy seems to have been in turmoil. Village elders were very reluctant to discuss the events of that period. Transportation to Palembang was cut because of the bad maintenance of the road and railway, and some parts of the route appear to have been impassable due to rebel activities. Labour was also scarce during this period.

As the Orde Baru (New Order) regime became established, however, conditions improved. In 1969, the Belatung village elected a new head, who was a member of the traditional village ruling family. He was a very strong leader, and has remained in this position until the present.

2.2.2.4 Post-1969 Period

Since the present village head was elected in 1969, the village has been stable. In general, South Sumatra has been enriched by the revenue from oil and natural gas production, and temporarily by the coffee boom between 1976 and 1980. Investment on infrastructure, especially on roads and schools, took place. Better infrastructure and socio-political stability enabled villagers in South Sumatra to have more and better opportunities to prosper in their agricultural production.

During the first part of this period (1969 - 1976), rubber prices gradually declined and villagers seem to have started to think about alternatives to rubber smallholdings. The coffee boom, which started in 1976, influenced these villagers' decisions. In non-coffee producing areas, villagers started growing alternative tree crops such as cloves, cinnamon, pepper and citrus siam. This process will be discussed in detail in Chapter 4. Although rubber price started to improve from 1976 onwards until 1980, prices of alternative crops increased far more rapidly and the move from rubber to alternative crops seems to have been unchanged or even accelerated.

Villagers in Belatung started growing citrus siam in 1969. Especially after the coffee boom started in 1976, the switch from rubber to citrus siam gathered momentum. This process was facilitated by the completion and improvement of roads to larger cities,

particularly the Sumatran Highway, as the market for agricultural products began to expand rapidly.

2.2.3 Economic Background

Belatung is located in the middle of the largest rubber producing area in South Sumatra (Figure 2-1). Rubber products from this area are transported to Muara Enim, Baturaja or Prabumulih. Since Belatung is less than 20 km away from Baturaja, it is very dependent on Baturaja's economy.

Baturaja is the centre for handling agricultural products from the south-western part of South Sumatra. Coffee produced in the high-altitude regions (Ranau, Lahat, etc.) is transported to Baturaja, and then diverted towards either Palembang or Tanjung Karang in Lampung Province. Rubber, both from individual smallholdings and from transmigration project areas (such as that of Batumarta 30 to 40 km from Baturaja), is taken to Baturaja, and then transported by truck to Palembang through Muara Enim, via the Sumatran Highway.

Various kinds of transportation are available for bringing goods into and out of Baturaja. The Ogan river is used to transport bamboo from Muara Dua and upper-stream areas to Baturaja. The railway from Palembang to Tanjung Karang passes through Baturaja, as already indicated.

The most recent improvement in transportation system comes from the Sumatran Highway, which starts from Aceh and terminates at Tanjung Karang (Figure 2-1). When the southern part of the highway was completed in 1983, it much enhanced the importance of Baturaja as a centre for agricultural products and tourism. The highway further altered the previous heavy dependency of Baturaja on Palembang and improved direct access through Tanjung Karang to Jakarta. The mass transportation ferries between Tanjung Karang and Jakarta have improved dramatically. These changes have not only affected trade, but have also enabled villagers to travel much more easily.

Further changes affecting Baturaja as a market have also occurred. Considerable amounts of vegetables are now produced from the vast previously unpopulated areas successively opened as transmigration projects. These are all transported to Baturaja and marketed there. The city administration of Baturaja is re-organising the market system in

Baturaja by opening a third official market place, as well as a new bus terminal for buses going towards Tanjung Karang.

2.3 Household Characteristics

2.3.1 Demography

In many economic studies, the term "household" has been interchangeably used with "domestic group". A "domestic group", which is a term used mainly in anthropology, may be defined as a group of people who habitually share a common dwelling and a common food supply. Domestic groups may be made up of individuals between whom no kinship ties exist.

For the purpose of this study in Belatung, the above definition of "household = domestic group" must be slightly modified. There are some groups of villagers who live in the same house but do not share food, cooking facilities and income. They actually live separately in upstairs and downstairs sections with different kitchens, though they have relatively close kinship ties. These would be understood as two separate households.

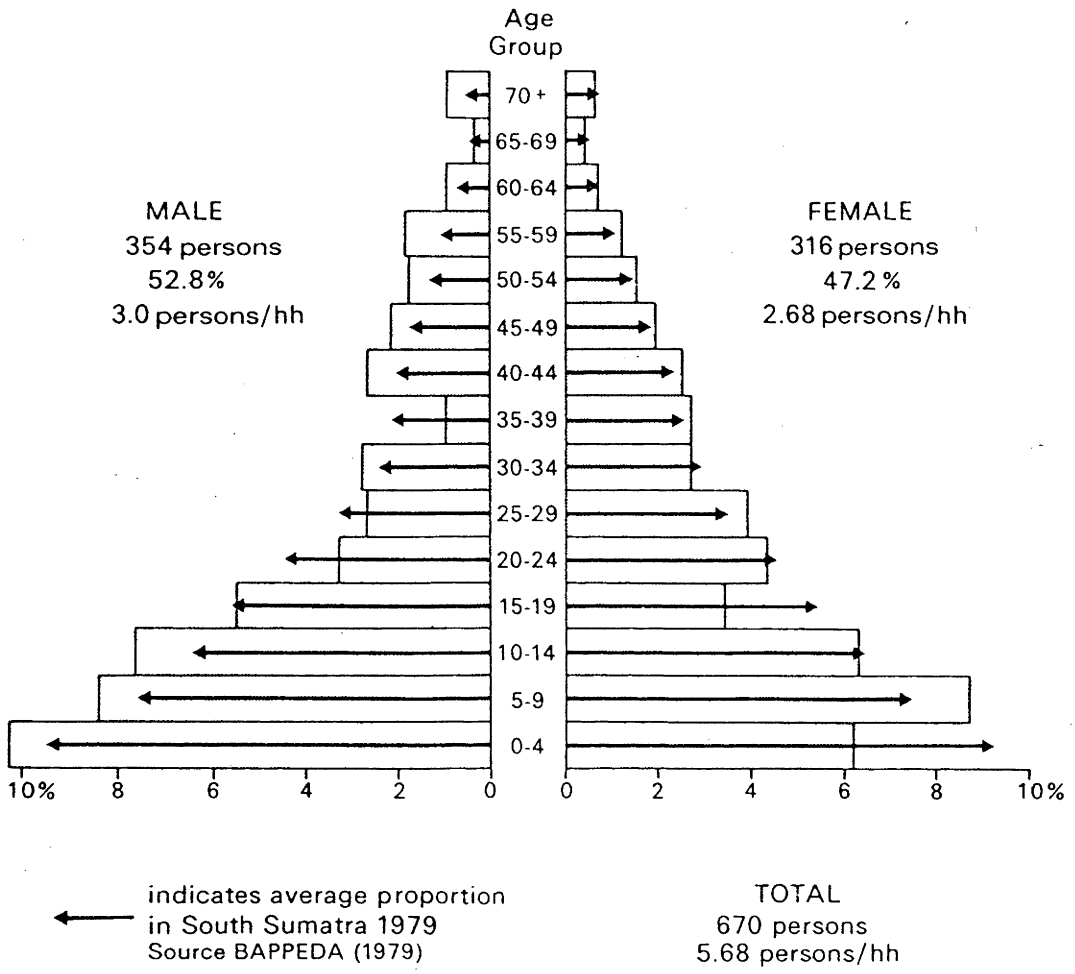
2.3.1.1 Age-Sex Structure

In December 1982, Belatung's population consisted of 670 persons, 354 males and 316 females, in 118 households. The number of households was about a half of the average for the 28 villages in Kecamatan Peninjauan. Because of the wide variance about this mean, however, the Belatung figures are still within the range of the Kecamatan average plus-minus one standard deviation.

The village's age-sex structure and its comparison with that of South Sumatra in 1979 are shown in Figure 2-5. Some observed differences are that the number of younger males aged between 20 and 39 years was relatively lower in the village. This was also the case with females upto 4 years and between 15 and 19 years.

In South Sumatra, young rural males tend to go to the cities so as to gain experience in non-agricultural occupations. They come back after a number of years, sometimes amounting to ten or more years, to inherit their lands. Villagers often claim that they have close relatives in Palembang, Jakarta or other major cities.

Figure 2-5: Belatung Village Population Pyramid



Source:
(a): Fieldwork
(b): BAPPEDA (1979)

2.3.1.2 Household Structure

Figure 2-6: Household-size Distribution

Household Size	No. of households		
1	1	0.8%	*
2	7	5.9	*******
3	12	10.2	**********
4	20	16.9	********************
5	18	15.3	******************
6	20	16.9	********************
7	18	15.3	******************
8	9	7.6	*********
9	4	3.4	****
10	5	4.2	*****
11	3	2.5	***
12	1	0.8	*
Total	118	99.8	
Average	5.68	persons/household	
S.D.	2.29		

Source: Fieldwork

The average size of a household is 5.68 persons and households with 4 to 7 members are dominant in the village (Figure 2-6). The usual pattern is a husband, a wife and two or three children for two-generation households. In three-generation households, typically there are, in addition to the household head and his wife, two parents of the household head, and two or three children. Some households also include unmarried siblings of either the husband or the wife.

2.3.2 Income

2.3.2.1 Agriculture

During 1982-83, annual incomes from agricultural products ranged up to Rp. 5.75 million reflecting the wide variety of cropping patterns. The few with the higher incomes usually had coffee plots in Kota Bumi, Lampung province, and were still earning good returns despite the recent fall in coffee prices. When such person were excluded annual agricultural incomes ranged up to Rp. 1.75 million. The average annual agricultural income for farmers is about Rp. 1 million (Figure 2-7).

Figure 2-7: Distribution of Annual Agricultural Income

Range (million Rp.)	Households No.	%	
N.A.(a)	5	4.2	*****
0	24	20.3	**********
-0.25	9	7.6	********
-0.50	16	13.6	**********
-0.75	17	14.4	**********
-1.00	11	9.3	**********
-1.25	15	12.7	**********
-1.50	5	4.2	*****
-1.75	8	6.8	********
-2.00	1	0.8	*
-2.25	1	0.8	*
-2.50	0	0.0	
-2.75	0	0.0	
-3.00	1	0.8	*
-3.25	1	0.8	*
-3.50	1	0.8	*
-3.75	0	0.0	
-4.00	1	0.8	*
-4.25	0	0.0	
-4.50	0	0.0	
-4.75	0	0.0	
-5.00	0	0.0	
-5.25	1	0.8	*
-5.50	0	0.0	
-5.75	1	0.8	*
Total	118	99.5	

All Villagers

Average = Rp. 771,117
S.D. = 945,048
n = 118

Farmers only (except n.a. and those without agricultural income)

Average = Rp.1,022,380
S.D. = 963,136
n = 89

Note:
(a) N.A. denotes a household which did not state its income. Some of these households appeared to belong to the high income group.
Source: Fieldwork

2.3.2.2 Non-agricultural Occupations

Table 2-1: Major Non-agricultural Income Sources

Source	Number of Households	Average (SD) (Rp.)*	Range (Minimum - Maximum)
Fishery	19	334474 (287474)	10000 - 1200000
Shop	5	712400 (411544)	162000 - 1200000
Remittance	13	82308 (134855)	5000 - 500000
Salary	27	654341 (162258)	312000 - 984000
Others	45	422320 (515220)	5000 - 3000000
Total	74	644035 (477556)	5000 - 3000000

Note: * Only for villagers who have incomes from these sources.
Source: Fieldwork

Villagers' non-agricultural income sources were classified into five categories: (1) fisheries (2) grocery shops (3) remittances (4) salaries and (5) others. The total number of villagers with non-agricultural income sources was 74 (Table 2-1).

During the dry season, when the Ogan river's water level is down, villagers set traps and nets in the river and catch fresh water fish. Nineteen villagers were identified in this class with annual incomes from fisheries ranging from Rp.10,000 to Rp.1,200,000. These villagers sold fish to itinerant fishmongers from other villages, who come in the early morning by motor bike and take fish to the Baturaja markets. Some villagers sold fish in the Baturaja markets themselves.

There were six small grocery shops in the village, and incomes from these shops were available for five cases, excepting the smallest unit. This shop had only two shelves and was not open regularly. The annual incomes from the five shops ranged from Rp.162,000 to Rp.1,200,000.

There were 13 villagers who received remittances from their sons outside the village, the annual amount ranging from Rp.5,000 to Rp.500,000.

There were 27 salary-earners who included four school teachers, one civil military officer, and 22 National Railway workers.

Other sources of income included lumbering, carpenters, pemborong rumah (house contractors), boat-making, etc, where 45 villagers were involved.

Figure 2-8 shows the distribution of the proportions of agricultural income in total annual income. 24 villagers were identified as having no source of agricultural income. But they were not necessarily non-farmers. They included farmers who did not sell but only consumed their agricultural products. They can be considered as non-commercial farmers. On the other hand, there were 39 full-time farmers who had only agricultural income sources. Of the remaining 50 villagers, 32 were part-time farmers of "Class-1" whose agricultural incomes were more than 50 percent of their total annual incomes, and 18 villagers were part-time farmers of "Class-2" whose agricultural incomes were less than 50 percent of their total annual incomes.

The distribution of villagers' total annual incomes is shown in Figure 2-9. The average is about Rp. 1.2 million. Although it has a wide deviation (standard deviation is Rp. 1.0 million), the Gini coefficient (0.3789) does not indicate a strongly unequal income distribution. Farm size was more unequally distributed (Gini coefficient = 0.5533, Section 2.4.2.1).

2.3.3 Expenditure

The villagers' household expenditure and consumption levels are investigated here from the viewpoint that these can indicate the relative living standards of households.

Figure 2-10 shows the distribution of total annual household expenditure. The average total expenditure was about Rp. 1 million, which is about 17% less than the average income level, and with a much narrower deviation (standard deviation is Rp. 0.6 million).

Since village households produced some subsistence foods such as rice, fish and vegetables, their home-production for consumption and subsistence expenditures[2] were also investigated. Nineteen major items were selected for examination:

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[2]The value of subsistence items both produced by the villagers and purchased.

Figure 2-8: Proportion of Agricultural Income

Proportion %	No. of Households	
0	24 **********	Non-commercial farmers
1 - 4	1 *	
5 - 9	0	
10 - 14	0	
15 - 19	3 ***	
20 - 24	4 ****	Part-time farmers Class-2
25 - 29	2 **	
30 - 34	0	
35 - 39	5 *****	(n=18)
40 - 44	1 *	
45 - 49	2 **	
50 - 54	4 ****	
55 - 59	3 ***	
60 - 64	0	
65 - 69	4 ****	
70 - 74	3 ***	Part-time farmers Class-1
75 - 79	2 **	
80 - 84	5 *****	
85 - 89	3 ***	(n=32)
90 - 94	4 ****	
95 - 99	4 ****	
100	39 **********	Full-time farmers
Total	118	

Average Proportion of Agricultural Income 60.94% (S.D.=40.72)

Source: Fieldwork

Figure 2-9: Distribution of Total Annual Income

Amount (x Rp 10^6)	No. of Households		
- 0.25	2	1.7	**
- 0.50	13	11.0	**********
- 0.75	26	22.0	**********
- 1.00	19	16.1	**********
- 1.25	15	12.7	**********
- 1.50	8	6.8	********
- 1.75	13	11.0	**********
- 2.00	5	4.2	*****
- 2.25	2	1.7	**
- 2.50	1	0.8	*
- 2.75	1	0.8	*
- 3.00	1	0.8	*
- 3.25	1	0.8	*
- 3.50	2	1.7	**
- 3.75	0	0.0	
- 4.00	1	0.8	*
- 4.25	0	0.0	
- 4.50	0	0.0	
- 4.75	1	0.8	*
- 5.00	0	0.0	
5.00 -	2	1.7	**
N.A.	5	4.2	*****
Total	118	99.6%	
Average	Rp 1,226,995		
S.D.	1,032,168		
Gini Index	0.3789		

Note: N.A. not available.
Source: Fieldwork.

Figure 2-10: Distribution of Total Expenditure

(million Rp.)	No. of Households	
0 - 0.25	3	***
0.25 - 0.5	18	******************
0.5 - 0.75	24	************************
0.75 - 1.0	23	**********************
1.0 - 1.25	11	**********
1.25 - 1.5	13	************
1.5 - 1.75	6	******
1.75 - 2.0	7	*******
2.0 - 2.25	4	****
2.25 - 2.5	1	*
2.5 - 2.75	1	*
2.75 - 3.0	2	**
N.A.	5	*****
Total	118	
Average	1.023	
S.D.	0.578	

Source: Fieldwork

1. Rice
2. Fish
3. Salted Fish
4. Coffee
5. Tea
6. Sugar
7. Salt
8. Cooking Oil
9. Cigarette
10. Soap
11. Kerosene
12. Flour
13. Milk
14. Eggs
15. Onion
16. Potato
17. Meat
18. Cassava
19. Fruits

The quantities of these items purchased and home-produced were determined from household heads and their wives, and evaluated at prevailing market prices. The value of aggregated monthly consumption was then compared with the household's estimated monthly expenditure for these items. The two values were found to be almost identical, indicating that the selected items and the estimates of expenditure were probably quite realistic.

On average, a household in Belatung purchased Rp.59,000 a month of subsistence

Table 2-2: Subsistence Consumption of Major Items

Items Purchased	Quantity Average (S.D.)	Value (Rp.) Average (S.D.)	Proportion (%) Average (a)	(b)
Rice(kg)	66.65(32.97)	19995 (9890)	34.9	27.2
Fish(kg)	11.24(13.37)	3295 (3482)	5.0	4.5
(Rp)	447.8(1857.)			
Salted Fish(kg)	1.235(1.873)	1566 (2058)	2.7	2.1
(Rp)	331.0(1245.)			
Coffee (kg)	2.349(2.621)	5872 (6553)	9.8	8.0
Tea(box)	1.473(2.661)	308 (543)	0.5	0.4
(Rp)	13.27(141.1)			
Sugar(kg)	7.597(4.988)	4558 (2993)	7.8	6.2
Salt(kg)	2.382(2.317)	238 (232)	0.4	0.3
Cooking Oil(l)	3.656(2.856)	2193 (1713)	3.8	3.0
Cigarette(Rp)	-----	8219 (7137)	12.8	11.2
Soap(No.)	6.416(3.605)	802 (451)	1.5	1.1
Kerosene(l)	17.61(12.65)	2641 (1897)	4.7	3.6
Flour(kg)	4.450(4.336)	1558 (1518)	2.7	2.1
Milk(tin)	2.522(3.003)	1261 (1502)	2.1	1.7
Eggs(No.)	12.89(12.23)	1289 (1223)	2.4	1.8
Onion(kg)	1.331(1.356)	666 (678)	1.1	0.9
Potato(kg)	0.653(1.306)	392 (783)	0.6	0.5
Meat(kg)	0.659(1.317)	1648 (3291)	2.5	2.2
Cassava(kg)	12.45(22.75)	622 (1138)	1.1	0.8
Fruits(Rp)	-----	2293 (3413)	3.5	3.1
Sub-total	-----	59381(27833)	99.9%	80.7%
Home-production	Quantity	Monetary Value (Rp)		
Rice(kg)	18.46(26.87)	5536 (8061)	39.3	7.5
Fish(kg)	7.969(13.37)	1992 (3343)	14.2	2.7
Coffee(kg)	2.313(2.619)	5783 (6547)	41.1	7.9
Eggs(No.)	3.283(11.86)	328 (1186)	2.3	0.4
Cassava(kg)	8.597(22.97)	430 (1148)	3.1	0.6
Sub-total	-----	14070(12666)	100.0%	19.1%
Total	-----	73451(36614)	-----	99.8%

Notes: (a) Average proportions in purchased items and in home-produced items.
(b) Average proportions in total subsistence consumption.
Source: Fieldwork

items, notably rice, coffee, sugar and cigarettes (Table 2-2). Evaluating home production at prevailing market prices, the total value of home-production was Rp.14,000. Adding the aggregated value of monthly home-production to the total monetary expenditure (or purchases), the total value of annual subsistence consumptions was calculated for each household. Thus the average village household used cash for 80 percent of its total subsistence consumption of Rp.73,000 in a month.

2.3.4 Education

Education in the village was provided in two forms: (1) formal schooling and (2) informal education. The former required attendance at government or private schools, and the latter was obtained by attendance at informal village religious class given by a khotib of the village or by on-the-job training on farms or elsewhere.

The village had one primary school situated in the middle of the village. Six years of primary education is required for every child. The villagers paid for textbooks, stationery and uniforms. Uniforms were by far the most expensive items, and according to recent legislation all the primary school pupils should wear uniforms. This caused problems, since villagers were reluctant to incur such expenditure, and in some cases could not afford this additional cost.

For secondary education, villagers had to send children to Baturaja or Palembang. In addition to the costs listed above for primary schooling, they had to pay transportation costs to and from Baturaja (Rp.500 return fare per day), and give some pocket money. Only richer villagers could afford these expenses. A few villagers sent children to stay in their relatives' places in Palembang and attend school from there.

Tertiary education was only available in provincial capitals. Only the wealthiest villagers could send their children to Palembang or other major cities in Java, no villager did so. Only one villager was a graduate of a university, and he was a teacher at the Belatung primary school. He belonged to the village's ruling family, and was sent to Lampung by his father who was a pasirah before World War II.

To discuss the formal educational attainment of household heads, some historical backgrounds is needed. During the colonial period, the sole education available for villagers was primary school, or Sekolah Rakyat (SR), for four years. The quality of this

Table 2-3: Educational Attainment

School	Grade (proxy)	Number of villagers: H.H. (a)	ALL (b) M	ALL (c) F	Age Group 0-5 M & F	6-11 M	6-11 F	12-14 M	12-14 F	15-17 M	15-17 F	18-30 M	18-30 F	31- M	31- F
None	0 (0)	17	128	111	140	14	8	0	1	4	0	9	8	18	37
Primary School	1 (1)	2	15	17		13	16	0	0	0	0	1	0	1	1
	2 (2)	7	23	20		15	14	0	1	1	2	2	3	5	0
	3 (3)	5	18	21		10	11	3	1	0	1	4	4	1	4
	4 (4)	3	12	19		3	8	5	2	1	0	2	3	1	6
	5 (5)	8	22	17		5	4	7	4	3	1	1	7	6	1
	6 (6)	3	12	17		1	2	8	9	0	1	2	4	1	1
	graduate (7)	54	79	86				5	4	3	6	31	46	40	30
Junior High School	1 (8)	0	4	0				0	0	3	0	1	0	0	0
	2 (9)	1	10	1				4	0	3	1	2	0	1	0
	3(10)	0	5	2				0	0	4	2	1	0	0	0
	graduate(11)	12	15	3						1	0	6	3	8	0
Senior High School	1(12)	0	0	0								0	0	0	0
	2(13)	0	0	0								0	0	0	0
	3(14)	0	0	0								0	0	0	0
	graduate(15)	5	10	2								5	2	5	0
University graduate	(20)	1	1	0								0	0	1	0
	Total	118	354	316	140	61	63	32	22	23	14	67	80	88	80
	Average	6.1	4.0	3.4	0	1.9	2.2	5.7	5.2	6.3	6.4	6.5	5.9	6.0	3.2
	S.D.	3.9	4.0	3.2	0	1.6	1.6	1.7	1.7	3.7	2.6	4.0	2.9	4.3	3.2

Note:
(a) Household heads
(b) Male villagers
(c) Female villagers

Source: Fieldwork

schooling seems to have varied between villages and cities. A few of the older villagers went to Baturaja, Palembang and even to Jakarta for this level of education.

Some years after Independence, the primary school was renamed and re-organised as the Sekolah Dasar, and compulsory education was extended to six years.

Secondary education in Baturaja started in the early 1970's and was available for general studies (three years in the junior high school, Sekolah Menengah Pertama, and three years in the senior high school, Sekolah Menengah Atas), economic studies (three years in Sekolah Menengah Ekonomi Pertama, three years in Sekolah Menengah Ekonomi Atas), technical studies (three years in Sekolah Teknik Menengah Pertama and three years in Sekolah Teknik Menengah Atas) and other categories. As the army has its hospital in Baturaja, a higher secondary school for nursing has also become available.

Under the Orde Baru regime, the drive for education has been considerable, and the construction of new village primary schools and secondary schools at kabupaten level has been booming. In the area surrounding Belatung, almost all villages with more than 100 households and located along major roads have their own primary schools, and Belatung's own primary school was built in the mid 1970's. Previously the children commuted to the neighbouring village.

The educational attainment proxy used in this study was defined with an emphasis on whether a person has finished the prescribed length of schooling. Thus, if a person had finished primary school education, he was given seven as his educational attainment adding one to six years in a primary school (Chaudhri 1979). This clearly distinguishes the primary school graduate from a person who has spent six years in a primary school, but did not graduate. Similar adjustments were conducted for junior and senior high school graduates and university graduates, who were given proxies of 11, 15 and 20 respectively.

The average educational attainment of household heads was 6.1 in terms of the educational attainment proxy (Table 2-3), which corresponds to Year 6 of primary school education, while the average for all males was 4.0, and that of all females, 3.4. The average educational attainment levels of the various age-sex groups indicate low educational attainment of persons, especially females, over 31 years old.

Villagers' informal education attainment was difficult to measure. Their attendance at the village religious class was the most easily quantifiable measure, but as the attendance at the class was a matter of religious faith, it was quite difficult to obtain reliable data.

In general, farming experience and other types of experience can be quantified by asking villagers the length of time spent on a particular occupation at a particular place, but it is very hard to integrate these data into a reasonably reliable measure. In the literature, farming experience is often used to represent all of these factors. This is usually simply taken to be the number of years in farming, and is found to be highly correlated with age, since farmers are characteristically immobile. Since the young villagers of South Sumatra, however, tend to go out of their native villages for non-agricultural occupations, years of farming experience may not be so strongly related to age.

Figure 2-11: Distribution of Farming Experience

Range (years)	No. of Households	
0	4	****
1 - 5	18	******************
- 10	23	**********************
- 15	18	******************
- 20	11	**********
- 25	10	**********
- 30	8	********
- 35	13	*************
- 40	7	*******
- 45	1	*
- 50	3	***
51 -	2	**
Total	118	
Average	18.27 (years)	
S.D.	13.40 (years)	

Source: Fieldwork

Figure 2-11 shows the distribution of the farming experience of household heads, measured in terms of years. On average, villagers had 18.27 years of farming experience.

2.3.5 Media Exposure

Media exposure has been regarded as an important factor influencing villagers' adoption behaviour. While villagers' educational attainment levels can be regarded as a proxy for their ability to evaluate information about an innovation from external sources, the magnitude of their media exposure can be regarded as a measure of their opportunities to receive external information about innovations.

To measure villagers' magnitudes of media exposure, the factors (1) radio possession, (2) frequency of listening to agricultural programmes on radio, (3) subscriptions to newspapers and (4) subscriptions to agricultural or general magazines were selected. However, neither newspapers nor magazines were available to the villagers, and in any case, would have been of little use due to the low level of literacy. Therefore, only the first two measures were used.

Villagers who had a radio could listen to agricultural programmes which are broadcast early in the morning and evening. The information these programmes provide was generally considered useful, especially for sawah rice-producers, as the programmes are coordinated by the Food Crop Agency (Dinas Pertanian dan Tanaman Pangan). Information about citrus siam production was broadcast sometimes, as this crop, too, is under the control of this agency. There was a commercial radio station in Baturaja but it rarely broadcast agricultural information.

Forty nine of the 118 villagers possessed a radio in their homes (Table 2-4). However, not all villagers who had a radio listened to agricultural programmes regularly. Four villagers with a radio did not listen to the programme at all, and only 19 villagers listened every day.

To measure the extent of villagers' exposure to the outside world, questions were asked about the frequency of their visits to Baturaja, Prabumulih, Palembang, Lampung and Jakarta. Baturaja is the nearest commercial centre and the capital of the Kabupaten Ogan Komering Ulu. It was about thirty minutes to an hour away by bus. Prabumulih was the second closest city and the capital of the neighbouring Kabupaten Ogan Komering Ilir (Figure 2-1). The railway to Palembang passed through this city, and was about one to one and a half hours away by train. Palembang, the capital of South

Table 2-4: Media and Outside Exposure

Radio Possession

Yes	49	(41.5%)
No	69	(58.5%)
Total	118	(100.0%)

Agricultural Programme on Radio

times/week		
0	73	(61.9%)
1-2	4	(3.4%)
3-4	17	(14.4%)
5-6	5	(4.2%)
7	19	(16.1%)
Total	118	(100.0%)

Visits to Cities

Times/ Year	Baturaja	Prabumulih	Palembang	Lampung	Jakarta
0	16	111	65	74	106
1		2	20	16	7
2		2	8	9	2
3			3	4	2
4	3	1	6	3	1
5	1	1	2	3	
6				1	
10			1	2	
12	37	1	11	4	
15	3				
20	3				
24	9		2		
30	1				
36	5				
40	1				
48	4				
52	18			1	
60	3				
90				1	
104	4				
156	3				
260	1				
365	1				
Total	118	118	118	118	118
Average	48.1	0.2	2.3	2.4	0.2
S.D.	82.7	1.3	4.6	9.7	0.6

Source: Fieldwork

Sumatra province, was about five hours away by train (several villagers sent children to high schools there). Lampung represents Lampung province, located to the south of South Sumatra province. In the Kota Bumi area, some villagers of Belatung had coffee smallholdings and went there twice a year to look after them. After the completion of the Sumatran Highway made it easy to go there, most citrus siam products went through this region and across the strait to Java. Apart from its role as the national capital, Jakarta is at present the largest market for citrus siam, and also a source of better-quality saplings. Although transport of citrus siam saplings from Java to the Outer Islands is prohibited due to concerns with virus disease, villagers often tried to smuggle these saplings into their villages.

Baturaja was visited almost once a week (48 times a year on average) while visits to other cities are much less (Table 2-4). Prabumulih and Jakarta were only visited 0.2 times a year on average, and more than 100 villagers never went there. Palembang and Lampung were visited 2.3-2.4 times a year on average, while about 50 villagers had been there at least once a year.

2.4 Agricultural Economy

2.4.1 Cropping Patterns

Major crops in the village were rice (padi lebak, padi ladang), rubber, coffee, citrus siam, duku, durian, rambutan, cloves, and pineapples. Rice (padi lebak, padi ladang), rubber, durian and duku could be classified as old or traditional crops, while coffee, citrus siam, clove, rambutan and pineapple were new. Other than these major crops, crops such as pepper, coconut, sugar cane, and sweet citrus (jeruk manis) were also grown. These crops were grown for both cash and subsistence by a small number of villagers (less than 10 percent). Banana and vegetables were grown by almost all villagers but on a very small scale and mainly for subsistence. Cassava was also grown by the Javanese National Railway workers on their alloted tiny plots, again for subsistence.

Farmers tended to grow some major crops together; hence there were significantly positive correlations among these major crops, but no significantly negative correlations

Table 2-5: Correlations among Major Crops

Crops	COFFEE	DUKU	CITRUS S.	RICE	RAMBUTAN	PINEAPPLE	RUBBER	CLOVE	DURIAN
COFFEE	--	.20		.21			.25	.35	.29
DUKU		--		.28		.20	.27		.45
CITRUS SIAM			--		.34				
RICE				--	.16		.23		.49
RAMBUTAN					--	.29		.17	
PINEAPPLE						--			
RUBBER							--	.23	.27
CLOVE								--	
DURIAN									--

Note:
Only significantly non-zero Pearson correlation coefficients are shown.
Source: Fieldwork

(Table 2-5).[3] This suggests that there were no crops seriously competing with each other. The crops which had strongly positive correlations were (1) durian and duku, (2) durian and padi, and (3) coffee and cloves. Durian and duku are fruits which grew almost naturally together in the village. Duku especially was a crop unique to this area, and was known in the markets as "duku Belatung". Durian and padi were another commonly found combination, and this was related to the land usage type often found in the farm (See Figure 2-3). The combination of coffee and clove was thought to be due to the fact

[3]Correlations are calculated with a Pearson correlation coefficient on the basis of existence of crops concerned.

that both crops were new. Coffee was very profitable in the late 1970's, but when the prices declined in the early 1980's, cloves were introduced as a replacement in some cases.

Villagers are classified into 12 cropping pattern groups, using Ward's hierarchical clustering method.[4] Figure 2-12 shows the hierarchical process of the cluster analysis. Basically, villagers with identical cropping patterns are grouped into one, and the groups of the identical cropping patterns are re-grouped according to their similarity until all villagers are put into one. There is no absolute criterion to determine the level of similarity to draw out a certain number of cropping pattern groups. Groups are selected, in this study, so that each group has one or two common crops grown by all of its member-villagers. Table 2-6 shows the results of this classification.

The members of each Cropping Pattern Group except No. 11 share some common crops, and the way in which this is done characterises the Groups. The Cropping Pattern Groups which share only old or traditional crops are Nos. 1 (duku, rice), 2 (rice, durian), 6 (rice), and 7 (rubber). On the other hand, members of No. 10 share pineapples, and those of No. 12 share coffee. The other groups have some old and some new crops in common.

2.4.2 Land

2.4.2.1 Farm Size

Farm size was often difficult to measure. Villagers were asked to quantify their farm sizes plot by plot in terms of both hectares and their conventional units of measurement. While large landholders had their land registration documents using hectares as units, small landholders often did not have them. In the latter cases, the villagers' conventional units of length were converted into hectares.

Some villagers had coffee and other plots in Kota Bumi, and their farm size included the area of these plots outside Belatung.

Figure 2-13 shows the distribution of farm sizes in hectare. The distribution centres around 4.5 ha., with a standard deviation of 5.7 ha. Its Gini coefficient is 0.5533, which

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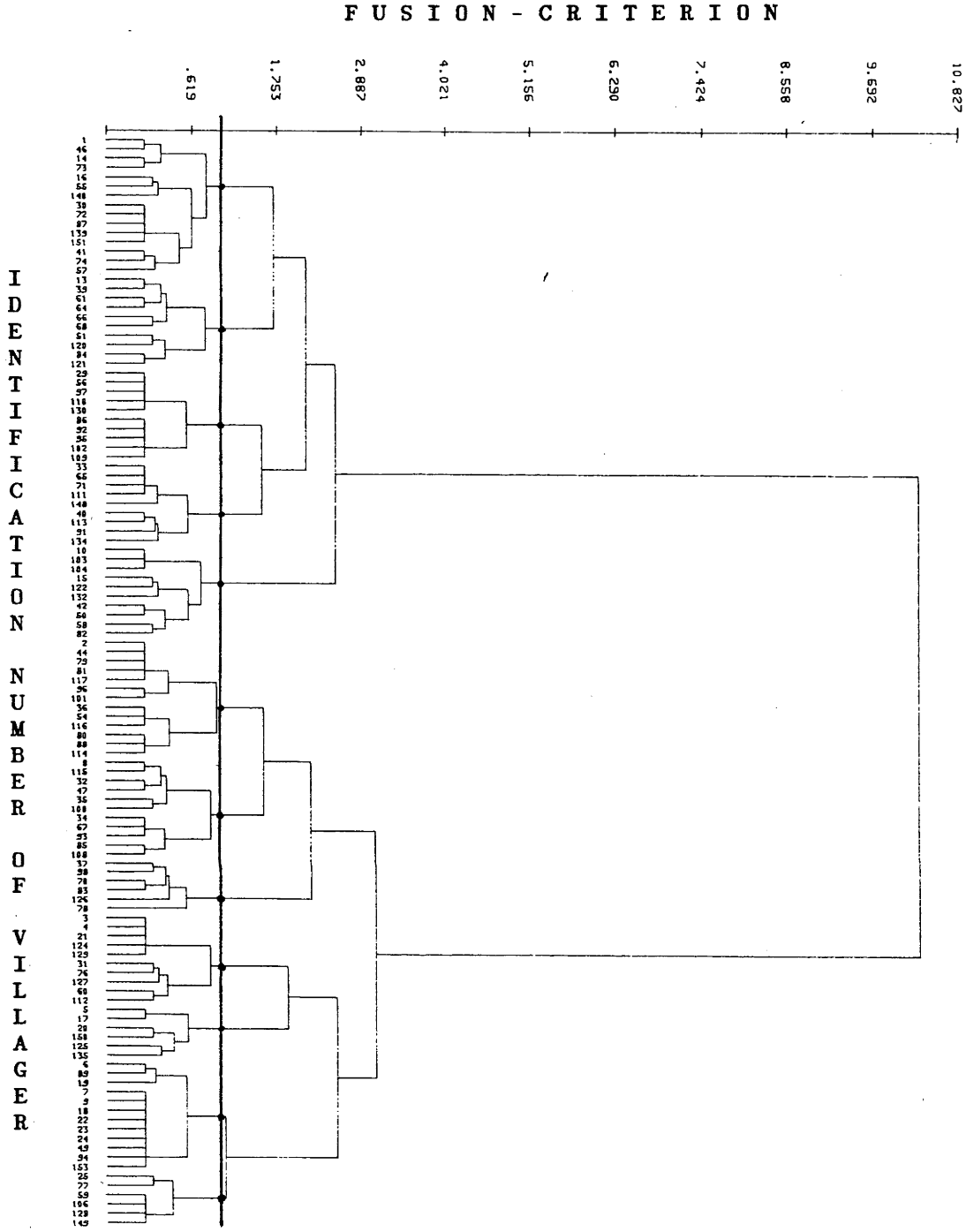
[4]Wishart (1975) argued the superiority of Ward's method (Ward 1963), but there is no criterion to judge its absolute superiority. Other numerical taxonomic methods were also used for confirming these results.

Figure 2-12: Clustering of Cropping Pattern Groups



Notes: (a) Villagers' identification numbers range up to 153. 35 villagers were found to be irrelevant to this study.
(b) The fusion criterion is twice the increase in the within-group variance caused by a fusion.
Source: Fieldwork

Table 2-6: Cropping Pattern Groups

Cropping Pattern Group	COFFEE	DUKU	CITRUS S.	RICE	RAMBUTAN	PINEAPPLE	RUBBER	CLOVE	DURIAN	(a)	(b)	(c)
1	12	15*	0	15*	0	2	10	3	13	15	4.67	4.95
2	7	0	4	10*	2	0	7	0	10*	10	4.00	11.44
3	10*	10*	10*	10*	0	0	10*	0	5	10	5.50	8.15
4	5	8	9*	9*	0	1	0	1	9*	9	4.67	2.69
5	5	10*	7	10*	10*	3	10*	4	10*	10	6.40	9.03
6	3	2	0	13*	0	0	6	0	0	13	1.85	3.50
7	0	6	7	5	0	0	11*	0	0	11	2.64	2.73
8	6*	2	2	2	1	1	6*	6*	0	6	4.33	5.83
9	5	0	10*	10*	7	0	1	2	0	10	3.50	2.43
10	0	4	3	3	3	6*	0	0	0	6	3.17	0.62
11	0	0	3	0	1	0	0	0	0	12	0.33	0.21
12	6*	1	4	0	0	0	0	0	0	6	1.83	3.25
Total	59	58	59	87	24	13	61	16	47	118	3.59	4.52

Notes:
Numbers of villagers who grow a certain crop within each Cropping Pattern Group are shown in cells.
Asterisks denote common crops shared by all member-villagers of the Cropping Pattern Group.
(a) No. of member-villagers of the Cropping Pattern Group.
(b) Average number of crops per member-villager of the Cropping Pattern Group.
(c) Average Farm Size (ha.)

Source: Fieldwork

Figure 2-13: Distribution of Farm Size

Area (ha.)	No.	%	
0	6	5.1	******
1	15	12.7	**********
2	18	15.3	**********
3	15	12.7	**********
4	17	14.4	**********
5	10	8.5	**********
6	7	5.9	******
7	9	7.6	*********
8	3	2.5	***
9	1	0.8	*
10	3	2.5	***
11	4	3.4	****
12	1	0.8	*
13	2	1.7	**
15	1	0.8	*
16	1	0.8	*
20-	5	4.2	*****
Total	118	99.7	
Average	4.52	Median	3.10
S.D.	5.71		
Gini Index	0.5533		

Source: Fieldwork

indicated a relatively unequal distribution. Many villagers had several parcels of land which were spatially scattered within the village.

2.4.2.2 Land Tenure Systems

Most villagers, except the National Railway workers, were owner-operators. The National Railway workers were given small-sized plots by their employer to grow subsistence food crops such as cassava and banana, as well as some cash crops.

Table 2-7 shows the villagers' tenure status. 94 villagers were owner-operators, while the 13 workers for the National Railway had plots given to them. Six villagers were landless, but two of them were retired, one was a widow, one was a shop owner and the other two were officials of the National Railway. Such landless villagers had no incentive to work for others and were not sources of hired labour. The remaining five villagers were mixtures of owner-operators and lessees.

Table 2-7: Number of Farmers by tenure

Tenure Status	No. of Households
Landless	6
Owner-operator	94
National Railway's Land	13
Numpang	1
Owner-operator + Leaseholder	1
Owner-operator + Numpang	1
Sharecropper + Leaseholder	1
Sharecropper + Numpang	1
Total	118

Source: Fieldwork

Land lease systems in the village had three categories: leaseholdings (fixed-rent), sharecropping and the "numpang" system. The first two categories need no explanation. The "numpang" system was an interesting indigenous land tenure system, where a landless farmer looked after the plot as a temporary care-taker and could later move to another tenure status. As indicated by the descriptive term used,[5] he resembles a passenger on a train who rides to a certain location where he changes to a further train.

In the numpang system, there is no obvious short-term transaction between the landowner and his lessee. The lessee may later purchase the plot, although there is no assurance. In situations where hired labour is expensive, land is abundant in relation to household labour, and potential lessees are usually Javanese migrants who do not have resources to purchase land, this arrangement seems suitable.

While the direct gain for a landowner from this arrangement is relatively small, he

[5]The word "numpang" originates from the word-root "tumpang" and a person who "tumpang" (as a verb) is called "penumpang" which means a passenger in Bahasa Indonesia and Malay.

also benefits from the control of undergrowth and the prevention of the establishment of "jungle" trees which would occur if the areas were not farmed.

In the village there are only three villagers who numpang plots, and only one of them is a pure penumpang.

2.4.2.3 Sales/Purchase of Land and Migration

There had been no recent sales and purchases of plots of land.[6] Such transactions appear to be related to the wealth of the villagers concerned and to migration. Thus, immediately after the 1965 incidents and right up until 1972, the living standards of some villagers deteriorated. In some cases this was due to their associations with the previous administrations. But, the regional level economic turmoils has a more general effect. A number of other villagers seem to have left the village during that period because of the greater profitability of coffee production at Kota Bumi in Lampung and Ranau in Ogan Komering Ulu. Many land sales occurred during that period. Plots of rubber land were sold to villagers who stayed, although some better quality plots, especially along the Ogan river, were not sold. For example, one villager who owned a grocery shop at that time appeared to have bought a considerable number of rubber plots. Other departing villagers sold their plots to close relatives, with the intention of redeeming the plots when they come back without great difficulty and high cost.

2.4.3 Labour

2.4.3.1 Family Labour

Household members who are 15 to 60 years old, and who are presently not going to school, are treated as the family labour force.

Of the 670 persons in the 118 households, 323 persons belonged to this category. Assuming that all those in the specified age range are productive, and the others consumer-members of the households, the ratio between these two categories is 1.07 : 1.00.

In the labour force, there were 161 males and 162 females, with an average of 1.363 male labourers and 1.373 female labourers per household. Most households had one male

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[6]Past transactions of land are recorded in Section 3.5.3.

and one female working age (45.8%). Details are given in Figure 2-14 and Tables 2-8 and 2-9.

2.4.3.2 Exchange Labour

Exchange labour in traditional societies functions as a means of coping with periodic or irregular concentrations of labour demand. In agriculture, the planting and harvest of rice, especially of sawah, require considerably more labour than a family can provide over this very short period concerned. In social life, tradition commands villagers to organise feasts at the times of births, circumcisions, weddings, construction of houses, and funerals. These, too, require substantial labour, and exchange labour becomes important.

In Malay-Indonesian culture, such exchange labour is called "gotong-royong" and is emphasised as a major principle of social life. "Gotong-royong" in Sawah production in the Malay-Indonesian culture also parallels similar arrangements in wet-land rice production elsewhere in Asia.

Actually "gotong-royong" is less prevalent in South Sumatra, especially in rubber producing areas, compared with other parts of Indonesia. South Sumatran culture has historically been characterised by stronger individuality and a simpler social structure than the hierarchical social system in Java. Certainly, the introduction of cash-cropping involving perennials has reduced the number of opportunities for "gotong-royong" in agriculture. In estates, the villagers are hired workers, and in smallholding areas, family labour is usually adequate for its own cash-crop production.

In Belatung, with its history of smallholding rubber production, "gotong-royong" was seen only in social life. During the festivities attending births, circumcisions, weddings, construction of houses, and funerals, a villager asks his relatives and neighbours to participate in various tasks, such as the delivery of invitations, preparation of food, night watches and narrations.[7]

These exchange arrangements are reciprocal in the long term, since almost all villagers participate in a very similar set of ceremonies on their own account.

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[7]During the author's fieldwork, he was present at three weddings, three funerals and one big-scale feast for three babies. There were also several other such occasions where he was not able to attend.

Figure 2-14: Family Labour Force Distribution by Sex

Male	Households No.	%	
0	12	10.2	******
1	69	58.5	**********
2	23	19.5	**********
3	10	8.5	*****
4	4	3.4	**
Total	118	100.1(a)	
Average	1.364 male labour per household		
S.D.	0.903		

Female	Households No.	%	
0	5	4.2	***
1	78	66.1	**********
2	22	18.6	**********
3	12	10.1	******
4	1	0.8	*
Total	118	99.8(a)	
Average	1.373 female labour per household		
S.D.	0.760		

Total	Households No.	%	
0	1	0.8	*
1	12	10.2	******
2	55	46.6	**********
3	18	15.3	*********
4	20	16.9	**********
5	6	5.1	***
6	5	4.2	***
7	1	0.8	*
Total	118	99.9(a)	
Average	2.737 labour per household		
S.D.	1.336		

Note: (a) rounding errors
Source: Fieldwork

Table 2-8: Labour vs. Non-Labour Household Members

		Non-Labour Force Household members									
		0	1	2	3	4	5.	6.	7.	8.	Total(%)
L	0.	0	0	1	0	0	0	0	0	0	1
A		0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	(0.8)
B	1.	1	3	4	2	1	1	0	0	0	12
O		0.8	2.5	3.4	1.7	0.8	0.8	0.0	0.0	0.0	(10.2)
U	2.	3	7	8	14	8	11	2	1	1	55
R		2.5	5.9	6.8	11.9	6.8	9.3	1.7	0.8	0.8	(46.6)
|	3.	1	6	1	4	3	1	2	0	0	18
F		0.8	5.1	0.8	3.4	2.5	0.8	1.7	0.0	0.0	(15.3)
O	4.	4	1	6	2	3	0	2	2	0	20
R		3.4	0.8	5.1	1.7	2.5	0.0	1.7	1.7	0.0	(16.9)
C	5.	1	1	2	0	0	1	0	1	0	6
E		0.8	0.8	1.7	0.0	0.0	0.8	0.0	0.8	0.0	(5.1)
H	M 6.	0	0	2	1	1	1	0	0	0	5
O	B	0.0	0.0	1.7	0.8	0.8	0.8	0.0	0.0	0.0	(4.2)
L	E										
D	R 7.	0	1	0	0	0	0	0	0	0	1
	S	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(0.8)
	TOTAL	10	19	24	23	16	15	6	4	1	118
	%	8.5	16.1	20.3	19.5	13.6	12.7	5.1	3.4	0.8	100.0

Notes:

A figure of a upper column in a cell represents the number of households which have certain numbers of labour-force household members and non-labour-force members. A figure of a lower column in a cell represents a percentage in all households.

Source:

Fieldwork

Table 2-9: Male vs. Female Labour

		FEMALE LABOUR					
		0.	1.	2.	3.	4.	Total
MALE LABOUR	0.	1	9	0	2	0	12
	%	0.8	7.6	0.0	1.7	0.0	10.2
	1.	3	54	8	4	0	69
	%	2.5	45.8	6.8	3.4	0.0	58.5
	2.	1	8	9	4	1	23
	%	0.8	6.8	7.6	3.4	0.8	19.5
	3.	0	7	2	1	0	10
	%	0.0	5.9	1.7	0.8	0.0	8.5
	4.	0	0	3	1	0	4
	%	0.0	0.0	2.5	0.8	0.0	3.4
Total		5	78	22	12	1	118
	%	4.2	66.1	18.6	10.2	0.8	100.0

Notes:

A figure of a upper column in a cell represents the number of households which have certain numbers of male and female labour-force members. A figure of a lower column in a cell represents a percentage in all households.

Source:

Fieldwork

The use of exchange labour during ceremonial occasions was investigated by the author during field work in the village in 1982-83 and information was obtained on its use in previous periods. However, it was not possible to identify social groupings which differed in their participation or non-participation in exchange labour. It can only be stated that such ceremonial exchange labour in its frequent use followed Adat, and any obvious segregation or discrimination within the village was strongly avoided.

2.4.3.3 Hired Labour

As discussed in Section 2.4.2.2, most villagers were owner-operators. They managed their agricultural activities using family labour from the household, and rarely hire labour from outside, especially from beyond the village. Hiring-in of labour for agricultural purpose was not observed. Two main factors are thought to explain this.

Firstly, the cropping patterns of the villagers, as discussed in Section 2.4.1, were dominated by perennial cash crops with few peak labour demand periods, in contrast to subsistence food crops which have more marked peaks. Although a considerable amount of labour is required for rubber re-planting, no replanting has been taken place in Belatung. When the villagers planted new rubber stands, they cleared the jungle by burning and planted conventional (unimproved) seedlings. Usually land was cleared in the dry season, and farmers worked on it for about three months with family labour including the wife and children, and occasionally with the help of relatives. Rice was planted with minimal labour at the end of this period. The harvesting of rubber was a regular activity, undertaken by household members, and which was sometimes interrupted during rice harvesting.

Secondly, sources of hired labour were limited. It is often stated that South Sumatran people are very proud of being owner-operators, and very reluctant to work for others. While precise figures were unavailable, the wage for South Sumatran labour was much higher than that for Javanese transmigrants who received Rp.1000-1500 per day for unskilled labour during 1982-83. The wage rate has been traditionally determined in accordance with the market price of three kg of rice plus one meal. The market price of rice in 1982-83 was Rp.300-350. At the time, the nearest source of Javanese labour was the transmigration project at Batumarta which was 50-60 km away from Belatung and Javanese transmigrants were unwilling to work in such villages at the prevailing wage rates. This was likely to change because a new transmigration project was opened near the village on the old long-term lease land called Erfpachtsperceel Maria Louisa. It is expected that the Javanese transmigrants would be willing to work outside the project for additional cash income during the period of seven to eight years that elapses before their rubber trees can be tapped.

2.4.4 Technology

As already discussed, the crops produced in the village were mainly rice (padi ladang, padi lebak) for subsistence, rubber and other cash-crops.

The padi ladang was grown in the following way[8]:

1. Brush grass and old rubber trees on pematang or ladang were cut with parang or kapak at the end of the dry season (September and October). Dried brush, grass and dead rubber trees were burnt in November just before the rainy season. Remnants of logs were not usually removed. Immediately after burning, small and shallow holes were punched out with a long tugal and 10 to 20 grains of rice seed were dibbled into each hole.

2. Weeding was rarely executed. The harvest took place between April and June, depending on the growth of rice.

3. A ladang plot was usually used successively for three years, with rice being followed by other crops, and then it was left for at least further three years to recover before it was used again. By 1982-83, however, a ladang plot was rarely left idle after three years of rice production.

The production of padi lebak is distinguished from padi ladang (Takaya 1980). But in Belatung and surrounding villages along the Ogan river (Figure 2-2-b), there was no clear distinction between the two. There were some differences, however; more frequent weeding was necessary for padi lebak production because of its closeness to water, and the three year rotation could not take place on lebak plots because of annual flooding.

The production technology of rubber was very primitive. The husband and wife started working early in the morning, usually about six or seven o'clock. They tapped the rubber trees, and subsequently collected the latex in coconut bowls. This job usually occupied their time until noon. A couple could manage to tap and collect latex from about two hectares of rubber trees a day, gaining about one or two 10 litre plastic buckets of latex. Depending on weather conditions, they usually worked for four to five days a week and produced 60 kg to 150 kg of rubber slab.

To coagulate the latex, the farmers used alum or tawas, which was available from grocery shops in local villages and weekly markets. The latex was sieved into a wooden box, and mixed with alum by hand. Sometimes, a hole dug in the ground was used instead of a box. The quality of slab produced under such conditions was poor.

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[8]Based on the author's observations in Belatung and Takaya's (1980) observations in Komering Ulu.

Stands of rubber trees were usually quite overgrown due to lack of weeding. They were called hutan karet (rubber jungle). Because of this, it was difficult to move through the trees to tap and collect latex.

2.4.5 Credit

The most approachable sources of general purpose credit for the villagers were close rich relatives. They could borrow money with no interest from such people if they were in a household crisis. However, they did not borrow money from such people for agricultural purposes, which were not regarded as emergency needs. For these purposes, they chose other richer villagers who are not close relations. While a certain interest rate may be charged, due to Islamic faith, this may not be observed by outsiders. No credit transactions could be found during fieldwork, although some past transactions were identified. These were all for non-agricultural purposes, such as buying furniture or a second-hand mini bus.

There were several official sources of credit for agricultural purposes. Credit may be obtained from the BIMAS scheme in the form of rice-seeds, fertilisers and insecticides, if there are sawah plots in a village. Amazingly, and even though the sawah plots in Belatung had long been unexploited owing to the water-course and dam problems mentioned in Section 2.2.1.1, the village head had once gathered some ten villagers and claimed BIMAS credits. The Dinas Pertanian (Food Crop Agency) gave these to villagers without actually investigating their claimed sawah plots. The rice-seeds were then sown on the ladang or lebak plots, and completely failed. After this incident, the villagers ironically lost confidence in the BIMAS scheme.

Because there is no obligation to repay BIMAS credits if production is unsuccessful, the village head was attempting during the time of the fieldwork to obtain further "free" fertilisers and insecticides, whose use would be indicated for sawah, but which would be actually employed for other crops such as citrus siam. While this was illegal, it was either undetected or simply ignored by the authorities, including the Dinas Pertanian dan Tanaman Pangan extension officers. The Dinas Pertanian dan Tanaman Pangan had already started a credit scheme specifically for citrus siam production, but this scheme had not yet covered Belatung or its surrounding areas.

2.4.6 Output Markets

The marketing of agricultural products was relatively easy for the villagers of Belatung. They could attend a weekly market, which was held every Tuesday in the adjacent village of Lebuk Batang Lama and served all the residents of Marga Lebuk Batang (Figure 2-2). It took the Belatung people about 20 minutes to walk to this village. The market opened early in the morning and closed by noon. Rubber merchants, who were mainly from Baturaja and other towns, gathered there and bought rubber slabs. Some merchants even sent their trucks to villages in the vicinity, and bought slabs directly from the farmers who had only to carry the slabs from their rubber plots to the roadside in their village.

In the weekly market, there were many merchants who sold various household goods. Occasionally, there were merchants who sold agricultural chemicals and fertilisers, as well as small agricultural machinery like sprayers.

Villagers went to Baturaja on average once a week mainly to buy household goods but also to sell their products (Section 2.3.5). During the dry season, they caught fish from the Ogan river and took them to Baturaja to sell. In Baturaja, there were two official agricultural products market places where individuals could become vendors on paying a certain tax for a small block of ground or stall. There were also three unofficial market places which operated without any tax payments. These were subsequently brought under the control of the city administration, but further unofficial market places appeared likely to emerge in an attempt to avoid official regulations.

With cash crops other than rubber, villagers had their own links with specific merchants, which might have developed over a long period. Villagers called these merchants pemborong buah-buahan (fruit contractors). They usually visited the villagers' fruit plots one or two months before harvest time and made contracts, sometimes with advance payments according to their estimation of the likely harvests. At harvest time, they visited the plots with a group of hired-labourers, usually from within the contractor's native village or a transmigration project. In Belatung, there was one regular fruit contractor. The village head was also a fruit contractor before he assumed his official position, and subsequently his youngest brother often organised this activity.

There were also two villagers who acted as fruit contractors for their relatives in-the village. All these fruit contractors hired trucks and carried the fruit harvests to Jakarta and other big cities in Java including Bandung or Surabaya.

There were also some itinerant fishmongers who were active during the dry season. On the way from their native villages to Baturaja, they bought the morning's catch of fish directly from the Belatung villagers.

The following means of transporting the agricultural products from Belatung were available to villagers: (1) railway (2) mini-buses and (3) hired-trucks. In the early 1970's, the villagers primarily used the railway to carry their products to Palembang or Tanjung Karang, sometimes with only a railway lorry which they pushed themselves. In 1977, the road to Palembang was opened through the old long-term lease land Erfpachtsperceel Maria Louisa, and another road to Palembang via Peninjauan was widened (Figure 2-1). The most recent improvement of roads was the southern portion of the Sumatran Highway which passes through the centre of Baturaja, and makes very easy access to both Tanjung Karang and Jakarta. Following this improvement, and prior to the study reported here, the villagers started self-organised truck loads of fruit crops to Java. The markets for fruits from this area were therefore further expanded.

2.4.7 Extension Service Activities

2.4.7.1 Dinas Perkebunan

The Dinas Perkebunan is the Estate Crop Agency of the Ministry of Agriculture, and is responsible for estate crops such as rubber, coffee, clove, cinnamon and pepper. Its Baturaja branch has been concentrating its efforts on the Kabupaten's major perennial crops, rubber and coffee, and had set up smallholder rubber demonstration schemes in three blocks in Kecamatan Peninjauan. The control office for these three demonstration blocks was built in Belatung in 1981, next to the village head's house. This office was called the Unit Peraksana Proyek, Pusat Koagulasi Karet Rakyat (U.P.P.K.K.R., Project Executive Unit, Smallholder Rubber Coagulation Centre) and had about thirty personnel. The head of the Unit and three officers lived in Belatung, while the other personnel lived at the demonstration blocks or in Baturaja. The office actively administered the three demonstration blocks and was planning for future plots in Kecamatan Peninjauan.

However, the demonstration block in Belatung itself seemed to be poorly maintained. The rubber smallholder scheme group, Sebimbing Sekundang, was nominally established at the block in Belatung with an ex-village official as chairman, but had attracted only a retired National Railway worker and a landless villager who had returned from Kota Bumi. To join this group a member had to abandon any activities on his own plots of land, but since most villagers were owner-operators, this regulation was a major obstacle to participation.

The villagers also did not appear to trust the Dinas Perkebunan personnel, whose performance was considered to be poor as demonstrated when the bushfire, said to have been started by a cigarette butt dropped from a train, damaged quite a large area of the Belatung demonstration block in August 1983. At the regular inspection by the Palembang provincial headquarters staff immediately after the fire, it was also revealed that most seedlings grown in the Belatung demonstration block had either died or been damaged reportedly by the long drought in 1982.

2.4.7.2 Dinas Pertanian dan Tanaman Pangan

The Dinas Pertanian dan Tanaman Pangan is the Food Crop Agency of the Ministry of Agriculture, and is responsible for food crops like rice, maize and cassava, and some horticultural crops, such as citrus siam. In 1982 it opened an extension office in Belatung, which was then used on Tuesdays for the meetings of extension workers in Kecamatan Peninjauan. The extension officer based at these premises was a young graduate of a high school for agricultural studies. At the time of this fieldwork he had not mixed with the villagers or won their trust in any way.

Apart from its extension service, the Dinas Pertanian dan Tanaman Pangan had also set up a credit scheme for citrus siam production, but had not extended its coverage to Kecamatan Peninjauan. Few villagers showed any interest in the credit scheme, however, as it only offered finance for sapling/grafts, fertilisers and agro-chemicals while hedging and other costs associated with citrus siam production were not covered.

CHAPTER 3

Belatung Socio-Economic Structure

3.1 Introduction

In this chapter, the socio-economic structure of Belatung is described and illustrated by the use of networks of several important socio-economic interactions among villagers. Groups of villagers are identified. A group is composed of villagers who can be considered as sharing information and playing similar roles in disseminating agricultural information in the village.

Firstly, in Section 3.2, several methods for identification of groups of villagers in a network system are briefly investigated. These methods have been developed by network sociologists and social anthropologists, although they were originally based on economic input-output analysis. One particular set of methods is chosen for use according to criteria considered appropriate to this study.

Secondly, in Section 3.3, some important types of socio-economic interactions among villagers are selected and discussed from the point of view of their ability to transmit agricultural information.

Thirdly, network systems of selected socio-economic interactions among villagers are then examined in Sections 3.4 to 3.7. Distinct groups of villagers within these network systems are identified.

Finally, in Section 3.8, these network systems are integrated into one network system, the village socio-economic structure, and then associations of villagers who share almost identical agricultural information and, at the same time, play similar roles in disseminating agricultural information are identified. Average socio-economic and agricultural characteristics of members of these associations are then examined.

3.2 Group Identification Method

Group identification methods in network analysis correspond to industrial classification or aggregation methods in an input-output matrix of industries. Basically these methods are permutation or decomposition problems in matrix algebra.

Individuals in a network matrix or an input-output matrix are classified into one group if they are similar in a certain respect. The similarity of two individuals has been measured in many ways.

In input-output analysis, Blin and Cohen (1977) used the "dissimilarity scale" which measures "quasi-input-heterogeneity (homogeneity)" on the input coefficient matrix and on the Leontief inverse multiplier matrix of the input-output table. According to this scale, industries were classified into groups by a method of hierarchical cluster analysis.

In economic input-output analysis, transactions between any two industries or sectors are measured in exact monetary terms, but the entries in a network analysis matrix are different. Since the latter analysis has been developed as a tool for qualitative examination of social structure, the entries in a matrix often merely indicate the existence of interactions of interest in the study. Entries are often dichotomous 0-1 variables.

Further, because of the emphasis on the structure of the system under study, the external environment of the system is not considered at all, or is assumed away as an unimportant factor. Generally, a large system is chosen, so that effects from the external environment may be assumed to be almost identical to members of the system or negligible.

Because of the simplistic dichotomous choices of network matrices, and the exclusion of the external environment,[1] network researchers had to develop new methods to identify groups of individuals in a system. Group identification methods in network analysis can be placed in two categories.[2] One is the relational approach, a group of clique-detection methods based on various definitions of the concept of "clique". The

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[1]This exclusion causes the problem of non-existent Leontief inverse multiplier matrix in input-output analysis.

[2]See also reviews of the sociological contextual analysis in Section 1.4.4.

other category is the structural approach (structural equivalence approach), which, though based on interactions in a network matrix, somehow derives similarity indices between any two persons and relies on methodology of numerical taxonomy (Lorraine and White 1971, Sneath and Sokal 1973).

3.2.1 Relational Approach

The concept of the "clique" has been central in small group research in sociology. The most stringent graph theoretical definition is that a clique is a set of completely linked points (individuals) not contained within a larger, completely linked set (of individuals).[3] This definition is too stringent for operational purposes, and has encouraged researchers to produce less restrictive definitions. Seidman and Foster (1978) developed the k-plex definition of "clique". A k-plex clique is a set of n individual points, in which each individual point is connected directly to at least n-k of the other individual points. This definition is consistent with the concept of a "social circle", a set of actors (individuals) with shared interests having direct or minimally indirect linkage with each other (Alba and Kadushin 1976), and includes the most stringent definition of "clique" as a special case, the 1-plex.

Everett (1982a, b, 1983a, b) developed a graph-theoretic clique detection procedure based on the k-plex definition, and published a FORTRAN programme for it. This method requires a large amount of computer memory, however, and is not suitable for the analysis of a large network system.

Definitions of "clique" based on graph theory are very stringent, and require considerable time and memory for computer analysis. To avoid this, some ad hoc and less restrictive definitions have been proposed.

Hubbell (1965) developed a method based on raising the original sociometric matrix to successively higher powers. In this method, the criterion for clique identification rests on a linkage distance measure of proximity; individuals are classified into a clique if they have a high degree of direct and/or one-step interactions with other members of the clique.

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[3]The meaning of "completely linked" is that each component of the clique has reciprocal interaction with every other component.

Hierarchical clustering has been utilised to identify cliques since Johnson (1967) used both the nearest neighbour, the farthest neighbour, and Ward's methods. Peay (1974) developed a hierarchical clustering programme that allows clusters (cliques) to overlap.

Numerous other clique identification methods exist, details of some of which have been published. Various clique-identification methods are reviewed in Lankford (1974), Rogers and Kincaid (1981), and Knoke and Kuklinski (1983).

Rogers and Kincaid (1981) classified the methods from a technical perspective as suitable for various purposes, and chose the NEGOPY method of Richards (1975) for their own study of the diffusion of family planning information in South Korean villages.

The NEGOPY method is a clique detection method based on the following very simple definition of "clique":

1. It is a subsystem whose components interact with each other relatively more frequently than with other members of the system.
2. Each one must have a minimum of three members.
3. A member must have at least 50 percent of his/her links within the clique.
4. All members must be directly or indirectly connected by a continuous chain of dyadic links[4] lying directly within the clique.

Theoretically, Richards' NEGOPY method is an iterative approximation method to identify an eigen-vector which corresponds to a maximum eigen value of a row-stochastic matrix derived from an original sociometric matrix (Higuchi 1983a). The merits of this method are as follows:

1. Various types of similarity or distance measures can be used.
2. It does not require a great amount of computer memory and computing time.
3. The algorithm is easily interpretable.

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[4]interactions between two members

On the basis of the similarity of results produced by several methods,[5] Rogers and Kincaid chose the NEGOPY method as being superior for an analysis of a large-sized network system.

Although these various clique identification methods are different from the technical point of view, they all imply the common proposition that members of a particular clique interact more strongly and share more similar information with each other than with non-members.

3.2.2 Structural Approach

In the structural approach, individuals are aggregated into a jointly occupied position to the extent that they have a common set of linkages to other individuals in the system.[6] This structural approach is identical to the approach used in an aggregation of American industries by Blin and Cohen (1977). Their concept of "quasi-input-heterogeneity" is a special case of the measure of structural equivalence Burt (1976) used. Hierarchical cluster analysis is then employed to identify groups of structurally equivalent individuals. Individuals of a particular group identified are then assumed to have similar roles in the system because they have a similar pattern of interactions with others. Thus, they are regarded to have similar patterns of preferences, and further to behave similarly if they have similar amounts of resources and similar information.

The structural approach to identifying groups in a network system has often been preferred to clique detection methods (Burt 1978) because groups identified by structural approach:

1. include a broader range of types of subgroups,

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[5]Rogers and Kincaid (1981) used (1) Direct Factor Analysis, (2) NEGOPY (3) CONCOR blockmodeling (4) Smallest Space Analysis.

[6]Formally and most stringently, the concept of "structural equivalence" is defined as follows: two individuals a and b of a set C are structurally equivalent if, for any given relation R and any individuals x of C, aRx if and only if bRx, and xRa if and only if xRb. In other words, a is structurally equivalent to b if a relates to every object x of C in exactly the same way as b does. From the point of view of the logic of the structure, then a and b are absolutely equivalent, they are substitutable (Lorrain and White 1971). This definition is made less restrictive using the concept of continuous "social distance" (Burt 1976).

2. extend the scope of types of subgroups in which homogeneity of attitudes and behaviour can be expected,

3. have a more consistent meaning as operationalised by available computer algorithms,

4. can be subjected to statistical tests of goodness-of-fit,

5. are accordingly more robust for random errors in relations,

6. provide a basis for sampling population networks in large systems.

Although the shortcomings of the structural approach are not listed by Burt, several shortcomings are evident. Individuals who interact with only a small number of other individuals can all be classified into one group with isolates, regardless of the existence of their interactions. Further, the results secured are dependent on the particular method of hierarchical clustering. Although Ward's method is usually believed to be the best method of hierarchical clustering (Wishart 1975), it seems that Burt and other proponents of the structural approach use the nearest neighbour method of the hierarchical clustering.

Finally, although a complete substitutability of individuals in terms of the pattern of interactions ensures that these individuals share identical information and have identical patterns of interactions, a weak substitutability (weak structural equivalence) may not necessarily ensure these two aspects. As the cut-off point for weak structural equivalence in a clustering analysis is raised and the number of individuals in a particular cluster increases, the number of interaction patterns in the cluster increases. Hence, the cut-off point should be kept as low as possible, but then the approach tends to produce several groups with a small number of individuals, and many unclassifiable individuals. With the structural approach, therefore, the cut-off point should be very carefully chosen, especially for a study of a large system.

Burt (1980c) provides a measure to cope with the last problem by including two-step interactions between a pair of individuals.[7] This suggestion coincides with Rogers

[7]Two-step interactions are defined as interactions of two individuals who do not interact with each other directly, but through a third individual(s). In the situation in which there are three individuals (A, B and C), suppose A interacts with C and C interacts with B. This exemplifies a two-step interaction between A and B.

and Kincaid's assertion that indirect interactions beyond two steps are not reliable with regard to communication between a pair of individuals, and corresponds with anthropological findings on the importance of two-step interactions in exchange systems (Hage and Harary 1983). It also matches the sociological findings concerning the importance of "weak-ties" in job searches (Granovetter 1973, 1982). The measure can further reduce the risk that individuals who interact with only a small number of others might be classified into a group together with isolates.

3.2.3 Integration of the Two Approaches

The relational and structural approaches should be judged in the light of their capability in identifying groups of individuals who share information and have similar roles in disseminating agricultural information. Some further technical criteria are that a suitable approach should

1. be able to ensure that members of a group share information.
2. be able to ensure that members of a group are similar in status, i.e., they are equals, and neither superior nor subordinate to one another, and thus have similar patterns of preferences for sources of their welfare, particularly, similar pattern of their interdependence.
3. be able to deal with a large system, and to classify members of the system into significantly large groups so that further analysis of the socio-economic characteristics of group members can be fruitful.
4. simultaneously use several types of interactions for the identification of groups (multiplicity of interactions).
5. have an easily interpretable algorithm.
6. have less requirements for computing.

The relational approach focuses on interactions between individuals, and identifies a group of individuals who share information which is transmitted by their interactions. However, the fact that individuals share information does not ensure that they play similar roles in disseminating information. Groups identified by this approach still include superiors and subordinates, opinion leaders and followers, landowners and lessees, and all these have different roles in disseminating information.

Groups identified by the structural approach are clearly composed of individuals who are similar in terms of patterns of interactions, and are thus more or less

substitutable for each other in terms of roles in disseminating information. Superiors and subordinates are thus separated into different groups. However, the structural approach classifies individuals who have no interactions with each other into one group if they do not interact with many other individuals. This is not allowable.

As mentioned above, inclusion of two-step indirect interactions into the structural approach seems to reduce the difficulty of this problem. By putting more emphasis on indirect interactions, this method can identify groups of individuals who play similar roles and share more of similar information at the same time.

A multiplicity of interactions can be treated by both approaches, but, as Knoke and Kuklinski (1983:60) noted, both approaches are "equally well (or ill) suited to" this problem. These two approaches are not robust enough in the sense that they still allow plausible, but arbitrary, choices of weights for each single network. Researchers should carefully select the weights according to the purpose of their study.

With the NEGOPY method where various types of similarity index can be handled, the sums of two individuals' coincidences in membership of groups across networks of several interactions can be used to identify groups in the total system. Researchers may weight the sums of coincidences in membership according to the purpose of their study.

With the structural approach, the difference in two individuals' patterns of interactions (the square of their social distance) is treated equally across networks of the several interactions considered. However, since total numbers of entries in a network significantly influences classification results, the squares of social distance in each network must be normalised by the standard deviations and then summed across all networks considered. This is an appropriate weighting procedure.

In order to overcome the problem about characteristics of groups, the concepts of a "basic group" and a "core group" are proposed. By cross-tabulating individuals according to their memberships of relational and structural groups,[8] it is ensured that individuals in cells share similar information and play similar roles in disseminating information. A set of these individuals in a cell is defined as a basic group. Among the

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[8]A relational group is a set of individuals identified by relational approach. Similarly, a structural group is a set of individuals identified by structural approach.

Table 3-1: Idea of a Core Group and a Basic Group

Structural Groups	Relational Groups 1	2	3	4	5	total
1	0	0	0	0	5#	5
2	0	0	3	7#	0	10
3	0	5	10*#	5	0	20
4	5	10*#	5	5	0	25
5	10*	5	2	8*	15*#	40
Total	15	20	20	25	20	100

Notes:
An * denotes a core group of a relational group, which corresponds with the largest cell within the relational group.
A # denotes a core group of a structural group, which correspond with the largest cell within the structural group.

basic groups, groups which can characterise relational or structural groups are defined as a "core group" of either the relational or structural group. A core group of a relational group is defined as a basic group which contains the largest proportion of members of the relational group. A core group of a structural group is similarly defined as a basic group which contains the largest proportion of members of the structural group. For example, if there are five relational groups and five structural groups identified, the cross-tabulation looks like Table 3-1. The core group of Relational Group 1 is a cell which corresponds with Structural Group 5, which contains 10 villagers of 15 villagers who belong to Relational Group 1. If these structural groups are already ordered according to the socio-economic status in the village, this cross-tabulation shows some interesting aspects.

Relational Group 1 is divided into two basic groups which are low in the socio-economic status. In this sense, this relational group is very homogeneous. But while Relational Group 5 is also divided into two basic groups one of which is the top in the socio-economic status and the other of which is the lowest in the socio-economic status, this relational group can be regarded as a very heterogeneous group, and possibly the bottom basic group is subordinate to the top basic group.

3.2.4 Selection of Method

While various clique identification, i.e. clustering, methods were developed for the relational approach, the structural approach lacked its particular method. The structural approach usually uses one of numerical taxonomic methods developed for bio-statistics (Sneath and Sokal 1973). For example, Burt and other proponents of the structural approach seem to have used the nearest neighbour (shortest distance) hierarchical clustering method.

A reason for this difference seems to be the relational approach's focus on actual interactions among members of a system. The relational approach puts much greater importance on strength or existence of interaction between two members. In the structural approach, members' roles, which are assumed to be derived from patterns of one's interactions with others, are focussed. The similarity of members' roles in a system is then quantified and used to classify members into groups.

The algorithm of the NEGOPY method is fairly simple. An individual is first given a random rank, and his rank is then revised by calculating the weighted average of ranks of those with whom he interacts directly or indirectly. Using this procedure, those persons with whom he interacts gradually converge into one area, given that there are no strong interactions with individuals outside the supposed convergence area.[9] While the convergence area is basically regarded as a clique, its nature should be examined in the light of the definition of a clique made above, and some manual adjustment may need to be made.

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[9]The NEGOPY method is basically equivalent to the Power method to calculate a maximum eigen value and its eigen vector. Its convergence is assured (Higuchi 1983a).

The NEGOPY method's requirement for computing is the smallest among all the methods used in applying both relational and structural approaches. Since its algorithm is simple, its programme can be easily written and executed even with a small memory, portable computer. All other methods require ready-made software which is only available in conjunction with main-frame computers at research institutions.

The algorithm of the structural approach is also quite simple, but the results secured depend on methods of hierarchical clustering. From the point of view of sizes of identified groups, Ward's method of hierarchical clustering with its objective function based on within- and between-group variances is generally believed to be the most suitable. The nearest neighbour method which has been used by Burt and other proponents of this approach tends to produce a large group and some small groups, and it is generally believed to be inferior to Ward's method.[10]

In general, network researchers have developed their own grouping methods quite independently of numerical taxonomy which has been developed for bio-statistics or biological taxonomy (Sneath and Sokal 1973, Dunn and Everitt 1982). However, their grouping methods basically belong to numerical taxonomy in the sense of grouping samples by their individual characteristics. A major difference between the grouping methods in network analysis and numerical taxonomy for bio-statistics is the definition of "similarity" between two samples (persons). In network analysis, emphasis is put on interactions between these two samples (persons), especially in the relational approach. Even in the structural approach, "similarity" is defined on the basis of their interactions, not their individual characteristics.

Once "similarity" is defined, the statistical procedure is almost identical in both network analysis and numerical taxonomy. Hence, the findings on results of grouping in numerical taxonomy are relevant to those in network analysis. A major lesson from numerical taxonomy is that the results of grouping should be checked by one or two other methods, and that stable groupings should be chosen for further analysis. Therefore, also in network analysis, results of one grouping method should be compared with those of other grouping methods.

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[10]See Wishart (1975) for general characteristics of hierarchical clustering methods.

In this study, the NEGOPY method is adopted, albeit in a slightly modified way so that computations with a small-memory computer may converge quickly on groups.[11] The basic procedure employed was to group individual villagers using a transportable micro-computer[12] in the field, and to conduct further precise analysis at the Australian National University with direct factor analysis as well. Ward's method of hierarchical clustering analysis was adopted to identify structural groups in the village socio-economic structure. Considering cross-checking and producing stable groupings, the actual procedure was set as follows:

1. After excluding isolated villagers and isolated groups,[13] the remaining villagers were processed by the modified NEGOPY method.

2. These remaining villagers were re-ordered within groups identified above according to the factor scores calculated by direct factor analysis. In order to disentangle villagers roughly ordered by the modified NEGOPY method, manual re-orderings were conducted within groups identified above.

3. Groups of villagers were derived according to coincidences of membership in networks of selected interactions using the same procedure above (1 & 2). Groups identified are for convenience called relational associations.

4. To identify basic and core groups of already identified relational associations in the whole system, the structural approach was used with Ward's method of hierarchical clustering analysis.

3.2.5 Some Important Concepts

3.2.5.1 Concept of Distance

Social scientists have developed various types of distance between two agents within a system.[14] They are classified into two categories:[15]

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[11]The complete FORTRAN programme called CLIQUE.FOR is listed in Appendix C.5.

[12]Osbourne 1 with two single density single-sided disk drives with 64K RAM.

[13]In network analysis, an isolate represents an individual who does not interact with any other individual, and with whom others do not interact. An isolate group represents a group of individuals who do not interact with individuals outside the group and with whom individuals outside the group do not interact.

[14]Economists tend to use physical distances measured in kilometers or minutes (See Lindner, Pardey and Jarrett 1982). Ongkili and Quilkey (1983) introduced "psychic distance". Refer Section 1.4.3.5.

[15]See Burt(1976) and Rogers and Kincaid(1981).

1. Individual distance (asymmetric)

   a. Based on individual socio-economic characteristics

   b. Based on socio-economic interactions

2. Social distance (symmetric)

Individual distance is measured from the perspective of two agents in a system as a pair (dyad) which is only secondarily associated with the overall system. It reflects an intensity of relationship from one agent to another, while all other agents in the system are ignored.[16] In other words, the individual distance between two agents does not change when individual distances between other pairs of agents change. In network analysis, the presence of interactions simply represented by 0-1 in a matrix can be treated as individual distance, and it is, in general, appropriate to utilise a kind of individual distance in relational approach.

Social distance is measured from the perspective of two agents as elements of the overall system. The social distance between two agents changes when individual distances between other pairs of agents change. It hence represents a contextual aspect of their relations within the system. For instance, if one agent is a member of one group and the other agent belongs to another group, the social distance between them is greater than it would be if both agents belonged to the same group --- even if the individual distances are identical in both cases. The social distance is therefore suitable for the structural approach, where roles in a system are focussed. This situation can be captured by defining social distance between two agents as difference between their patterns of relations to all others measured in terms of individual distances. The concept of social distance is therefore suitable for capturing institutional aspects of villagers in a village system.[17]

The social distance may be defined as follows:

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[16]Except for some measures which consider agents involved in the two agents' relation. See Burt (1976).

[17]This line of argument coincides with the classification of proximities by Rogers and Kincaid(1981). They classified proximities into (1) communication proximity and (2) structural proximity. The criterion for their classification is almost identical with the one Burt used for the classification of concepts of distance, but is more precisely defined in network terminology.

(3.1)

$$s_{ij} = s_{ji} =$$

$$\{ (d_{ij} - d_{ji})^2 + \sum_{k \neq i,j}^{n} (d_{ik} - d_{jk})^2 + (d_{ki} - d_{kj})^2 \}^{1/2}$$

where d_{ij} stands for a type of individual distance between Villager i and Villager j. Social distance between two agents is zero, only if these two agents have identical individual distances to and from all other agents in a system and their individual distances are identical.

The individual distance used for capturing villagers' socio-economic interactions should not be based on their personal socio-economic characteristics, because a similarity of such characteristics does not always ensure the presence of interactions between two agents.[18] The distance should be based upon their socio-economic interactions.

Using the network approach, the actual socio-economic interactions among villagers in a village can be depicted in matrix form. As noted above, several types of socio-economic interactions among villagers can also be incorporated. Substituting the contents of the network matrix for individual distance between two villagers in Equation (3.1), we can elicit the social distance between those villagers.

Social distance based on network matrices of several socio-economic interactions has a definition slightly different to that embodied in Equation (3.1). Individual distances depicted by the network approach are based on various types of villagers' socio-economic interactions. The following definition, therefore, becomes applicable:

(3.2)

$$s_{ij} = s_{ji} =$$

$$(\sum_{q} \{ (d_{qij} - d_{qji})^2 + \sum_{k \neq i,j}^{n} (d_{qik} - d_{qjk})^2 + (d_{qki} - d_{qkj})^2 \})^{1/2}$$

where the subscript q represents the q-th type of their socio-economic interactions. The

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[18] Rogers and Bhowmick (1971). While similarity (homophily) of characteristics may well assure particular kinds of interactions between two agents, difference (heterophily) of characteristics may also assure other kinds of interactions.

first term in the second summation indicates the difference in their output patterns, and the second term indicates the difference in their input patterns.[19]

A smaller social distance means that Villager i interacts with a greater proportion of villagers with whom Villager j also interacts. These two villagers are structurally more equivalent than other sets of two villagers who have greater social distances. The proportion of villagers with whom the two villagers mutually interact determines their structural equivalence in a system.

This type of Euclidean distance was used to cluster and aggregate various industrial sectors in United States according to the 1967 input-output matrix (Blin and Cohen 1977). In the latter study, only the input-side is made use of, i.e., only the second term in the second summation in Equation (3.2).

In Section 3.8, this measure of social distance is used to identify structural groups whose members play more or less identical roles in terms of disseminating agricultural information, and thus more interdependent with each other than with outsiders.

3.2.5.2 Interdependence Coefficients

Pollak (1976) studied "interdependent preferences", and used interdependence coefficients in linear expenditure systems. Burt (1980a) used structural equivalence proximities as interdependence coefficients in interdependence utility functions as already indicated (Sections 1.4.4.2, p.31, and 1.4.6). The mechanism of determining such interdependence coefficients has been rarely studied by economists.

A villager's interdependence with another villager is defined as the similarity of the two villagers' roles in terms of disseminating agricultural information in the village. If they play similar roles, they concern with each other more strongly than with others who do not play such roles. The similarity of roles is defined as the difference in the two villagers' patterns of interactions with others which transmit agricultural information.

The village's interdependence structure can thus be elicited by using the structural

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[19]Types of interactions are assumed to be independent of each other. In Appendix C.4, relations among these interactions are shown and found to be very low. If they are high, dependence among these interactions should be considered. Principal components of these interactions should replace 0-1 representation of interactions. However, this approach has not been so far proposed in network analysis literature.

approach of network analysis. This structural approach is based on the concept of "social distance" between any two villagers.

Villager i's interdependence on Villager j is defined as a function of the difference between (1) the social distance between Villager i and the villager(s) who is farthest away from him in terms of social distance (Villager m_i), s_{im_i}, and (2) the social distance between Villager i and Villager j, s_{ij}. Therefore Villager i's interdependence on Villager j is:

$$s_{im_i} - s_{ij},$$

where

$$s_{im_i} = \max_k s_{ik}.$$

The most remote villager from Villager i (Villager m_i) is thus used as his reference point. As the difference between (1) and (2) becomes greater, Villager j's influence on Villager i becomes stronger, i.e., the latter's interdependence with Villager j is assumed to become stronger.

Villager i's independence in decision-making is defined as the remnant after removing all others' influence. Considering independence in this subsidiary way is quite different from the orthodox starting point for discussions, but for generality of the definition of the interdependence above, it is appropriate to start with interdependence and to derive independence as a special case.

According to the definition of interdependence above, Villager i's interdependence with himself, i.e. his independence, is

$$s_{im_i} - s_{ii} = s_{im_i}.$$

Because the social distance between Villager i and himself, s_{ii}, is defined as zero, Villager i's interdependence with himself is thus his distance from the villager farthest away, s_{im_i}. In other words, since the most remote villager, Villager m_i, is used as his reference point, he becomes more independent as the radius of his area of interactions becomes greater.

Interdependence is a relative concept. The total magnitude of a villager's

interdependence with others, or the absolute magnitude of his interdependence with a particular villager, does not affect his decision making. As in the planetary system, changes happen only when the relative pattern of other planets changes. By using a method of standardisation, it is possible to determine comparable measures of villagers' independence and interdependence in their decision making. On the basis of the analogy to the relationship between gravity and distance in the planetary system, the following standardisation is proposed:[20]

Villager i's interdependence coefficient with Villager j:

$$l_{ji} = \frac{(s_{im_i} - s_{ij})^2}{\sum_{k=1}^{n} (s_{im_i} - s_{ik})^2} \quad (j \neq i) \tag{3.3}$$

Villager i's independence coefficient:

$$l_{ii} = \frac{s_{im_i}^{\ 2}}{\sum_{k=1}^{n} (s_{im_i} - s_{ik})^2} \tag{3.4}$$

these sum up to unity:

$$\sum_{k=1}^{n} l_{ki} = 1.$$

where the summation in the denominator corresponds with the total magnitude of influence from or interdependence with other villagers.

These standardised indices are, as a group, especially called "interdependence coefficients" in this study. If the two subscripts are different, as in the first equation, they

[20]In the planetary system, gravity is related to the square of the distance.

are called "interdependence coefficients". If the subscripts are identical, as in the second equation, they are called "independence coefficients". In matrix form where columns and rows represent villagers, diagonal elements of the matrix are independence coefficients and non-diagonal elements are interdependence coefficients. These coefficients can be summarised as follows:

Interdependence coefficients

(1) Independence coefficients (diagonal elements),

(2) Interdependence coefficients (non-diagonal elements).

An increase of Villager i's interdependence with Villager j means that either:[21] (1) the social distance between Villager i and Villager j becomes shorter or (2) the social distance between any third villager (Villager k) and Villager i increases. Additionally, if the social distance to Villager j is greater than a certain length, an increase in the distance to the most remote villager, s_{im_i}, causes an increase of his interdependence on Villager j. On the other hand, if Villager j is located within the certain radius, the increase in the distance to the most remote villager reduces his interdependence with Villager j.[22]

An increase of Villager i's independence coefficient, l_{ii}, means either[23] (1) a decrease of social distance from his farthest villager (Villager m_i) or (2) an increase of social distance from any villager except the one who is most remote. Figure 3-1 illustrates the

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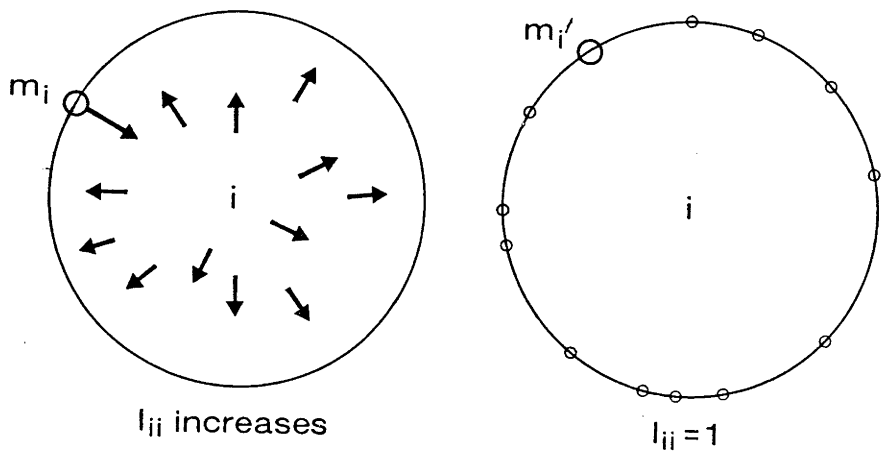
[21]While a visual impression of Equation (3.3) may suggest the opposite, its derivatives with respect to the relevant distance variables give the results explained. Derivatives are supplied in Appendix C.1.

[22]This finding may correspond with the classification of members of a village system in terms of reciprocity of exchanges, which was conceptualised by the economic anthropologists Service (1966) and Sahlins (1968, 1974). The reciprocity is classified into the following three levels according to the closeness of a villager's counter-part, as follows: (1) generalised reciprocity with members of his kinship group, (2) balanced reciprocity with villagers of other kinship groups, and (3) negative reciprocity with non-villagers or outsiders. The suggestion here may correspond with the first two levels because Villager i's reference point, Villager m_i, seems to correspond with the boundary of his area of interactions (exchanges), i.e., his village in Service and Sahlins' conceptualisation.

[23]While a visual impression of Equation (3.4) may suggest the opposite, its derivatives with respect to the relevant distance variables give the results explained. Derivatives are supplied in Appendix C.2.

Figure 3-1: Independence Coefficient and Social Distance



movements which cause an increase in Villager i's independence coefficient, and the ultimate situation resulting from these movements. These movements imply an equalisation of social distances. If the social distances to other villagers are all equal, Villager i has the maximum independence coefficient, which equals one. Burt called this villager a structurally unique villager, meaning that he is completely independent of others in his decision making, like the individual assumed in neo-classical economics.

3.2.5.3 Numerical Examples

Some numerical examples are now given of eliciting the social distance and the interdependence coefficients defined in Equations (3.2), (3.3) and (3.4). For simplicity, only one aspect of socio-economic interactions among five villagers is used, i.e., relations in giving agricultural information.

Tables 3-2 and 3-3 include networks of villagers' hypothetical information flows, social distances, and interdependence coefficients. Thus in the information flow section, the arrows represent a flow of agricultural information, and 0 and 1 in matrices respectively denote the non-existence and existence of a flow of information between a

donor villager (rows) and a receiver villager (columns). In the social distance and interdependence coefficient sections, the numbers in each cell respectively indicate these coefficients between two villagers (rows and columns). Especially, it should be noted that interdependence of a villager (columns) with another villager (rows) is indicated by a number in a corresponding cell.

For understanding of the numerical procedures explained above, the procedure to calculate social distance and interdependence coefficient between Villagers 1 and 2 in Table 3-2 is described here. In a system depicted in the "information flows" in Table 3-2, since Villager 1 is a sole donor of information and all others are receivers of information from Villager 1, this system of information flow can be represented by a matrix "Matrix Presentation". "1" represents an information flow from a villager in a row to a villager in a column, and "0" indicates a non-existent information flow between these two villagers. Social distance between Villager 1 and Villager 2 is calculated as follows, comparing Villager 1 and Villager 2's column vectors and row vectors.

$$S_{12} = S_{21} = \{(0\text{-}1)^2+(0\text{-}0)^2+(0\text{-}0)^2+(0\text{-}0)^2+(1\text{-}0)^2+(1\text{-}0)^2+(1\text{-}0)^2\}^{1/2} = 2.0$$

Subsequently, Villager 1's interdependence coefficient with respect to Villager 2 is calculated as follows with the maximum social distance shown in Villager 1's column:

$$l_{21} = (2\text{-}2)^2/\{(2\text{-}0)^2+(2\text{-}2)^2+(2\text{-}2)^2+(2\text{-}2)^2+(2\text{-}2)^2\} = 0.$$

This coefficient is placed in the cell of Row 1 and Column 2.

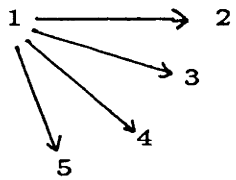
Table 3-2 shows that:

1. Villager 1 is unique, because his independence coefficient is one. He is not interdependent with any other villagers and neither are others interdependent with him. Since he is the only villager that transmits information, he has a unique role in the village.

2. Other villagers are interdependent with each other to a small degree. Although they do not pass agricultural information to each other, their positions are similar in the sense that they do not transmit any information and only receive it from Villager 1. This aspect gives these villagers' interdependence.

Table 3-3 shows that:

Table 3-2: Numerical Example 1



donor

receiver

	1	2	3	4	5
1	0	1	1	1	1
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0

Information Flows

	1	2	3	4	5
1	0	2.000	2.000	2.000	2.000
2	2.000	0	0	0	0
3	2.000	0	0	0	0
4	2.000	0	0	0	0
5	2.000	0	0	0	0
Max.	2.000	2.000	2.000	2.000	2.000

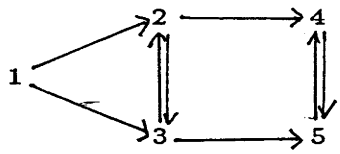
Social distance

Matrix Presentation

	1	2	3	4	5
1	1.	0.	0.	0.	0.
2	0.	0.25	0.25	0.25	0.25
3	0.	0.25	0.25	0.25	0.25
4	0.	0.25	0.25	0.25	0.25
5	0.	0.25	0.25	0.25	0.25
Total	1.	1.	1.	1.	1.

Interdependence Coefficient

Table 3-3: Numerical Example 2



donor

receiver

	1	2	3	4	5
1	0	1	1	0	0
2	0	0	1	1	0
3	0	1	0	0	1
4	0	0	0	0	1
5	0	0	0	1	0

Information Flows

	1	2	3	4	5
1	0	1.732	1.732	2.000	2.000
2	1.732	0	1.414	2.449	1.732
3	1.732	1.414	0	1.732	2.449
4	2.000	2.449	1.732	0	1.414
5	2.000	1.732	2.449	1.414	0
Max.	2.000	2.449	2.449	2.449	2.449

Social distance

Matrix Presentation

	1	2	3	4	5
1	0.91	0.06	0.06	0.01	0.01
2	0.05	0.74	0.13	0.	0.07
3	0.05	0.13	0.74	0.07	0.
4	0.	0.	0.06	0.79	0.14
5	0.	0.06	0.	0.14	0.79
Total	1.01	0.99	0.99	1.01	1.01

Interdependence Coefficient

1. Villager 1 passes information only to Villagers 2 and 3, both of whom pass it on to each other. Villager 2 passes it on to Villager 4. Villager 3 passes it on

to Villager 5. Villagers 4 and 5 pass it on to each other. This is a more decentralised structure than the first case.

2. Villager 1 is less independent, and more interdependent with Villagers 2 and 3. All other villagers are interdependent with Villager 1 to a small degree. His role in terms of transmitting information is less special, because all other villagers are also transmitting information to others.

3. Villagers 2 and 3 are interdependent with each other, because they assume similar roles in receiving information from Villager 1 and passing it on to two villagers.

4. Villagers 4 and 5 are interdependent with each other, because they are in similar roles in which each receives information from another villager and passes it on to the other.

Comparing these two networks, we can draw an implication for the effectiveness of extension services, on the assumption that a villager's greater interdependence with others affects his decision making more strongly. If the extension personnel choose a village head like Villager 1 in Table 3-2, the new agricultural technology which they pass on to him may not be implemented in the village, even though the information is diffused. Villager 1 is too different from others in terms of his role in the village. No other villager is interdependent with him. On the other hand, other villagers are strongly interdependent with each other. In this sense, the new technology has the potential to spread among them very quickly, but since they are not affected by the donor of the information, where only Villager 1 is approached, this does not occur.

If the extension personnel pass on the new technology to a village head like Villager 1 in Table 3-3, the new technology will be implemented, sooner or later, as the information about it diffuses within the village. In a village with a structure like that portrayed in Table 3-3, where, in terms of transmission of information, several groups are established, an innovation may well be more quickly diffused and implemented than in a village like Table 3-2, where the information is spread through a centralised network.

3.3 Selection of Network Systems

In selecting network systems for elicitation of the structure of a West Sumatran village, Dahlan (1979) chose networks with seven types of interactions. The approach in Dahlan's study may be very relevant to the present study owing to its nearby location. However, the size and agriculture of the West Sumatran village are different from those of Belatung.

Dahlan's study was oriented towards the identification of the importance of religious leaders, Adat leaders, and agricultural leaders in disseminating information in villages. He chose seven types of consultation activities, and examined the numbers of citations pertaining to the respective leaders. The consultations concerned (1) wedding ceremonies, (2) family planning issues, (3) financial matters, (4) epidemics, (5) deaths and funerals (6) agricultural intensification programmes and (7) crop failures.

Dahlan's selection of these consultations may be sufficient for the purpose of his study, but it seems that they are not sufficient for elucidation of the village structure with respect to the diffusion of agricultural information. There are three drawbacks if his selection of these consultations is adopted for the present study.

The first shortcoming of Dahlan's selection of interactions was his failure to include, and take account of, the village kinship system. In a traditional society the kinship system can be regarded as the most important network, on which many other socio-economic interactions may be based. Ben-Porath (1980) pointed out the importance of kinship and friendship relations for economic transactions in developing countries in his study of "F-connections".

The second drawback in Dahlan's selection of interactions was that he did not include many other kinds of socio-economic interactions which could have assisted in elucidating the village structure. The chosen consultation activities, other than these concerning agricultural intensification programmes and crop failure, did not seem very important, especially in relation to the diffusion of agricultural information.

Agricultural and economic transactions which transmit agricultural information among villagers should be considered more intensively. While villagers mainly sell their produce to merchants from outside, they consume their profits in purchasing their food

and household goods from grocery shops inside the village. Villagers may also borrow household goods from certain other villagers if they temporarily lack those goods. They may again lend or borrow money, exchange labour for agricultural and ceremonial activities, hire family labour in or out; and buy, sell or lease plots of land. All these activities may be conducted with certain villagers.

The third drawback in Dahlan's selection of interactions was that he chose consultation activities which clearly involved hierarchical relationships between villagers. Such relationships can be used to identify whether one villager is superior or inferior to other villagers, but not to identify a group of equals in the village structure. A group of villagers of almost equal socio-economic statuses can only be identified by examining relations which take place between villagers with the same subjectively and mutually perceived status. The hierarchy of individual villagers or groups can then be identified by investigating hierarchical relations between groups which have been identified as having different statuses or belonging to different groups. Hierarchical or non-hierarchical relations can be identified by considering the nature of an interaction in terms of reciprocity. In general, exchanges of items involved between two villagers are recognised as reciprocal and thus as non-hierarchical relations. A question like "With whom do you exchange .... ?" reveals non-hierarchical relations. On the other hand, answers to a question which involves a direction of a villager's action such as "For whom did you work as a hired labourer?" can indicate hierarchical relation between two villagers.

It is maintained that all the activities and relationships mentioned may well transmit the agricultural information indirectly between two individual farmers. They should therefore be recorded and utilised in the form of matrix for elucidating the agricultural information structure of the village. This should be in addition to data obtained by asking questions about villagers' direct exchanges of information on agricultural matters (direct agricultural information).

Resources which are involved in interactions between villagers can be classified into the following six categories:

1. Kinship
2. Capital
3. Labour
4. Land
5. Household Goods
6. Information

In the present study of Belatung, the following aspects of villagers' agricultural and socio-economic interactions are selected to elicit the agricultural information structure:

1. Kinship relations. Information about ± 2 generations of a villager and his wife (50 types of kinship relations used).
2. Money Borrowing/Lending. "If you want to borrow a small amount of money, whom do you deal with?".
3. Exchange labour. "With whom have you exchanged family labour for agricultural or ceremonial activities?"
4. Hired labour. "For whom have you worked as a hired labourer?", "Whom did you hire for your agricultural activities?"
5. Land sales and purchase. "From whom have you bought a plot of land since 1965?", "To whom have you sold a plot of land since 1965?"
6. Land lease. "Whose land do you lease-in?", "To whom do lease-out your land?", "Whose rubber are you tapping?".
7. Household goods exchange. "If you do not have some groceries today, from whom do you borrow them?", "To whom do you lend groceries?"
8. Meeting-at-shops. "At which grocery shop in this village do you buy your daily needs?". To shop owners, "Who has an account in your shop?".
9. Direct communication on agricultural information. "With whom do you often talk about your agricultural problems?"
10. Citrus Siam observation. "Whose citrus siam plot do you most often observe?"

Among these relations and interactions, kinship relations, money

borrowing/lending, household goods exchanges, meeting-at-shops, and direct communication of agricultural information are regarded as reciprocal and thus non-hierarchical, and others are hierarchical.

3.4 Kinship System

Figure 3-2 shows how the villagers of Belatung related to each other. Kinship ties are carefully selected within the range of 2 generations so that the reciprocity of ties is not violated. Thus, if Villager 1 is Villager 2's grandfather, Villager 2 is Villager 1's grandson or granddaughter and both relations are equally recorded in the matrix.[24]

The kinship groups identified from the kinship network and the villagers in such groups are listed in Table 3-4.

There are two findings concerning the characteristics of the Belatung kinship system.

Firstly, there were two obvious sets of kinship groups. One was the set comprising the native Belatung villagers (Groups 1 - 7), and the other was the set comprising the Javanese who were working for the National Railway (PJKA). The latter set consisted of four isolated kinship groups (Groups 8 - 11).[25]

Secondly, and as shown in Figure 3-2, the kinship relations of the native Belatung villagers (Groups 1 - 7) were all located on a continuum. There was no discontinuity from the villagers at the top end of the figure to those at the bottom end, and there was no

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[24]In the following sections, villagers' major socio-economic characteristics are frequently referred to. The list of characteristics for all individual villagers is found in Appendix C.6. In Figure 3-2 (and in the networks in later figures), the numbers on the left side identify villagers, and corresponding rows indicate their patterns of interactions with the villagers in the columns (placed in the same order as the villagers in rows). Thus, the #-symbols on the diagonal line represent villagers' interactions with themselves (regardless whether these interactions exist or not). Other #-symbols represent the interactions of a villager in a row with villagers in columns. In several networks, the locations of #-symbols are not symmetric along the main diagonal line, and here, non-reciprocal hierarchical interactions such as hired labour are denoted. Thus, a villager in a row may hire-in a villager in a column, but the reverse does not happen. The rectangles which enclose #-symbols along the diagonal line represent identified groups within which there are, in general, many more interactions among villagers within the group than with villagers of other groups. The numbers in the top right corners of the rectangles indicate the identification numbers of groups.

[25]An isolated group is a group of persons who only interacts with other members of the group, and not with persons outside the group.

distinct loop which connects kinship groups which were located far apart.[26] In this sense, the villagers' saying that "We are all members of one family" turns out to be true, although they were not members of the family to the same degree. They had a clear concept of distant relatives even within their village.

The characteristics of several kinship groups are discussed, in the following sections.

3.4.1 Minor Groups

The members of Groups 1, 2 and 3 were very loosely connected with members of their own groups. These groups were also loosely connected[27] to other groups. The number of members of these groups was smaller than that in other native Belatung groups (Groups 4 - 7). In this sense, these groups are regarded as minor kinship groups in this village.

Group 1

The prominent member of Group 1 was the ex-religious teacher, Villager 103. The members of this group were all related to this ex-religious teacher. Half the members of this group were originally from Karta Mulya, a neighbouring village (See Figure 2-2).

Group 2

Group 2 consisted of four sub-groups.[28] Villagers 60 and 108 were somewhat distinctive in that the former was the wealthiest villager by reputation, and the latter was an active trader/grower of citrus siam. Villagers 58 and 66 were the oldest members of this group.

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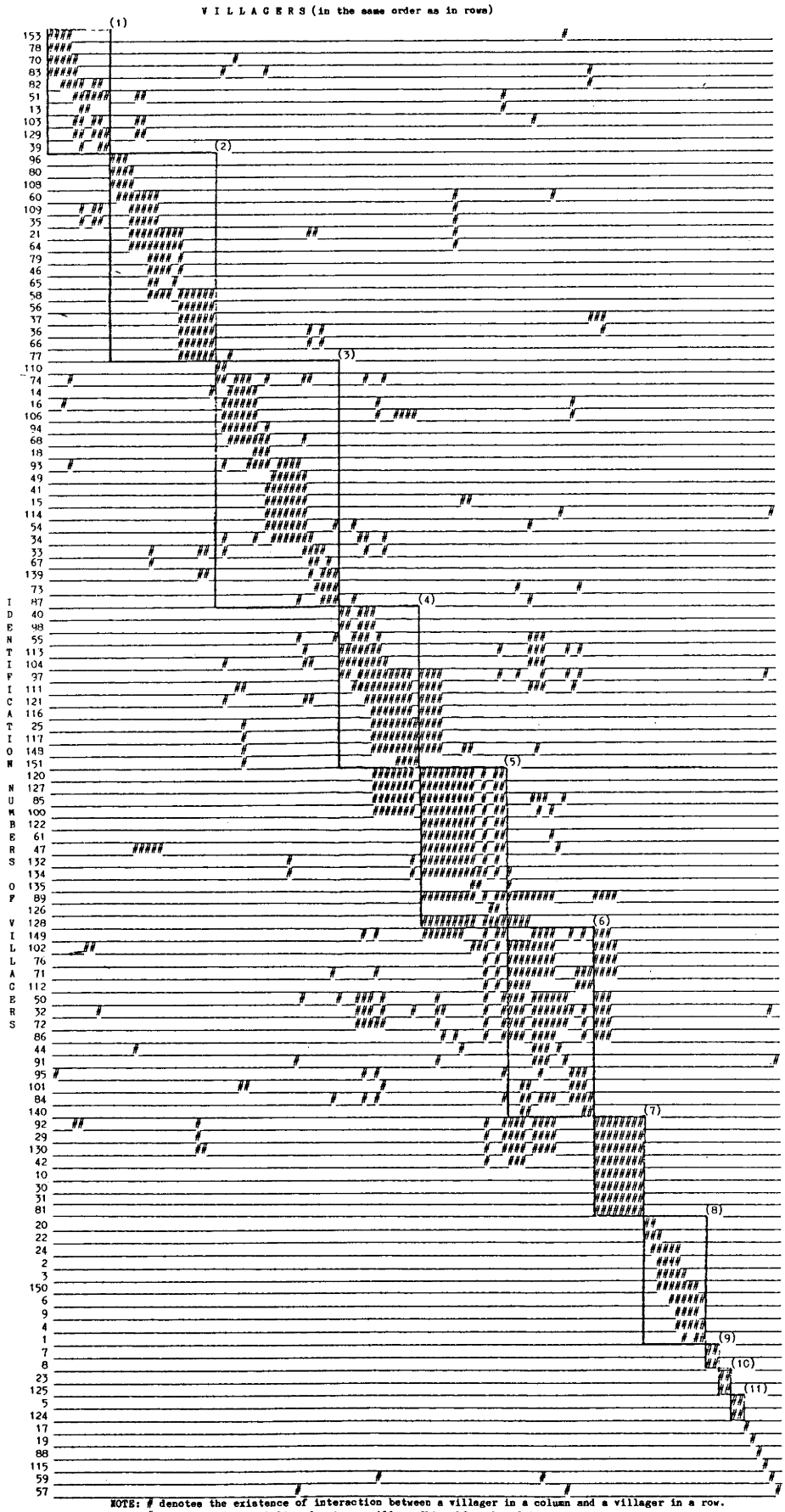
[26]The term "discontinuity" means here the situation where there is no direct and indirect interaction between two persons concerned. The term "loop" means the interaction between two persons who belong to two different groups which are located far apart in the figure of the identified network. If one person who interact with two other persons that belong to two different groups, this person is called especially a "bridge", and this person is regarded as not belonging to any group at all.

[27]Connectivity of a group is defined as the ratio of the number of observed interactions between members of the group to the possible maximum number of interactions, and the connectivity of two groups is defined as the ratio of the number of observed interactions between members of the two groups to the possible maximum number of interactions between them. Visually the first connectivity is identical with density of #-symbols in a rectangle which corresponds with the group. The second connectivity is identical with the density of #-symbols in the area which corresponds with both groups. If this density is low, the two groups are regarded as being "loosely connected".

[28]A group may consists of several smaller sub-groups. The memberships of these sub-groups may largely overlap. While a member of a sub-group strongly interacts with other members of the sub-group, he may interacts with members of another sub-groups of the group.

Figure 3-2: Kinship Network



NOTE: # denotes the existence of interaction between a villager in a column and a villager in a row.
along the diagonal line denotes a villager himself numbered in a row.
Numbers in parentheses are groups' identification numbers.

Table 3-4: Groups in the Kinship Network

Group	Villagers
Group 1	153,78,70,83,82,51,13,103,129,39
Group 2	96,80,108,60,109,35,21,64,79,46,65,58,56,37,36,66,77
Group 3	110,74,14,16,106,94,68,18,93,49,41,15,114,54,34,33,67, 139,73,87
Group 4	40,98,55,113,104,97,111,121,116,25,117,148,151
Group 5	120,127,85,100,122,61,47,132,134,135,89,126,128,149
Group 6	102,76,71,112,50,32,72,86,44,91,95,101,84,140
Group 7	92,29,130,42,10,30,31,81
Group 8	20,22,24,2,3,150,6,9,4,1
Group 9	7,8
Group 10	23,125
Group 11	5,124
Unclassified	
Isolates	17,19,88,115
Bridges	59(97,32), 57(114,91)

Note:
Numbers in parentheses indicate two villagers with whom the bridge villager has a kinship tie. See a footnote on p. 116.

Source:
Figure 3-2

Group 3

Group 3 consisted of three sub-groups. Villager 34 was an elder of this group, but was born in another village, and came to Belatung as a dukun.[29] Recently he did not have strong influence on villagers, however, and in this sense, the group was not closely tied by kinship.

3.4.2 Major Groups

Members of Groups 4 to 7 were very closely connected by kinship ties both within and between groups, and can be regarded as the major kinship groups of this village.

Group 4

Members of this kinship group were relatives of Villager 113 and his wife. The son of Villager 113, Villager 104, was a very active farmer living in the Lekis area of the village (he assisted with the author's research in this area). Villagers 104 and 121 married daughters of Villager 34, a dukun of this village. Villager 121 was a very politically active villager, and had wide experience of trade in Java and a good education. He was once described by the present village head as "Orang Politik", a political man.

On Villager 113's wife's side, there were several farmers who had come back from the Lampung area. They produced coffee in that region, but after the fall of coffee prices, they gave it up and came back to their native village.[30]

Group 5

This kinship group consisted of Villager 100's sons-in-law (Villagers 120, 127 and 85) and his wife's relatives. Villager 120 was an assistant to the incumbent kerio,[31] and owned a shop at the centre of the village. Villager 89, who was Villager 100's wife's sister's husband, was an assistant village official during the period of Federation (1946-1954) and was the father of Villager 128, who owned a shop at the southeast end of the village.

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[29] A traditional healer.

[30] Refer Section 2.2.2.3 for villagers' migrations.

[31] A traditional head of a South Sumatran village.

Group 6

Members of this kinship group were all related to Villager 71, who was the incumbent religious teacher of Belatung. His son, Villager 112, was a teacher in the primary school of Lebuk Batang Lama, the neighbouring village. His sister's husband was the kerio during the Federation period. His wife's brother, Villager 76, was the principal of the Belatung primary school. This kinship group was at the centre of cultural and religious affairs in the village.

Group 7

This kinship group was centred around Villager 29, the ex-village head. This group included two of his younger brothers, the incumbent village head (Villager 130) and Villager 92, three of his sons, two of whom were teachers of the village primary school, and two sons-in-law.

This had been the ruling family of Belatung. Villager 29's father was the pasirah,[32] and the owner of the largest area of land in the village and its surrounding regions. His son, Villager 29, became a kerio after his education in Java, several years before the Japanese invasion. Following independence, Villager 29's younger brother succeeded the pasirah by popular election and Villager 29 resigned as the kerio. After a period of leadership by two successive kerios from different families (at present these correspand to Groups 5 and 6), Villager 130 became a kerio in 1969 and he is still incumbent. He became a kepala desa[33] in the administrative reform of April 1983.

National Railway groups

The villagers who worked for the National Railway (PJKA) were basically migrants from Java, mainly from Central Java. The children of these workers have married each other, and isolated kinship groups have accordingly been formed. These groups were completely isolated from the native Belatung villagers' kinship groups. Although some

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[32] A traditional head of a marga, a unit immediately above villages (dusun).

[33] An official term for a village head in the present administration system.

native Belatung National Railway workers were living in the bedeng,[34] they did not have any kinship ties with the Javanese workers.

Others

There were six villagers who could not be classified into groups. Among them, four villagers, Villagers 17, 19, 88 and 115 were isolates, who did not have any relatives in the village. Villagers 17 and 19 were Javanese National Railway workers and Villagers 88 and 115 were Sumatrans. Villager 115 was a resident junior extension worker for the Dinas Perkebunan (Estate Crop Agency). Villagers 59 and 57 were "bridges"[35] who respectively had only two relatives in two different kinship groups. Villager 59 was a relative of Villager 97 of Group 4 and of Villager 32 of Group 6. Villager 57 was a relative of Villager 114 of Group 3 and of Villager 91 of Group 6.

3.5 Economic Exchange Network System

3.5.1 Money Lending-Borrowing

In the Islamic religion, the lending and borrowing of money with interest is prohibited. Because South Sumatra province is strongly Islamic,[36] reliable answers to questions about transactions among villagers of large sums of money could not be expected. If much money was involved, interest may have been charged in some form, and the transactions would thus have been treated to be formal and non-reciprocal, so that some form of hierarchy was established between the two villagers involved. Where accurate data can be secured on such transactions, they can be used to identify relationships between a superior villager and an inferior villager in the village structure. It is anyhow more useful in examining villagers' informal relations to ask questions about transactions of small sums of money. Such transactions often do not involve any type of formality, and can be used to identify relationships between two equals in terms of their

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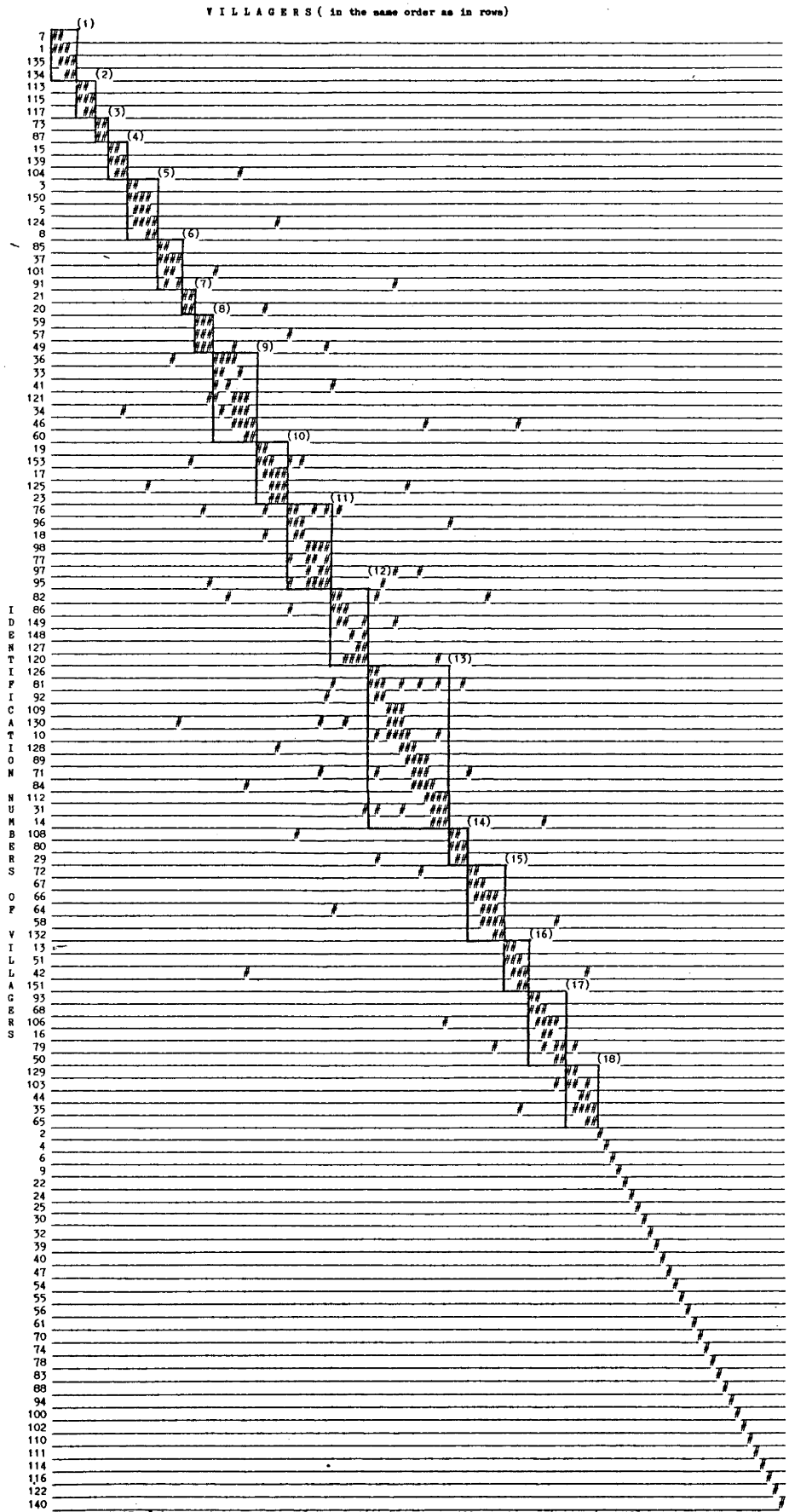
[34] A long house for workers' families.

[35] See a footnote on p.116.

[36] For example, South Sumatra sent 2321 persons to Mecca to become Haji in 1980. The ratio to the whole population of the province is one of the highest among provinces (Biro Pusat Statistik, 1982).

Figure 3-3: Money Lending-Borrowing Network



NOTE: # denotes the existence of interaction between a villager in a column and a villager in a row.
along the diagonal line denotes a villager himself numbered in a row.
Numbers in parentheses are identification numbers of groups.

Table 3-5: Groups in the Money Lending-Borrowing Network

Group	Villager
Group 1	7,1,135,134
Group 2	113,115,117
Group 3	73,87
Group 4	15,139,104
Group 5	3,150,5,124,8
Group 6	85,37,101,91
Group 7	21,20
Group 8	59,57,49
Group 9	36,33,41,121,34,46,60
Group 10	19,153,17,125,23
Group 11	76,96,18,98,77,97,95
Group 12	82,86,149,148,127,120
Group 13	126,81,92,109,130,10,128,89,71,84,112,31,14
Group 14	108,80,29
Group 15	72,67,66,64,58,132
Group 16	13,51,42,151
Group 17	93,68,106,16,79,50
Group 18	129,103,44,35,65
Isolates	2,4,6,9,22,24,25,30,32,39,40,47,54,55,56,61,70,74,78, 83,88,94,100,102,110,111,114,116,122,140

Source: Figure 3-3

socio-economic status in the village structure. These transactions may also be promoted by other informal activities and relations, and may promote other informal activities and relations. Agricultural information can also be disseminated through them.

The identified groups in this money lending-borrowing network are mostly small, implying that such activity is confined within limited numbers of mutually intimate villagers (Figure 3-3). In the following paragraphs, several major groups are described with a focus on prominent members but it does not necessarily suggest that these villagers were the sources of money in the groups.

The workers of the National Railway formed the three separate groups (Groups 5, 7 and 10), between which there were no considerable transactions.

Amongst the more important group were Group 9 whose members centred around Villager 121, who was one of the active entrepreneurial farmers. In addition, another member, Villager 60, was by reputation the most wealthy villager.

Group 11 was composed of middle class villagers at the east end of the village, who centred around Villager 76, the principal of the primary school. Villager 18 was a National Railway worker, but belonged to this group because of his deceased father's relation.

Group 12 consisted of wealthy villagers at the East end of the village together with Villager 100's relatives.

The core of Group 13 was the ruling family of the village, which corresponded to Group 7 in the kinship system.

Other groups consisted of a small number of villagers and it is difficult to describe characteristics of each group. Descriptions of each group, except that they were mutually intimate villagers, may not be crucial for the sake of the further discussion.

There were thirty isolates, who did not cite any others as partners of this activity. As mentioned in Chapter 2, South Sumatran people is generally believed to be very independent especially in financial matters, the presence of many isolates in this activity is naturally expected.

3.5.2 Labour

Transactions among villagers which involve family labour can be viewed from two aspects. Firstly, Indonesian-Malay peoples exchange family labour, in preparations for religious ceremonies and agricultural activities, doing this in accordance with Adat. This tradition has been especially strong in the rice-growing areas in Indonesia and Malaysia, and observed in a strict manner. However, in South Sumatra, the long history of cash cropping has weakened the exchange labour custom for agricultural activities. As already indicated, smallholders' rubber production in particular does not require any addition to family labour, or any periodical concentration of labour usage. Yet, exchange labour still continues for such ceremonial purposes as wedding ceremonies, babies' circumcisions, house construction and funerals, where villagers mutually help each other over a long time span.

At the village level the range of villagers who exchanged family labour with each other included almost the whole population. Although questions were asked about this exchange labour network, the answers were, as expected, almost always "most of the villagers" or "cannot specify". This network was therefore not included in the further analysis.

Secondly, hired labour was sometimes used for agricultural activities, although villagers rarely hired Sumatrans and recruited Javanese from either outside or inside of the village.[37] If Sumatran workers were hired, they were often villagers, and the purpose seems to have been (1) financial assistance for the hired worker's household which also fulfilled unskilled jobs such as weeding, or (2) utilising skilled labour for work such as lumbering, house construction and boat-making. Hired labour transactions for these purposes do not seem to effectively transmit agricultural information between villagers, and no attempt was, therefore, made to identify groups in the hired labour network.

Figure 3-4 shows that 76 of the 118 villagers were involved in the hired-labour transactions. 28 of these persons only hired-in while 34 only hired-out, and 14 both hired-in and hired-out.

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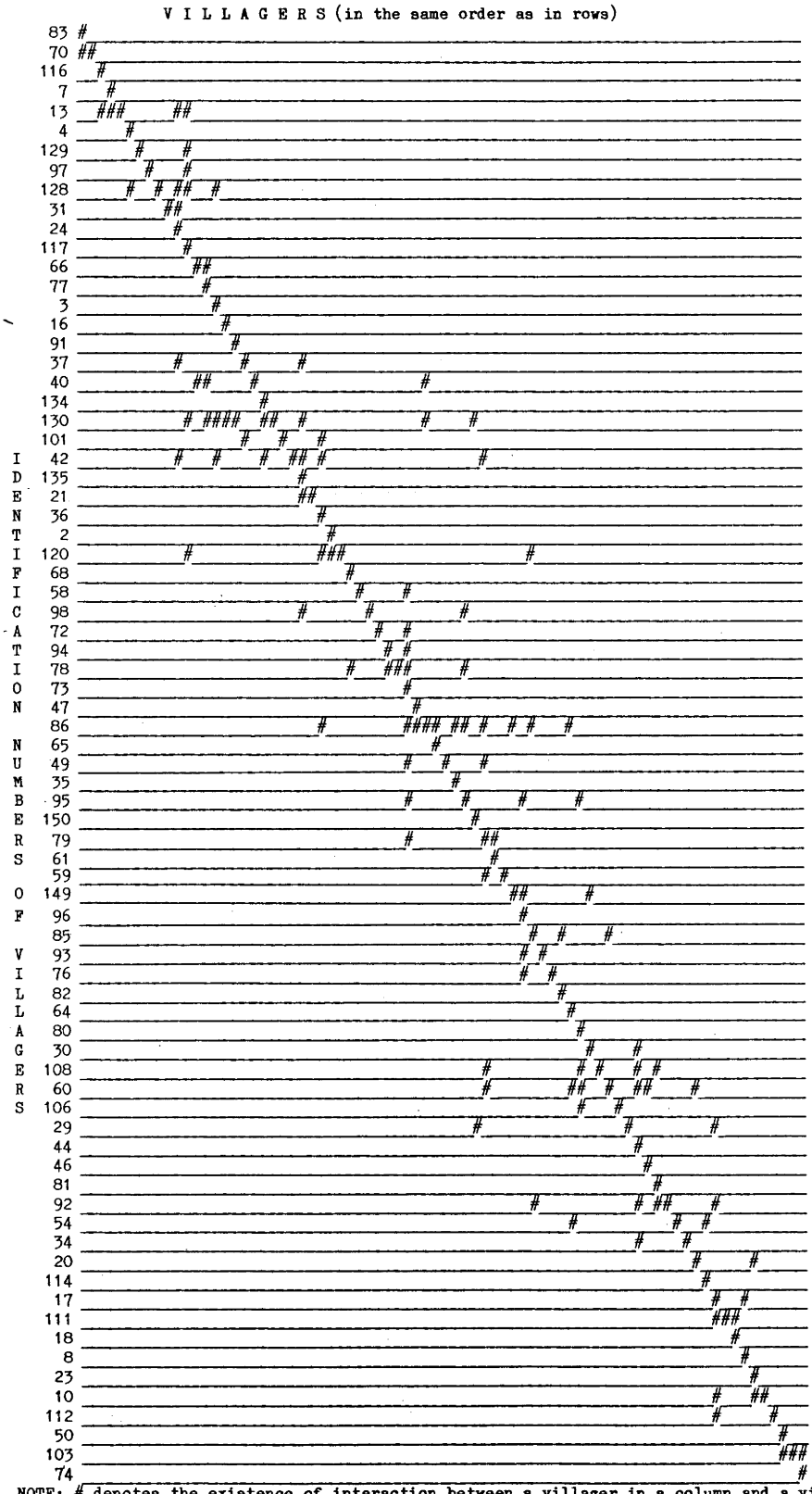
[37]Refer Section 2.4.3.3 for actual hired labour usage.

Figure 3-4: Hired Labour Network

(Asymmetric)



NOTE: # denotes the existence of interaction between a villager in a column and a villager in a row.
along the diagonal line denotes a villager himself numbered in a row.

Distinctive hiring-in villagers were Villagers 13, 128, 130, 42, 120, 78, 86, 108, 60 and 92. These pemborongs were all shop owners and entrepreneurs, and provided some temporary jobs, especially in the fruit harvesting seasons (duku in March, and citrus siam in July). On the other hand, Villagers 24, 117, 135, 36, 73, 79, 96, 80, 44 and 17 were distinctive suppliers of labour. They were all less wealthy, and either very young or very old.

3.5.3 Land

Socio-economic interactions related to land are sales, purchases, and leases.

3.5.3.1 Sales and Purchases of Land

Whether or not sales and purchases of land transmit agricultural information can be determined by what crops are grown on the relevant plots of land, and by whether relationships between ex-owners and new owners after the transactions continue to influence crop choices.

If a plot of land with old stands of rubber trees is sold, it is not expected that any agricultural information will be transferred between the two villagers concerned. Techniques to grow and maintain rubber are known to almost all farmers, and new technologies for rubber production have not been absorbed by any villagers in this area. The cases examined in Belatung correspond with such an expectation.

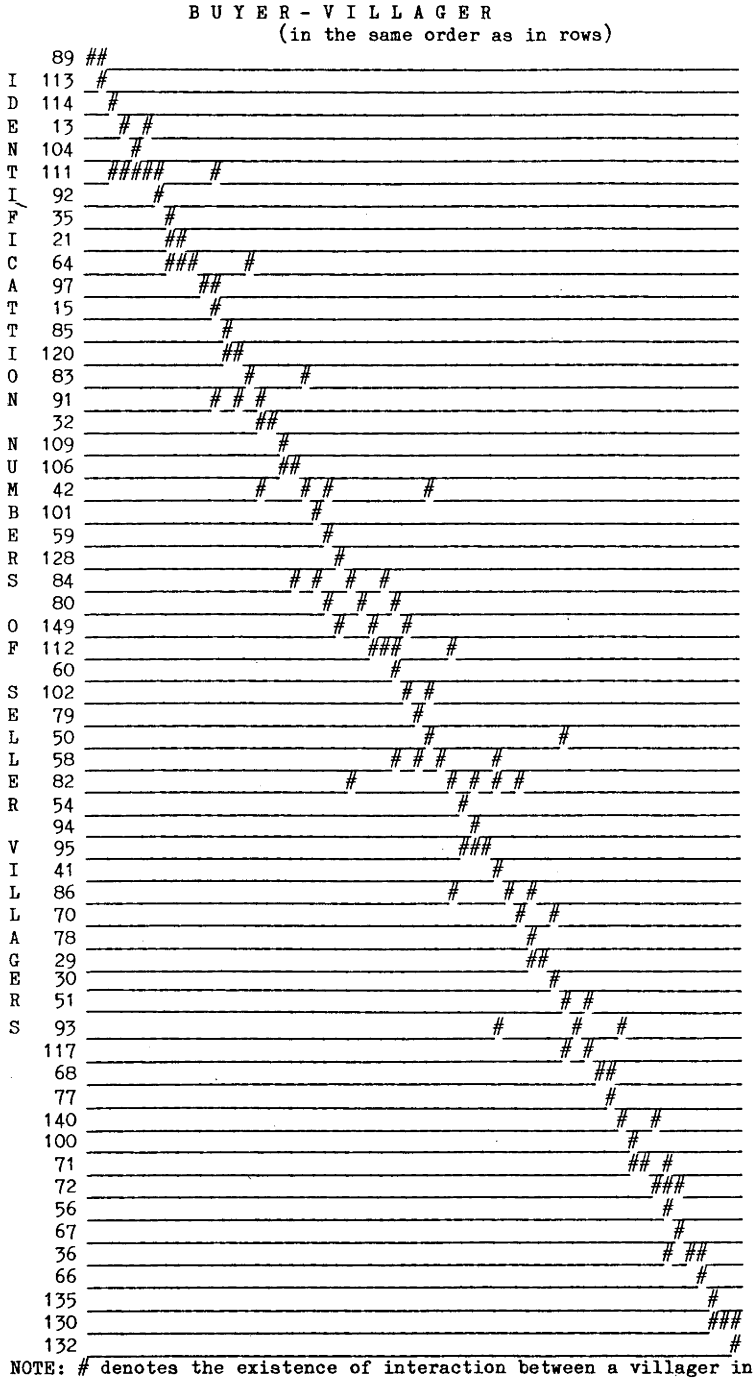
Thus, even though 58 villagers had been involved in land transactions since 1965, these all concerned old rubber and it could not be expected that any effective dissemination of agricultural information occurred through these transactions. Thus groups in this networks were again not identified.

Figure 3-5 shows the network expression of these land sales-purchases transactions among villagers. Distinct sellers were Villagers 111, 64, 42, 84, 112, 58 and 82. Except for Villagers 58 and 64, these sellers had also bought land. It seems that they sold lower-quality plots and bought better-quality ones.

Distinctive buyers were Villagers 56, 41, 60 and 15. Villager 60 was reported to be the most wealthy farmer, and it seems that he bought more plots of land from more farmers than could be recorded from interviews. Villager 56 was an energetic farmer and bought plots of land in the lebak area for citrus siam production. Villager 41 bought

Figure 3-5: Land Sales/Purchase Network

(Asymmetric)



NOTE: # denotes the existence of interaction between a villager in a column and a villager in a row.
along the diagonal line denotes a villager himself numbered in a row.

some plots using profits from the coffee boom in Lampung in the late 1970's. Villager 15, who lived in the Lekis area, was a very successful and economically independent farmer. He was the only farmer that produced enough rice for his household's subsistence, and even sold some.

3.5.3.2 Leases of Land

The types of land lease in the village are (1) one-to-one sharecropping, "paruhan", and (2) the "numpang" system in which, as already described (Section 2.4.2.2), a lessee can use a lessor's land without charge. However, these two types of land lease do not seem to be differentiated in terms of the dissemination of agricultural information. The crop grown on these plots of land was without exception rubber, and only 29 villagers were involved in the land lease transactions. The overall effect on agricultural information dissemination can, therefore, be regarded as negligible.

3.5.4 Household Goods

Socio-economic interactions which involve household goods such as rice, cooking oil, kerosene, sugar, etc., can be largely classified into two categories. The first category is exchanges among households. The second is related to meeting-at-shops at grocery shops in the village, which seem to enhance the possibility for villagers to meet others and exchange information.

3.5.4.1 Exchanges among Households

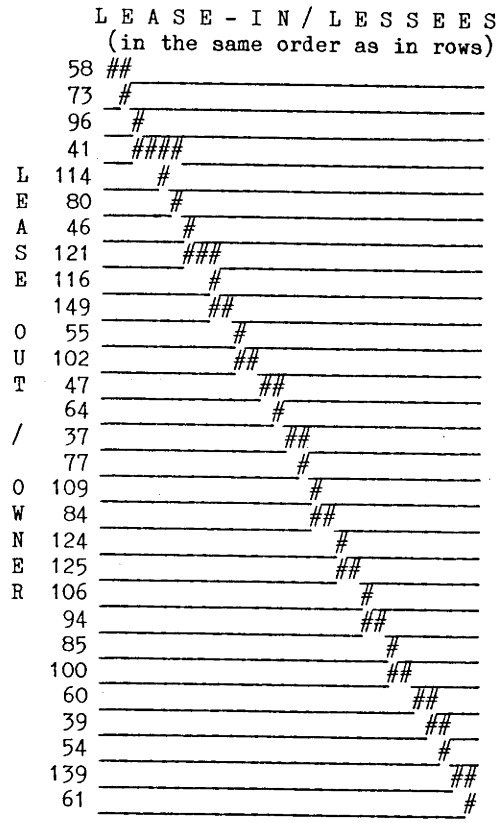
Villagers often borrow small amounts of foods, kitchens tools or sometimes furniture, when they are temporarily short of these items. This relation is reciprocal. Once they borrow, they are not required to return the items immediately, but they have to be prepared for the reverse transaction when the former lender is short of some household goods, often the identical items. Agricultural information may well be transferred via these interactions.

Figure 3-7 and Table 3-6 show the household goods exchange network and the groups within this network.

Most of these groups consisted of villagers who lived very near to one another.

Figure 3-6: Land Lease Network

(Asymmetric)



NOTE: # denotes the existence of interaction between a villager in a column and a villager in a row.
along the diagonal line denotes a villager himself numbered in a row.

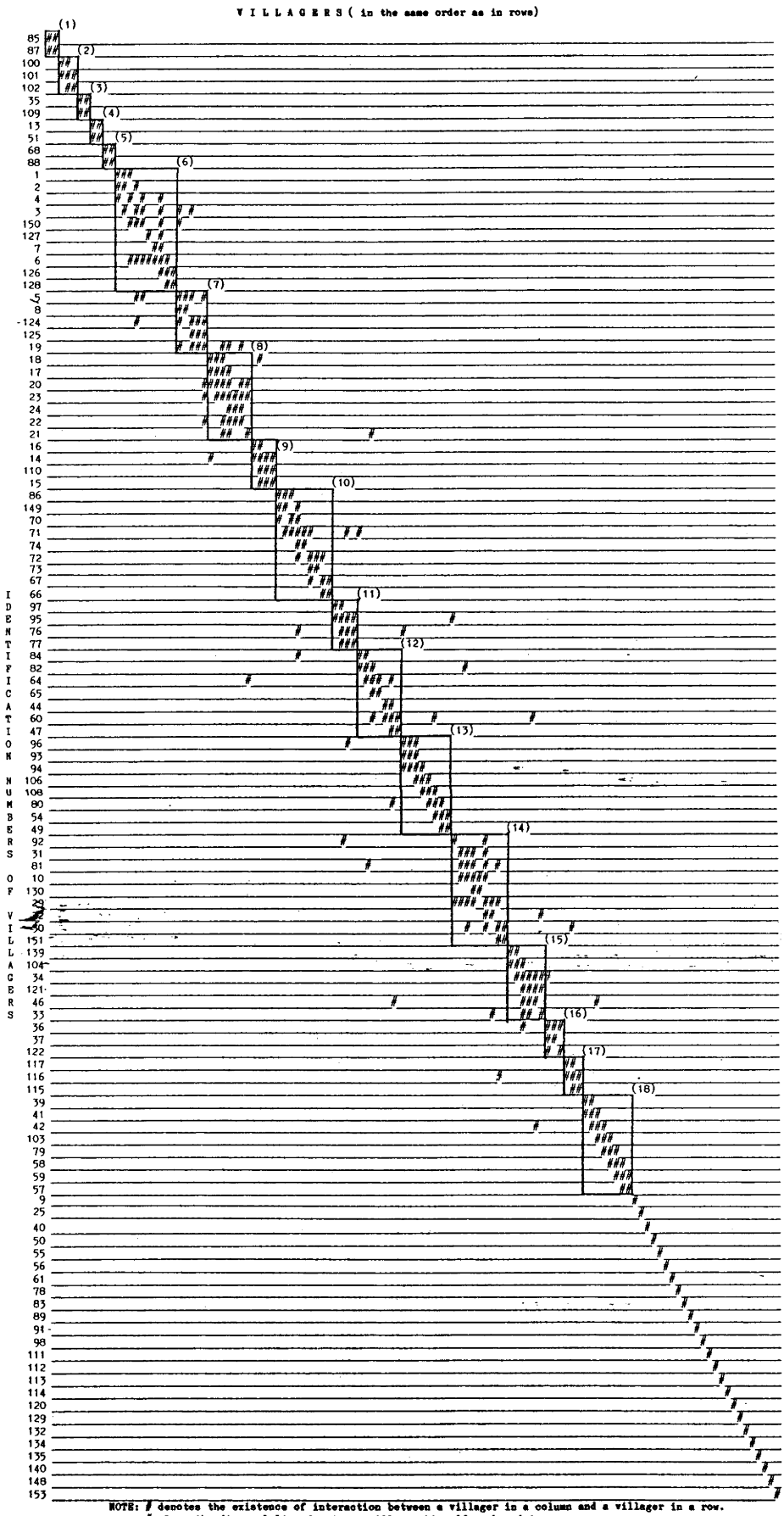
Some of them comprised villagers with very strong kinship ties.[38]

Examples of the former sort were Groups 1, 2, 6, 7, 8, 10, 11, 16 17 and 18, while those of the latter sort were Groups 3, 4 and 5. Other groups appeared to be a mixture of the two sorts.

Workers of the National Railway were somewhat isolated, from the native Belatung

[38]Table C-1 in Appendix C.4 shows the statistically very significant relations between the household goods exchange and (1) kinship relation, (2) money lending/borrowing, or (3) geographical distance.

Figure 3-7: Household Goods Exchange Network



NOTE: # denotes the existence of interaction between a villager in a column and a villager in a row.
along the diagonal line denotes a villager himself numbered in a row.
Numbers in parentheses are identification numbers of groups.

Table 3-6: Groups in the Household Goods Exchange Network

Group	Villager
Group 1	85,87
Group 2	100,101,102
Group 3	35,109
Group 4	13,51
Group 5	68,88
Group 6	1,2,4,3,150,127,7,6,126,128
Group 7	5,8,124,125,19
Group 8	18,17,20,23,24,22,21
Group 9	16,15,110,14
Group 10	86,149,70,71,74,72,73,67,66
Group 11	97,95,76,77
Group 12	84,82,64,65,44,60,47
Group 13	96,93,94,106,108,80,54,49
Group 14	92,31,81,10,130,29,32,30,151
Group 15	139,104,34,121,46,33
Group 16	36,37,122
Group 17	117,116,115
Group 18	39,41,42,103,79,58,59,57
Isolates	9,25,40,50,55,56,61,78,83,89,91,98,111,112,113,114, 120,129,132,134,135,140,148,153

Source: Figure 3-7

villagers in terms of these types of interactions. They basically formed Groups 6 to 8, although Group 6 also included Villagers 1, 128 and 126 who also lived close to these workers.

There were 24 isolates identified. They responded to the questions about the household goods exchanges by saying that they were financially independent of others and that they did not borrow or lent household goods. Their answers have been cross-checked by examining whether others quoted them or not.

3.5.4.2 Meeting-at-shops - Daily Shopping and Customers

A further type of socio-economic interactions relating to household goods is meeting-at-shops relations. There were seven small grocery shops in Belatung, which were owned by Villagers 6, 13, 49, 111, 120, 128 and 153. The three shops run by Villagers 13, 49 and 120 each had tables and benches for customers. Villagers were often seen there having a glass of Sumatran coffee, and conversing with shop owners or other villagers. This is a Sumatran version of the "kedai kopi".[39]

These small grocery shops offered opportunities to exchange information, and especially that concerning agriculture. The owners of the shops also provided credit for villagers. Further, workers of the National Railway received their salary in kind (rice) at the shops of Villagers 13 and 120, and they had debts there as well as at the nearest shop of Villager 128. Other villagers also had debts at some shops, and made repayments without obvious interest charges when they had money.

Figure 3-8 and Table 3-7 show the groups of villagers who used these grocery shops for their daily shopping and conversations. This network is called especially "meeting-at-shops" network. Figures in a cell indicate numbers of shops where the corresponding villagers met.

There were four groups of villagers and seven isolates in the meeting-at-shops network. Members of Group 1 were users of shops owned by Villagers 49 and 153, which were located in the south-east half of the village. Group 2 was a set of villagers who used

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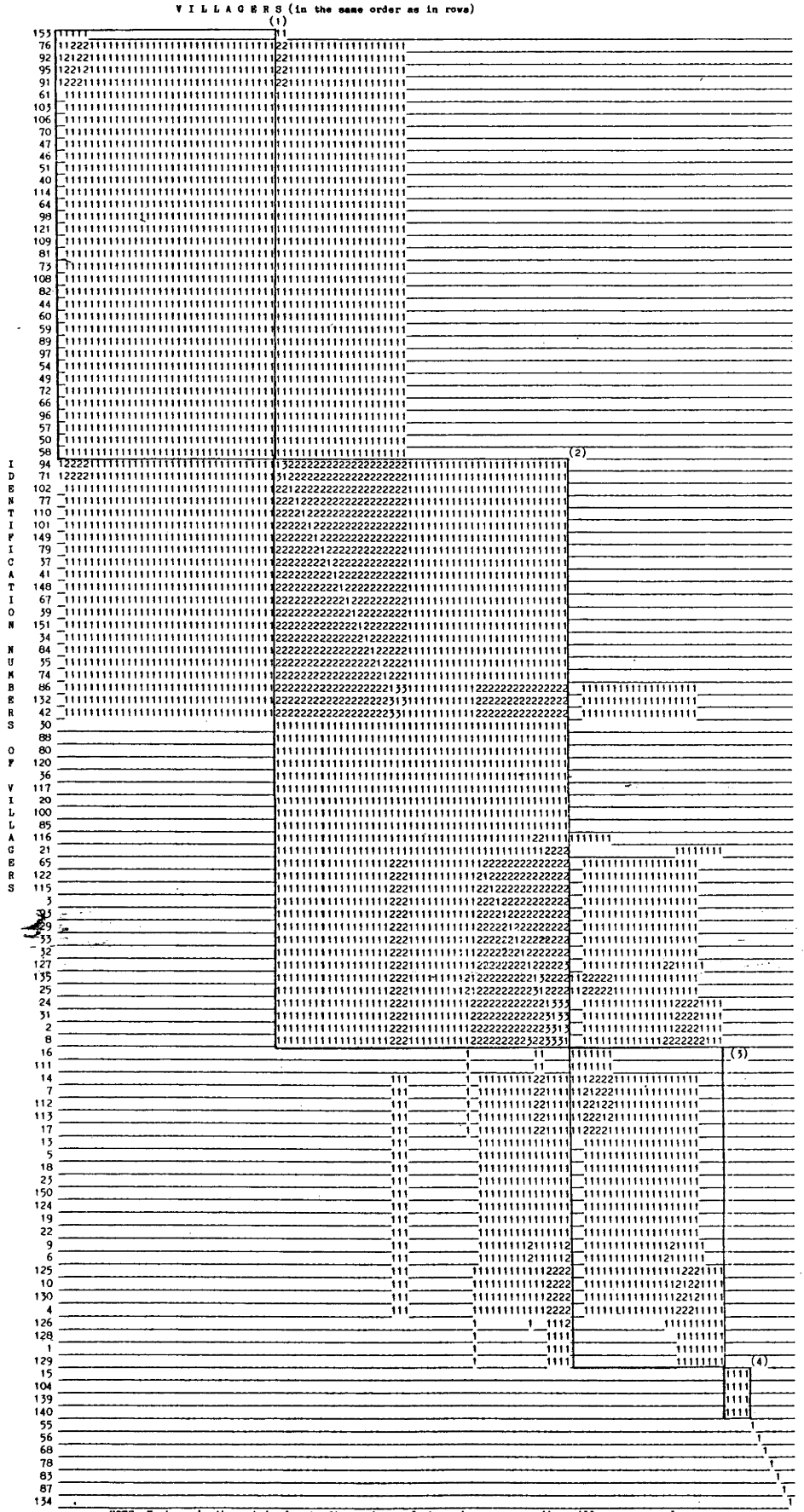
[39] In the Malay language, this means a coffee shop. In Indonesian, toko kopi is equivalent. Tsubouchi, Kuchiba and Maeda (1976), p.312-335.

Figure 3-8: Meeting-at-shops Network



NOTE: Numbers in the matrix denote the numbers of shops two corresponding villagers commonly use.
'1's along the diagonal line denote villagers themselves numbered in rows.
Numbers in parentheses indicate the numbers of groups identified.

Table 3-7: Groups in the Meeting-at-shops Network

Groups	Villagers
Group 1	40 44 46 47 (49) 50 51 54 57 58 59 60 61 64 66 70 72 73 76 81 82 89 91 92 95 96 97 98 103 106 108 109 114 121 (153)
Group 2	2 3 8 20 21 24 25 29 30 31 32 33 34 35 36 37 39 41 42 65 67 71 74 77 79 80 84 85 86 88 93 94 100 101 102 110 115 116 117 (120) 122 127 132 135 148 149 151
Group 3	1 4 5 (6) 7 9 10 (13) 14 16 17 18 19 22 23 (111) 112 113 124 125 126 (128) 129 130 150
Group 4	15 104 139 140
Isolate	55 56 68 78 83 87 134

Notes: Figures in parenthesis are villagers who owned grocery shops.
Source: Figure 3-8

Villager 120's shop which was located at the centre of the village. Group 3 consisted of villagers who used four shops run by Villagers 5, 13, 111 and 128, that were situated in the north-west half of the village. Group 4 was a group of villagers who only used the weekly market at Lebuk Batang Lama.

3.6 Direct Agricultural Information Network System

The direct agricultural information network was constructed from villagers' answers to the question "With whom do you often talk about your agricultural problems?". Because of the characteristics of this question, choices of partners to talk with, which were identified by these answers, were regarded as reciprocal, and the network matrix was processed to be symmetric.

The network shown in Figure 3-9 is much more complicated than the network expression of any other socio-economic interaction. This indicates that the direct agricultural information activities were farther reaching than other socio-economic interactions, and not restricted within small ranges of villagers.

Nine groups were identified from the network and listed in Table 3-8.

Group 1

This was a group of National Railway workers. Eight of them were living in the National Railway bedengs on the north side of the railway where they had been given a small plot of land by the Railway, as already indicated.

These workers, nevertheless, had an interest in agriculture in general, and especially in profitable cash crops such as pineapples, rambutan and citrus siam. They also looked for opportunities of being hired or being penumpangs of native villager's rubber lands. Actually, Villager 17 was a sharecropper for the Director of the Belatung station, who lived in Lampung.

Figure 3-9: Direct Agricultural Information Network

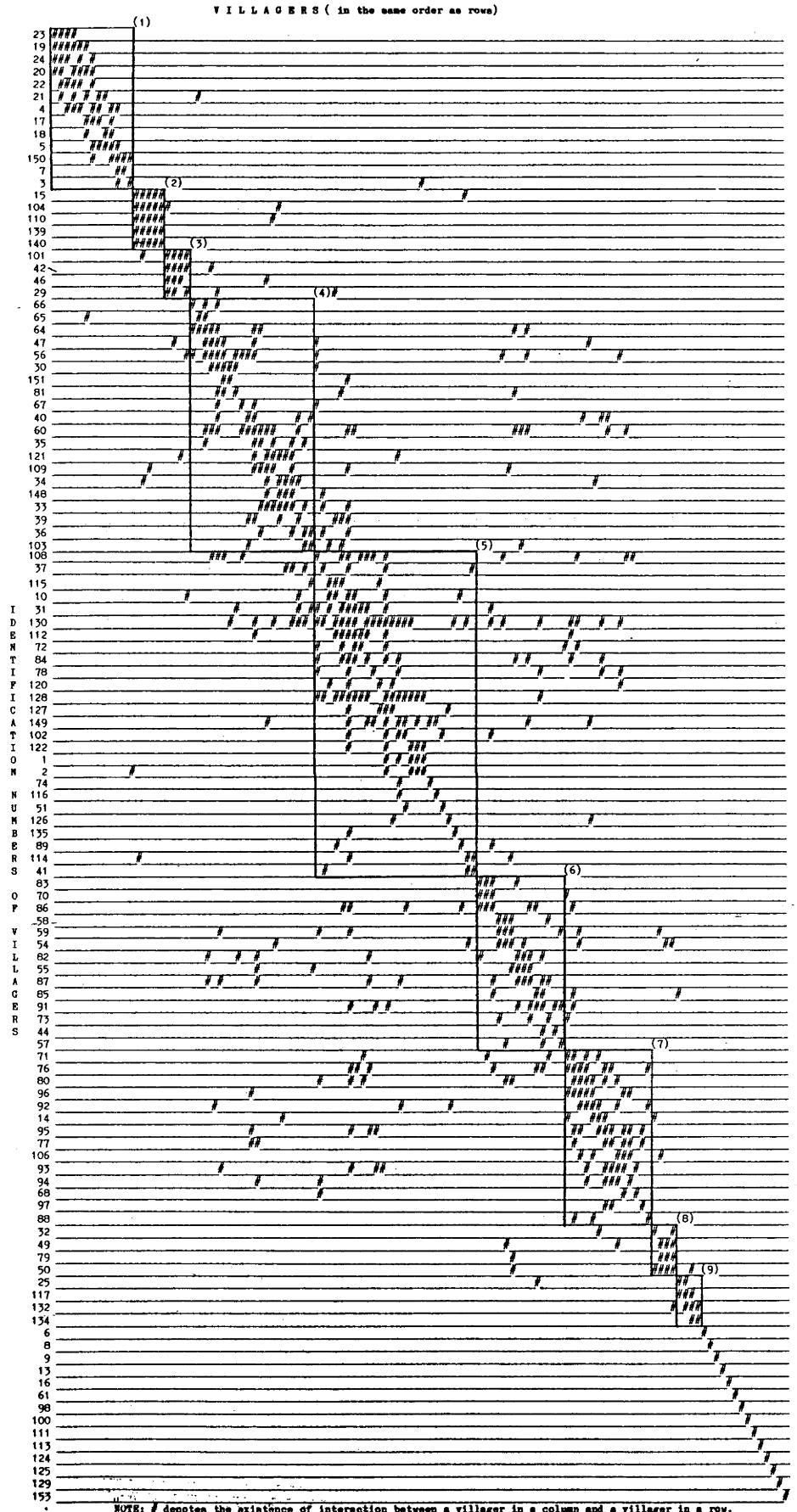


Table 3-8: Groups in the Direct Agricultural Information Network

Group	Villager
Group 1	23,19,24,20,22,21,4,17,18,5,150,7,3
Group 2	15,104,110,139,140
Group 3	101,42,46,29
Group 4	66,65,64,47,56,30,151,81,67,40,60,35,121,109,34, 148,33,39,36,103
Group 5	108,37,115,10,31,130,112,72,84,78,120,128,127, 149,102,122,1,2,74,116,51,126,135,89,114,41
Group 6	83,70,86,58,59,54,82,55,87,85,91,73,44,57
Group 7	71,76,80,96,92,14,95,77,106,93,94,68,97,88
Group 8	32,49,79,50
Group 9	25,117,132,134
Isolates	6,8,9,13,16,61,98,100,111,113,124,125,129,153

Source: Figure 3-9

Group 2

The members of Group 2 lived in the Lekis area, although they had their own houses in Belatung, as already explained. Every Tuesday, they went to the weekly market in Lebuk Batang Lama, the neighbouring village, to sell the week's rubber harvest and to purchase daily household goods and foods. They had good contacts with Javanese migrant farmers in the Lekis area and in Lebuk Batang Lama.

Group 3

This group consisted of younger middle-aged farmers looking for new knowledge of agricultural technology and of general economic opportunities. Villager 29's son, who lived with his father, was a teacher of the Belatung primary school, and the other members of the group were centred around him in terms of interactions. This teacher asked the author for a textbook of techniques of citrus siam production (Rismunandar 1981), and was himself a diligent part-time farmer. The others had considerable outside experience as taxi/truck-drivers, traders or mechanics.

Group 4

The members of this group lived at the geographical centre of the village, or had good-quality lebak plots along the Ogan river, especially on the north side of Belatung. On the way to their plots from their houses in the village, they could observe each other's agricultural situation, and possibly shared opinions on their agricultural activities.

Group 5

This group consisted of the more distinctive villagers and their followers. Villager 130 was the incumbent village head. Villagers 10, 31, and 112 were primary school teachers. Villager 120 was a village official and a shop-owner. Villager 84 was an ex-village head and Villager 89 was an ex-village official. Villagers 108, 149, and 41 were successful farmers. Villager 128 was a trader and shop-owner. Villager 78 was a part-time farmer who worked in the army office in Baturaja, and recently became the village head of Karta Mulya, the neighboring village. In this sense, this group can be regarded as the leaders' group, although it also included some followers of these people.

Group 6

The members of this group lived at the East side of the village, and had Villagers 82 and 86 as leaders. Villagers 85 and 91 were brothers, while Villagers 70 and 83 had coffee production plots in Kota Bumi, Lampung, and always travelled there and back together. Villager 54 had been a village official.

Group 7

The leaders of this group were Villager 71, a religious teacher (Khotib), Villager 76, the head-master of the Belatung primary school, and Villager 92, an energetic young trader/farmer. Except for Villager 14, the members lived close to one another at the East end of the village. Villager 14 was a brother of Villager 95, and both worked for the National Railway as senior staff at Belatung station.

Group 8

Excepting Villager 32, this was basically a group of young villagers who often met at Villager 49's shop. Villager 32 was Villager 50's grandfather, had already retired, and was cared for by his unmarried daughter. Villager 49's shop was located in the middle of the old section of the village. It sold coffee, had several benches inside and outside, and was a natural meeting place for many villagers. However, Villager 49, the shop owner, had long been sick and too weak to work on the land. He was not, therefore, attractive as a source of agricultural information. The young villagers of this group helped Villager 49 when he went to Baturaja to buy commodities for his shop, and used this excursion to look for other economic opportunities.

Group 9

The plots of members of this group were located close together in the Talang Kisam area of the village (Figure 2-2), where their geographical situation offered them opportunities to exchange opinions. Villagers 25 and 117, as well as Villagers 132 and 134, were brothers. However, the two sets of brothers did not have close kinship ties.

Isolates

The isolates were either (1) uninterested in agriculture because of their primary

occupation or declining physical strength, or (2) self-asserting independent farmers who claimed that they had their own external sources of agricultural information.

Villagers 8, 9, 124 and 125 were National Railway workers. Villagers 6, 13, 111 and 153 owned small grocery shops. Villagers 100 and 113 had almost retired, and were cared for by their sons or daughters. Villagers 16, 98 and 129 claimed that they had private contacts with agricultural extension officers in Baturaja or Kota Bumi.

3.7 Citrus Siam Observation

The observation of other villagers' citrus siam can be considered as the most direct and effective way of obtaining agricultural information about techniques of growing the crop. These observations are of course subject to a time lag. That is, a villager can only observe other villagers' citrus siam plots after they adopt the crop, and indeed may not have much observation until they start producing it in a large quantity. In this sense, the network of citrus siam observation is much more dynamic than the networks of other interactions. For pioneers, this network does not exist, but as the adoption process of citrus siam proceeds, the number of participants in this observation activity increases and consequently the network changes and grows. While it is thus not necessary to include this network in eliciting the basic aspects of village socio-economic structure, it is surely important in investigating the dynamic change of the village socio-economic structure (Refer Section 1.4.5.2 for a discussion of network stability.).

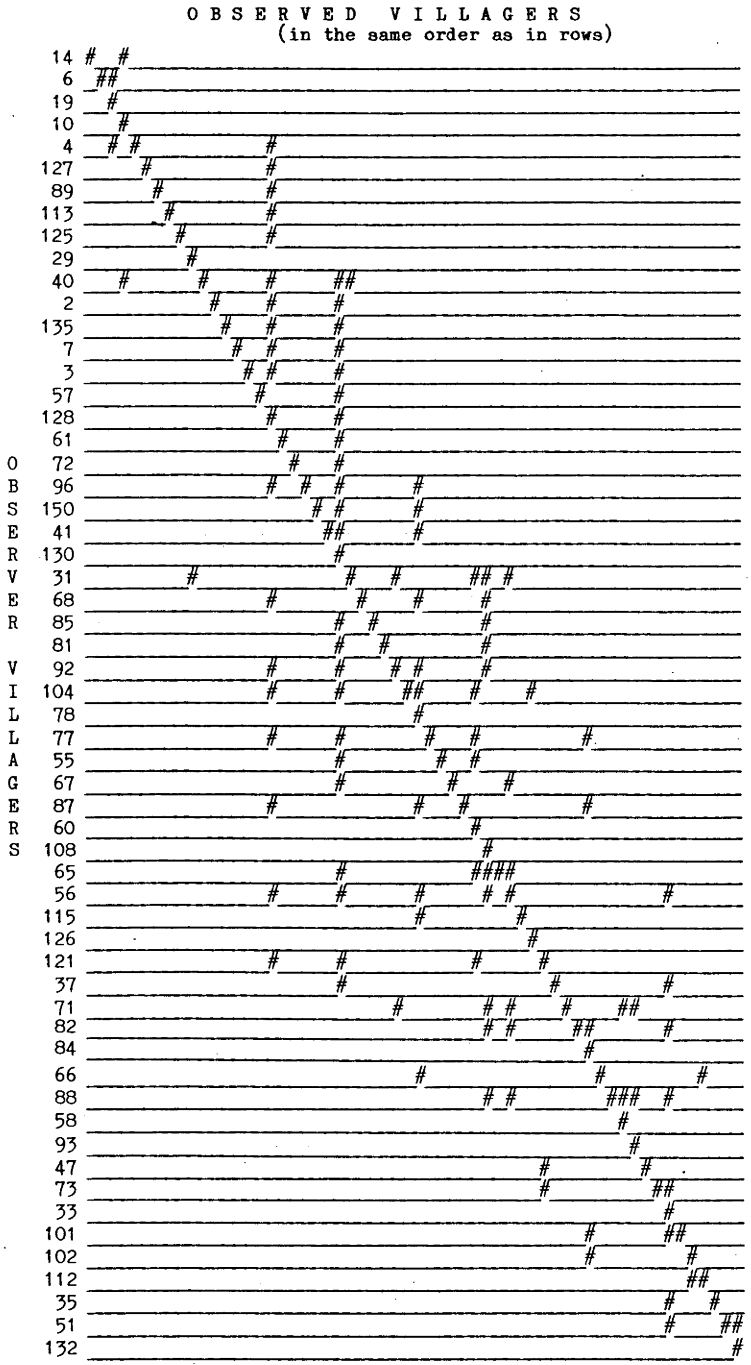
Figure 3-10 is the network expression of villagers' citrus siam observation activities. 58 villagers were involved in these activities (Refer Section 2.4.1 for numbers of villagers who had adopted certain crops.). In this network, citrus siam plots of Villagers 128, 130, 78, 60, 108 and 33, who were either early adopters or growers of large plots of citrus siam were observed by a relatively large number of others.

3.8 Belatung Socio-Economic Structure

The results in the preceding sections clearly indicated that the numbers of villagers involved in non-hierarchical interactions were much greater than those of villagers involved in hierarchical interactions. As discussed elsewhere, hierarchical relations between villagers can be elicited after identifying groups of villagers who shared almost

Figure 3-10: Citrus Siam Observation Network

(Asymmetric)



NOTE: # denotes the existence of interaction between a villager in a column and a villager in a row.
along the diagonal line denotes a villager himself numbered in a row.

identical agricultural information through either the direct exchanges which are represented by the direct agricultural information exchange interactions, or indirect exchanges represented by other non-hierarchical interactions. The fact that the number of villager involved in hierarchical interactions was much smaller than those involved in non-hierarchical interactions implies that the effect of incorporation of hierarchical interactions into the elicitation of groups of villagers who shared almost identical information did not seriously alter the elicitation of those groups without these hierarchical interactions. Hence, hierarchical and non-hierarchical relations can be separately analysed for the elucidation and explanation of the village socio-economic structure. In the analysis of this section, firstly, the following five non-hierarchical relations are used:

1. Direct agricultural information exchange,
2. Household goods exchange,
3. Money lend/borrowing,
4. Kinship relations,
5. Meeting-at-shops.

If these five types of non-hierarchical relations are used with relational approach, associations[40] identified may represent sets of villagers who shared almost identical direct or indirect agricultural information. These associations are called, from here on, relational associations. Hierarchical relationships among these relational associations are then identified by examining the remaining four types of hierarchical interactions among them.

Secondly, the five non-hierarchical relations are examined by structural approach, and structural associations are derived. Members of these structural associations are considered as playing similar roles in disseminating agricultural information in the village.

Finally, memberships of the relational and structural associations are cross-

[40]The term "association" is used to avoid confusions expected if the term "group" is used again for labelling a set of villagers identified according to villagers' memberships of groups in various interactions.

tabulated, and basic associations are derived. Member-villagers of a basic association are regarded as both sharing similar information and playing similar roles in disseminating information. Since relational associations, being based on actual interactions among villagers, are thought to be more observable, socio-economic characteristics and cropping patterns of the relational associations are investigated.

3.8.1 Relational Associations

The village socio-economic structure was elicited according to the networks of socio-economic interactions among villagers, namely, those of direct agricultural information, kinship relations, household goods exchange, money lending/borrowing, and meeting-at-shops relations. The procedure in eliciting this village socio-economic structure was based upon villagers' membership in certain groups within socio-economic networks. Their membership in the same group in respective network systems was summed across all five networks. Any two villagers who had a high coincidence of membership in several groups were grouped together in one association in the village socio-economic structure. The procedure is in fact almost identical to that employed for identifying groups in the respective network system.[41] The results are shown in Figure 3-11.

In Figure 3-11, the numbers on the left side of the matrix represent the villagers' identification numbers (one for each row). The symbols in the rows indicate the strength of interactions with the villagers in the columns who are in the same order as those in the rows. The S-symbols on the diagonal line represent villagers' interactions with themselves. The +, *, and #-symbols stand for the strength of interactions. Thus if a villager in a row belonged to the same group as a villager in a column for one network only, a + symbol is given. The * and the # symbols respectively indicate correspondence in two and three or more networks. Identified associations are enclosed in rectangulars.

Five associations were identified in the analysis of network systems of the above five types of socio-economic interactions among villagers.[42]

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[41] For actual procedures, see Section 3.2.4.

[42] As reviewed in Section 3.2.4, numerical taxonomy recommends some other clustering methods for confirming results by the first method. A discriminant analysis was conducted on the results of this group identification, whose results were 100% justified.

Figure 3-11: Relational Associations

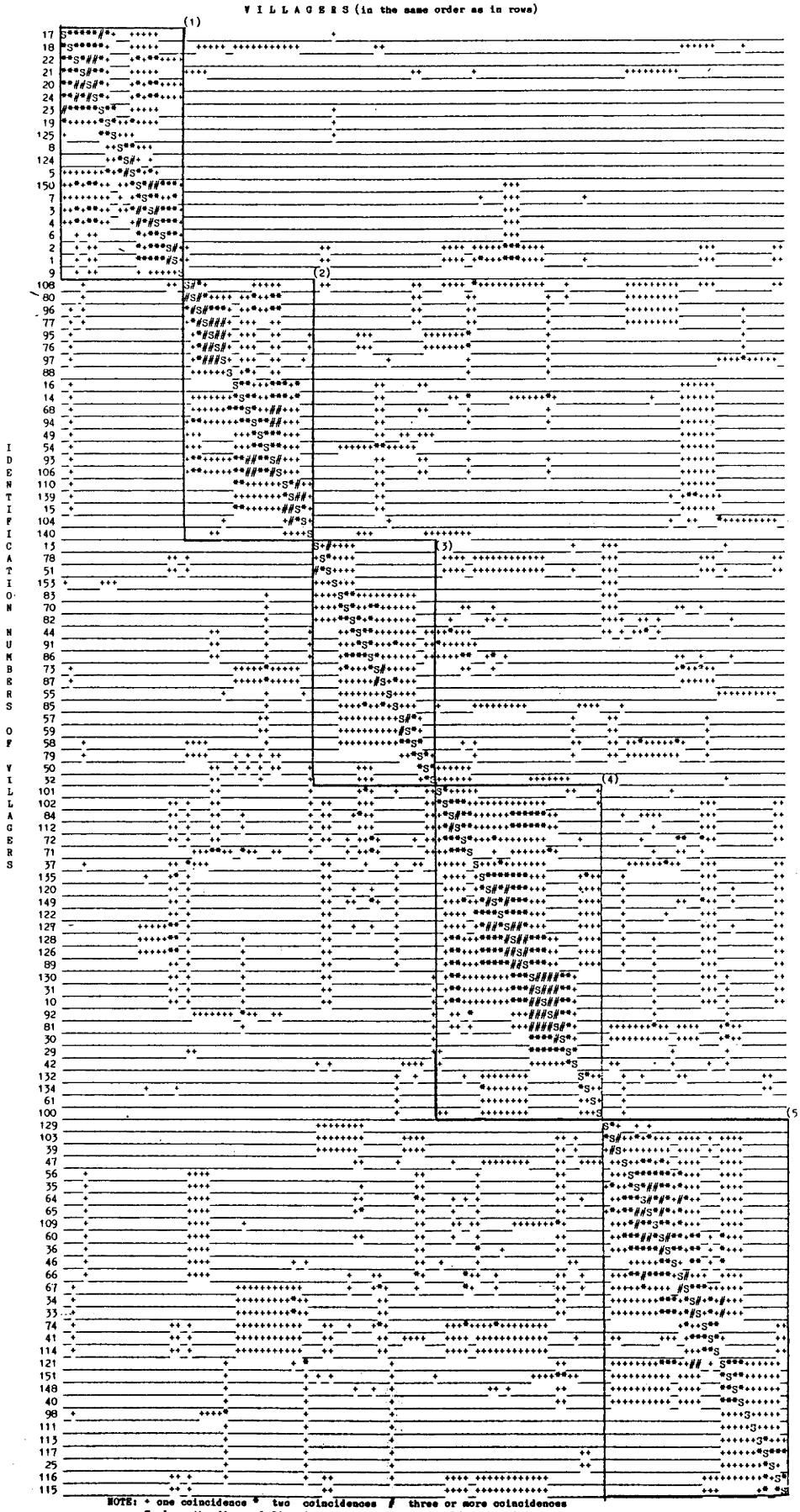

Table 3-9: Interactions between Relational Associations - 1

		ASSOCIATIONS 1	2	3	4	5		
	AGRICULTURAL INFORMATION						DENSITY(b)	N
A	1	50(.89)	0(.00)	0(.00)	5(.09)	1(.02)	0.13158	20
S	2	0(.00)	72(.56)	17(.13)	24(.19)	15(.12)	0.17143	21
S	3	0(.00)	17(.20)	42(.49)	17(.20)	9(.11)	0.11053	20
O	4	5(.03)	24(.15)	17(.10)	86(.53)	31(.19)	0.12251	27
C.	5	1(.01)	15(.11)	9(.07)	31(.23)	76(.58)	0.08736	30
	HOUSEHOLD GOODS EXCHANGE							
	1	64(.94)	1(.01)	0(.00)	2(.03)	1(.01)	0.16842	20
	2	1(.02)	38(.88)	0(.00)	2(.05)	2(.05)	0.09048	21
	3	0(.00)	0(.00)	12(.55)	6(.27)	4(.18)	0.03158	20
	4	2(.04)	2(.04)	6(.12)	32(.63)	9(.18)	0.04558	27
	5	1(.02)	2(.04)	4(.09)	9(.20)	30(.65)	0.03448	30
	LEND/BORROW MONEY							
	1	22(.76)	1(.03)	4(.14)	2(.07)	0(.00)	0.05789	20
	2	1(.02)	28(.61)	6(.13)	6(.13)	5(.11)	0.06667	21
	3	4(.11)	6(.17)	12(.34)	7(.20)	6(.17)	0.03158	20
	4	2(.03)	6(.09)	7(.10)	44(.65)	9(.13)	0.06268	27
	5	0(.00)	5(.10)	6(.12)	9(.18)	30(.60)	0.03448	30
	KINSHIP RELATIONS							
	1	40(.75)	2(.04)	2(.04)	0(.00)	9(.17)	0.10526	20
	2	2(.01)	46(.32)	18(.13)	29(.20)	49(.34)	0.10952	21
	3	2(.01)	18(.11)	56(.35)	50(.31)	35(.22)	0.14737	20
	4	0(.00)	29(.08)	50(.14)	232(.66)	39(.11)	0.33048	27
	5	9(.04)	49(.20)	35(.14)	39(.16)	112(.46)	0.12874	30
	TOTAL (a)							
	1	176(.85)	4(.02)	6(.03)	9(.04)	11(.05)	0.11579	20
	2	4(.01)	184(.51)	41(.11)	61(.17)	71(.20)	0.10952	21
	3	6(.02)	41(.14)	122(.40)	80(.26)	54(.18)	0.07895	20
	4	9(.01)	61(.10)	80(.13)	394(.62)	88(.14)	0.13960	27
	5	11(.02)	71(.15)	54(.11)	88(.19)	248(.53)	0.07126	30

Source: Figures 3-2, 3-3, 3-7, and 3-9

Notes:

Figures without parentheses are total numbers of interactions.

Figures in parenthesis are ratios of number of interactions between two groups to total number (across) of interactions.

(a) The meeting-at-shops network only indicates weakly probable interactions, while other four networks above indicate the actual presence of or strongly probable interactions. Therefore, this network is excluded from the totals. No arbitrary weights were used for summation. (continues to Table 3-10)

Table 3-10: Interactions between Relational Associations - 2

		A S S O C I A T I O N S						
		1	2	3	4	5		
HIRED-IN/OUT LABOUR		H I R E D					DENSITY(b)	N
H	1	2(.67)	0(.00)	0(.00)	1(.33)	0(.00)	0.00526	20
I	2	0(.00)	6(.38)	6(.38)	1(.06)	3(.19)	0.01429	21
R	3	2(.08)	4(.16)	9(.36)	2(.08)	8(.32)	0.02368	20
E	4	16(.39)	3(.07)	8(.20)	8(.20)	6(.15)	0.01140	27
R	5	3(.17)	4(.22)	5(.28)	1(.06)	5(.28)	0.00575	30
LAND SALES/PURCHASE		S E L L E R						
B	1	0(.00)	0(.00)	0(.00)	0(.00)	1(1.0)	0.00000	20
U	2	0(.00)	5(.50)	1(.10)	1(.10)	3(.30)	0.01190	21
Y	3	0(.00)	2(.12)	6(.35)	4(.24)	5(.29)	0.01579	20
E	4	0(.00)	1(.05)	7(.33)	8(.38)	5(.24)	0.01140	27
R	5	1(.09)	2(.18)	3(.27)	1(.09)	4(.36)	0.00460	30
LAND LEASE		L E A S E - I N						
L	1	1(1.0)	0(.00)	0(.00)	0(.00)	0(.00)	0.00263	20
E	2	0(.00)	1(.50)	0(.00)	1(.50)	0(.00)	0.00238	21
A O	3	0(.00)	0(.00)	1(1.0)	0(.00)	0(.00)	0.00263	20
S U	4	0(.00)	1(.20)	2(.40)	0(.00)	2(.40)	0.00000	27
E T	5	0(.00)	3(.38)	0(.00)	0(.00)	5(.63)	0.00575	30
CITRUS SIAM OBSERVATION		O B S E R V E R						
O	1	2(1.0)	0(.00)	0(.00)	0(.00)	0(.00)	0.00526	20
B	2	0(.00)	3(.25)	2(.17)	5(.42)	2(.17)	0.00714	21
S V	3	1(.08)	4(.33)	1(.08)	2(.17)	4(.33)	0.00263	20
E E	4	9(.16)	10(.18)	7(.13)	17(.30)	13(.23)	0.02422	27
R D	5	0(.00)	4(.18)	6(.27)	5(.23)	7(.32)	0.00805	30
TOTAL		I N F E R I O R					TOTAL N	AVE.
S	1	5(.71)	0(.00)	0(.00)	1(.14)	1(.14)	7 20	.35
U	2	0(.00)	15(.38)	9(.23)	8(.20)	8(.20)	40 21	1.90
P I	3	3(.05)	10(.18)	17(.31)	8(.15)	17(.31)	55 20	2.75
E O	4	25(.20)	15(.12)	24(.20)	33(.27)	26(.21)	123 27	4.56
R R	5	4(.07)	13(.22)	14(.24)	7(.12)	20(.36)	59 30	1.97
TOTAL		37(.13)	53(.19)	64(.23)	57(.20)	73(.26)	284 118	2.41
AVE.		1.85	2.52	3.20	2.11	2.43		
NET(c)		-1.50	-0.62	-0.50	2.45	-0.46		

(b) (continued from Table 3-9) Density is a measure of intensity of interactions within an association, defined as ratio of the number of actual interactions within the association to the possible maximum number of interactions within the association. If there are N members in an association, the latter is N(N-1).
(c) NET is the difference between the average number of superior relations (average in row) and the average number of inferior relations (average in column). If negative, the association is net inferior, and if positive, the association is net superior.

The original network system of direct agricultural information represents the relationships of villagers in terms of their "direct" information flows, such as conversations about agricultural problems. Other networks are regarded as media which indirectly transmitted agricultural information, through their respective socio-economic interactions and relationships. The relational associations revealed by studying these network systems of socio-economic interactions and relationships can accordingly be viewed as indicating how agricultural information was transferred both directly and indirectly, and as indicating those who shared agricultural information with each other.

This function of the relational associations can be examined by checking interactions between associations, rather than between individual villagers. Tables 3-9 and 3-10 show how relational associations interacted with each other and themselves in particular socio-economic networks.

Table 3-9 summarises how relational associations interact with each other in networks of four non-hierarchical relations. As indicated by numbers along the diagonal lines in matrices, the largest proportion of all interactions were within each association. On the other hand, hierarchical relations were mostly between different associations, as shown in Table 3-10, with an exception of Relational Association 1. This association had few hierarchical relations as superior, and therefore, can be excluded from considerations.

3.8.2 Structural Associations

As shown in the "Total" section of Table 3-9, members of each association shared information more with each other than with villagers of other associations. This satisfies one condition whereby the members of a set of villagers may be expected to behave similarly. Another condition still to be assumed is that the villagers in an association played almost identical roles in the network of agricultural information diffusion in the village.[43]

Villagers who played similar roles in terms of disseminating agricultural information in the village are expected to have been more interested in each other's socio-economic condition and behaviour than other villagers'. Thus it is plausible to assume that a

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[43]Refer Section 3.2.3.

villager was more or less substitutable with, and interdependent with villagers who played similar roles, and all these villagers may be assumed to have identical utility functions in terms of their pattern of interdependence. For the villagers who did not play similar roles, somewhat different utility functions should be assumed.

The adoption process model of Burt (1980b) with an interdependence utility function was constructed on this basis. For villagers to have identical utility functions, they must play similar roles in disseminating agricultural information in the village, as well as having identical amounts of sources of their welfare.[44]

To aggregate villagers with similar patterns of interdependence, social distances among villagers were calculated according to the five types of reciprocal interactions used to identify relational associations, and Ward's method of hierarchical clustering was then used, and Figure 3-12 shows the results. In this study, the author chose 35 of the fusion criterion (within-group variance) for the cut-off point, since the value of the fusion criterion (within-group variance) also started increasing very rapidly around this point.[45] According to the average independence coefficient of members of the structural associations (Table 3-11), Structural Associations 5 and 3 were identified as being strongly independent, i.e., opinion leaders' associations, while Structural Associations 4 and 1 were identified as being the least independent. Structural Association 2 was in the middle, but closer to Structural Associations 4 and 1 than to Structural Associations 5 and 3.

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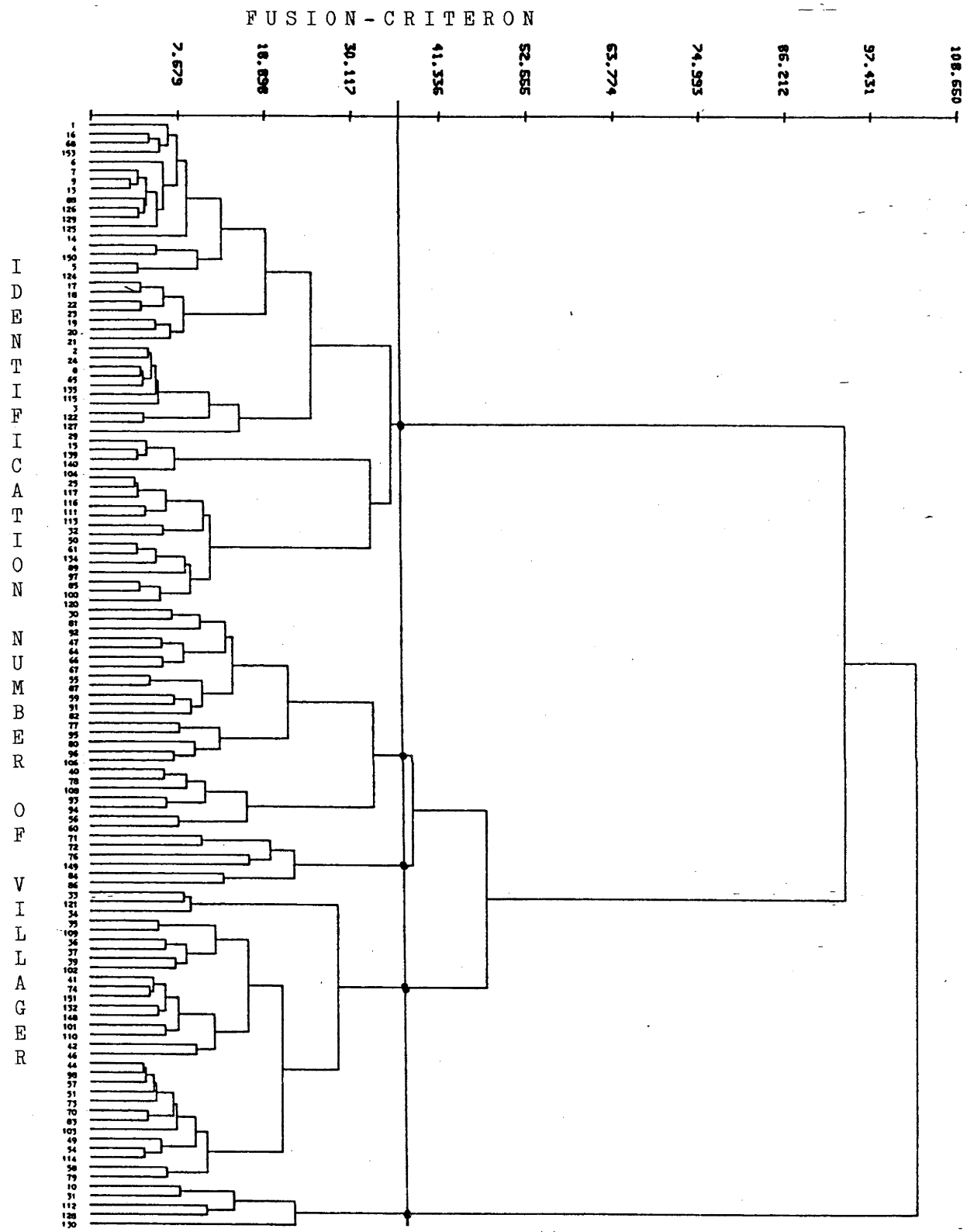
[44]See reviews in Section 1.4.4.2.

[45]The author utilised Ward's hierarchical clustering method in two segments in this study (Section 2.4.1 and this section). A statistically robust criterion for selecting the optimal number of clusters is not yet available, although there are numerous criteria in the literature. The values of the particular fusion criterion are plotted with the numbers of clusters. The point where the value suddenly increases is selected as the optimal number of clusters. For details, see Everitt (1977, 1979).

Figure 3-12: Cluster Analysis of Structural Associations



Note: The fusion criterion of Ward's method is twice the increase in the within-group variance caused by a fusion.

3.8.3 Basic Associations

Table 3-11: Basic Associations

		RELATIONAL ASSOCIATIONS						
		1	2	3	4	5	Total	Average Independence Coefficient
STRUCTURAL ASSOCIATIONS	5.	0	0	0	(14) 5#	0	5	0.280177
	3.	0	(5) 1	(9) 1	(13) 4#	0	6	0.172932
	2.	0	(4) 8#	(8) 6	(12) 3	(17) 7	24	0.062650
	4.	0	(3) 3	(7) 8*	(11) 5	(16) 15*#	31	0.040549
	1.	(1) 20*#	(2) 9*	(6) 5	(10) 10*	(15) 8	52	0.038335
	Total	20	21	20	27	30	118	0.060953

Notes:
A number in a parenthesis is an identification number of a basic association.
An asterisk denotes a core association of a relational association, which corresponds with the largest cell within the relational association.
A # denotes a core association of a structural association, which correspond with the largest cell within the structural association.
See also Table 3-1 for the idea of basic associations.
Sources:
Figure 3-11: relational associations.
Figure 3-12: structural associations.

Table 3-11 shows the cross-tabulation of the villagers according to the relational and structural associations. Each cell is a basic association, members of which are regarded as sharing almost identical information and playing almost identical roles in disseminating information. Seventeen basic associations were identified. A cell with * or # respectively represents a core association of a particular relational or structural association.

Relational Association 1 was not divided at all, and completely corresponded to Basic Association 1. Hence, this association can be regarded as a homogeneous one.

Relational Association 5 was divided into three basic associations and mainly characterised by Basic Association 16 which corresponded to Structural Association 4. Relational Association 3 was divided into four basic associations, and mainly

characterised by Basic Association 7 which also corresponded to Structural Association 4. These two relational associations were thus mainly represented by one basic association. In this sense, these can also be regarded as homogeneous.

Relational Associations 2 and 4 were polarised and heterogeneous. Relational Association 2 was divided into four basic associations and mainly characterised by Basic Associations 2 and 4 which respectively corresponded to Structural Associations 1 and 2. Relational Association 4 was divided into five basic associations and mainly characterised by three basic associations. Two of them correspond with structural associations which had higher average independence coefficients, and the rest corresponded to the lowest structural association in terms of the independence coefficient. This association was more polarised and heterogeneous than Relational Association 2, because the higher characteristic basic associations were much higher than that of Relational Association 2 in terms of independence coefficient. Though members of these two relational associations shared almost identical information, their roles in disseminating the information were clearly different. Members of higher basic associations (Basic Associations 13 and 14 in Relational Association 4, and Basic Associations 4 and 5 in Relational Association 2) may be regarded as groups of leaders of these relational associations, while the remaining lower basic associations may be regarded as groups of subordinates or followers.[46]

Table 3-12 shows members of each basic association, their memberships of groups in networks of interactions, and their independence coefficients.

3.8.4 Socio-Economic Characteristics of Relational Associations

Table 3-13 details some important socio-economic characteristics of relational associations in the village socio-economic structure, and Table 3-14 presents their cropping patterns. Six extremely successful villagers were excluded from the former table, since it was felt that socio-economic characteristics of these associations were thus better indicated.

In the following paragraphs, the characteristics of the five relational associations are

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[46]Refer Section 3.2.3 and Table 3-1.

Table 3-12: Villagers in Basic Associations

ASSOCIATIONS			Villager	INTERACTIONS(b)					INDEPENDENCE
BASIC	RELATIONAL	STRUCTURAL	ID(a)	1	2	3	4	5	COEFFICIENT
1	1	1	1	5	8	6	1	2	0.039116
			2	5	8	6		3	0.039011
			3	1	8	6	5	3	0.036711
			4	1	8	6		2	0.040994
			5	1	11	7	5	2	0.039691
			6		8	6		2	0.037853
			7	1	9	6	1	2	0.032023
			8		9	7	5	3	0.032969
			9		8			2	0.028751
			17	1		8	10	2	0.037063
			18	1	3	8	11	2	0.034437
			19	1		7	10	2	0.041162
			20	1	8	8	7	3	0.038347
			21	1	2	8	7	3	0.036695
			22	1	8	8		2	0.035813
			23	1	10	8	10	2	0.040418
			24	1	8	8		3	0.036134
			124		11	7	5	2	0.039218
			125		10	7	10	2	0.036096
			150	1	8	6	5	2	0.041765
2	2	1	14	7	3	9	13	2	0.045360
			15	2	3	9	4	4	0.044109
			16		3	9	17	2	0.032167
			68	7	3	5	17		0.035361
			88	7		5		3	0.030646
			97	7	4	11	11	1	0.043477
			104	2	4	15	4	4	0.048328
			139	2	3	15	4	4	0.039719
			140	2	6			4	0.039429
3	2	4	49	8	3	13	8	1	0.035378
			54	6	3	13		1	0.040927
			110	2	3	9		3	0.036570
4	2	2	77	7	2	11	11	3	0.053350
			80	7	2	13	14	3	0.071032
			93	7	3	13	17	3	0.070387
			94	7	3	13		3	0.082397
			95	7	6	11	11	1	0.080256
			96	7	2	13	11	1	0.046496
			106	7	3	13	17	1	0.038940
			108	5	2	13	14	1	0.120180 *
5	2	3	76	7	6	11	11	1	0.313290 *

Notes are shown on page 156. (continues)

Table 3-12, continued

ASSOCIATIONS			Villager	INTERACTIONS(b)					INDEPENDENCE
BASIC	RELATIONAL	STRUCTURAL	ID(a)	1	2	3	4	5	COEFFICIENT
6	3	1	13		1	4	16	2	0.030488
			32	8	6	14		3	0.044188
			50	8	6		17	1	0.037997
			85	6	5	1	6	3	0.043591
			153		1		10	1	0.034087
7	3	4	44	6	6	12	18	1	0.030476
			51	5	1	4	16	1	0.032218
			57	6		18	8	1	0.031821
			58	6	2	18	15	1	0.042262
			70	6	1	10		1	0.036200
			73	6	3	10	3	1	0.033980
			79	8	2	18	17	3	0.037421
			83	6	1				0.035413
8	3	2	55	6	4				0.037770
			59	6		18	8	1	0.041760
			78	5	1				0.077648
			82	6	1	12	12	1	0.051732
			87	6	3	1	3		0.048850
			91	6	6		6	1	0.046745
9	3	3	86	6	6	10	12	3	0.070787
10	4	1	29	3	7	14	14	3	0.082289
			61		5			1	0.029349
			89	5	5		13	1	0.043904
			100		5	2		3	0.032759
			120	5	5		12	3	0.059030
			122	5	5	16		3	0.045448
			126	5	5	6	13	2	0.032078
			127	5	5	6	12	3	0.043639
			134	9	5		1		0.033429
			135	5	5		1	3	0.033744
11	4	4	37	5	2	16	6	3	0.046370
			42	3	7	18	16	3	0.051150
			101	3	6	2	6	3	0.036799
			102	5	6	2		3	0.052506
			132	9	5		15	3	0.034467
12	4	2	30	4	7	14		3	0.040626
			81	4	7	14	13	1	0.052853
			92	7	7	14	13	1	0.055865

Notes are on page 156. (continues)

Table 3-12, continued

ASSOCIATIONS			Villager	INTERACTIONS(b)					INDEPENDENCE
BASIC	RELATIONAL	STRUCTURAL	ID(a)	1	2	3	4	5	COEFFICIENT
13	4	3	71	7	6	10	13	3	0.088135
			72	5	6	10	15	1	0.115545
			84	5	6	12	13	3	0.128561 *
			149	5	5	10	12	3	0.321273 *
14	4	5	10	5	7	14	13	2	0.182356 *
			31	5	7	14	13	3	0.307934 *
			112	5	6		13	2	0.197614 *
			128	5	5	6	13	2	0.308205 *
			130	5	7	14	13	2	0.404775 *
15	5	1	25	9	4			3	0.032566
			65	4	2	12	18	3	0.032035
			111		4			2	0.033260
			113		4		2	2	0.034648
			115	5		17	2	3	0.037371
			116	5	4	17		3	0.032329
			117	9	4	17	2	3	0.031444
			129		1		18	2	0.030866
16	5	4	33	4	3	15	9	3	0.066439
			34	4	3	15	9	3	0.056449
			35	4	2	3	18	3	0.042124
			36	4	2	16	9	3	0.043463
			39	4	1	18		3	0.055818
			41	5	3	18	9	3	0.033760
			46	3	2	15	9	1	0.041574
			74	5	3	10		3	0.035531
			98		4		11	1	0.030670
			103	4	1	18	18	1	0.041678
			109	4	2	3	13	1	0.040270
			114	5	3			1	0.033053
			121	4	4	15	9	1	0.055980
			148	4	4		12	3	0.034697
			151	4	4	14	16	3	0.031547
17	5	2	40	4	4			1	0.046176
			47	4	5	12		1	0.042763
			56	4	2				0.095467
			60	4	2	12	9	1	0.179143 *
			64	4	2	12	15	1	0.050165
			66	4	2	10	15	1	0.037520
			67	4	3	10	15	3	0.035469

Notes are on page 156. (continues)

Table 3-12, continued

Notes:
(a) ID: Identification numbers of villagers.
(b) INTERACTIONS
Figures are group identification numbers in the network of:
1. Agricultural Information, Figure 3-9, Table 3-8.
2. Kinship, Figure 3-2, Table 3-4.
3. Household Goods exchange, Figure 3-7, Table 3-6.
4. Money Lending/Borrowing, Figure 3-3, Table 3-5.
5. Meeting-at-shops, Figure 3-8, Table 3-7.
(c) A figure in a column is the number of a group to which villagers belong in the network of interaction represented by the column number.
(d) An asterisk indicates the independence coefficient is greater than the average plus one standard deviation (about 0.12).

described from the point of view of the network systems to which they relate, referring to Table 3-9 as well as Tables 3-13 and 3-14. Further, some prominent villagers are identified according to independent coefficients from Table 3-12.

3.8.4.1 Relational Association 1

This association consisted of the National Railway workers and two villagers who lived at the southwest end of the village, where most of the Javanese National Railway workers outside the *bedeng*s lived. As seen in previous sections, the National Railway workers formed very isolated groups in every network system. Hence, they were naturally classified into this association in the village socio-economic structure.

The figures in Table 3-9 show that the isolation of this association was outstanding. The highest proportion of interactions were confined within the association itself. In total, 85 percents of all interactions were confined within this association, compared with 40 - 62 percent of all interactions for the other associations.

Although interactions with other associations were relatively few, there were some conspicuous ones. Thus, nine percent of direct agricultural information exchange interactions were with Association 4, 14 percent of money lending/borrowing interactions were with Association 3, and 17 percent of kinship relations were with Association 5. Association 4 included most of the village elites, and it therefore seems natural that members of Association 1 should have had contact with its members. Association 3 includes Villager 153, a widow of a section head of the National Railway, who bought groceries for the National Railway workers who could not often go to Baturaja. She often

Table 3-13: Socio-Economic Characteristics of Relational Associations

	Relational Associations					
	1	2	3	4	5	All
Annual Income (Rp)	680070 (253424)	1051963 (437727)	1034741 (533320)	1382177 (712283)	978623 (602840)	1034911 (581402)
Agricultural Income(a)	15750 (66989)	692563 (477912)	689941 (396114)	905885 (570760)	815366 (664481)	645672 (586615)
Non-Agric. Income	664320 (206396)	359400 (440264)	344800 (425180)	476292 (510306)	163257 (287624)	389239 (416848)
Land (Ha)	0.60 (0.61)	3.56 (3.47)	4.72 (3.77)	4.54 (3.05)	6.39 (6.88)	4.13 (4.70)
Age (Yr.)	41.00 (10.81)	46.30 (13.44)	45.53 (18.34)	40.00 (12.42)	44.34 (13.47)	43.34 (13.75)
Household Size	5.40 (1.79)	5.90 (2.61)	5.07 (1.71)	5.79 (2.47)	5.71 (2.64)	5.62 (2.31)
Male [0,15]	1.50 (1.19)	1.65 (1.79)	0.87 (0.99)	1.42 (1.35)	1.43 (1.37)	1.40 (1.37)
[16,60]	1.45 (0.60)	1.65 (1.04)	1.20 (1.08)	1.13 (0.85)	1.43 (0.92)	1.37 (0.91)
[61,--]	0.00 (0.00)	0.10 (0.31)	0.40 (0.63)	0.08 (0.28)	0.21 (0.42)	0.15 (0.38)
Total	2.95 (1.43)	3.40 (1.93)	2.47 (1.13)	2.63 (1.69)	3.07 (1.59)	2.93 (1.60)
Female [0,15]	1.00 (0.92)	1.15 (0.93)	1.13 (0.92)	1.67 (1.49)	1.04 (1.29)	1.21 (1.18)
[16,60]	1.40 (0.82)	1.30 (0.73)	1.27 (0.70)	1.46 (0.78)	1.46 (0.79)	1.39 (0.76)
[61,--]	0.05 (0.22)	0.05 (0.22)	0.20 (0.41)	0.04 (0.20)	0.14 (0.36)	0.09 (0.29)
Total	2.45 (1.23)	2.50 (1.32)	2.60 (1.35)	3.17 (1.58)	2.64 (1.75)	2.69 (1.49)
Farming Experience(Yr)	16.50 (11.12)	19.95 (12.12)	21.27 (19.02)	15.13 (10.90)	18.89 (14.86)	18.13 (13.53)
Education (proxy)	4.80 (3.72)	4.95 (3.20)	6.47 (3.64)	7.79 (5.00)	5.89 (3.40)	6.02 (3.96)
Radio	0.30	0.35	0.47	0.58	0.39	0.42
Radio Agric. Prog.(time/wk)	1.00 (1.97)	1.30 (2.30)	1.27 (2.22)	2.75 (2.77)	1.93 (2.94)	1.73 (2.56)
Visits to Baturaja (time/yr.)	20.8 (17.4)	61.6 (107.0)	50.9 (97.7)	81.7 (106.0)	34.5 (69.4)	49.9 (86.5)

Notes: (a) Agricultural income from sources in and outside Belatung.
(b) Figures in parentheses are standard deviations.
Source: Fieldwork

Table 3-14: Cropping Pattern of Relational Associations

Crop	Relational Association 1	2	3	4	5	All
Coffee	5%	52%	50%	67%*	62%	50%
Duku	25	57	45	52	60*	49
Citrus S.	40	38	40	74*	50	50
Rice	40	81	70	81	87*	74
Rambutan	40*	14	25	22	7	20
Pineapple	25*	10	10	15	0	11
Rubber	5	57	70*	56	63	52
Cloves	0	5	25*	19	17	14
Durian	0	43	50*	48	50*	40
Ave.Crops	1.80	3.57	3.85	4.33*	3.97	3.59

Note: Asterisks denote the highest proportions or average among associations.
Source: Fieldwork

lent money to these workers. The connections with Association 5 involved two members of Association 1 who were Belatung native villagers.

Association 1 had seven superior and 37 inferior relations with villagers of other associations with a net average of 1.5 inferior relations per member. The association is therefore regarded as the most inferior association in the village (Table 3-10).

There was no particularly prominent member in this association, but in fact Villager 1 was relatively important (Table 3-12). He was born in the neighbouring village, Lebuk Batang Lama, but his daughter married Villager 4. Villagers 1 and 2 had a great degree of coincidence in their memberships of network systems, and at the same time had close associations with members in Association 4 in the village socio-economic structure. The reason for this strong association may be attributed partly to their meeting-at-shops

relationship with Villager 128, who owned a grocery shop in their residential area, but mainly to their relations with Villager 122, 128 and 149 in the direct agricultural information network. Villager 2 was a hired labourer for the National Railway. He needed additional income from employment by native villagers.

Association 1 had the lowest annual income, about two thirds of the village average, and since the National Railway workers involved are given only a small plot of land, the area under their management was the smallest among all associations (Table 3-13). The members were also young on average, with less farming experience. They also had the lowest educational attainment, the lowest radio possession ratio, the lowest agricultural programme listening rate, and even the lowest frequency of visiting Baturaja. In these senses, Association 1 was the lowest socio-economic association in the village, which apart from ethnic differences explains their isolation from native Belatung villagers' associations. The cropping pattern of this association was also markedly different from that of the rest of the village, essentially because of the small areas of land (Table 3-14). The members grew on average 1.8 crops, with the distinctive aspect that 25 to 40 percent of them cultivate citrus siam, rambutan and pineapple. These are perennial fruit crops which do not require large areas. The association also had the highest proportion of members growing rambutan or pineapple, while the proportion of those growing citrus siam was almost on the average village level.

3.8.4.2 Relational Association 2

This association consisted mainly of members of Groups 2 and 7 in the direct agricultural information network system, and Groups 2 and 3 in the kinship system (Table 3-12). These villagers had relatively loose connections with each other, if compared with members of other associations in the village socio-economic structure.[47]

Although villagers in the Lekis area were included in this association by virtue of their kinship and money lending/borrowing relationships, they were quite isolated.

Other members of this association had many contacts with native villagers' associations, especially Association 4 through direct agricultural information exchanges

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[47]For the definition of "loose connection", see a footnote on page 116.

and money lending/borrowing interactions. The hierarchical relations of Association 2 with Associations 3, 4 and 5 were most commonly inferior in net terms (Table 3-10), and this association can be regarded as the second most inferior in the village.

Association 2 included three prominent villagers, in terms of independence coefficients (Table 3-12): Villager 76, the principal of the primary school, Villager 95, a brother of the ex-village head, and Villager 108, a notable citrus siam trader/grower.

Association 2 may be termed as an "average" association in the village, with its average features approximately equal to the Belatung averages in most respects (Tables 3-13 and 3-14). However, members had the highest average age and the shortest formal education. The cropping pattern was relatively more oriented towards traditional crops, rice, rubber, coffee, duku and durian.

3.8.4.3 Relational Association 3

The members of Association 3 were mainly members of Groups 6 and 8 of the direct agricultural information network, and membership in groups in other network systems did not seem important in determining their membership of this association. Members of this association were not particularly closely connected to each other. Only 40 percent of their interactions were within the association. They were well connected to Association 4, the "Village Elites". Thus in the networks of the non-hierarchical relations (Table 3-9), more than 20 percent of interactions in each network were with Association 4. Association 3 had inferior relations only with Association 4, and had superior relations with all other three associations (Table 3-10). This association is accordingly viewed as the equal second superior, together with Association 5.

There was no prominent villager in this association (Table 3-12). However, if relationships in the direct agricultural information network were examined (Figure 3-9), it appeared that four villagers were well connected to those outside the association. Villagers 78 and 59 had many contacts with members of Association 2, Villager 86 with Association 4, and Villager 87 with Association 5. These villagers were relatively more prominent than other members of this association.

Association 3 is another association not too far from the average but had slightly more land, the smallest household size, the smallest male labour, the longest farming

experience, and the second longest formal education (Table 3-13). The association's average cropping pattern was more oriented towards rubber and new perennial crops, rambutan and clove, since more of its members' lands were situated in the ladang area. The proportion of those growing rubber was the highest (Table 3-14).

3.8.4.4 Relational Association 4

The village head (Villager 130), the ex-village head (Villager 84), four primary school teachers (Villager 10, 29's son, 31, 112), the Islamic religious teacher (Villager 71), a village official (Villager 120, shop owner) and two notable entrepreneur/farmers (Villagers 128 and 149) were all included in this association (Table 3-12).

Members of Group 7 of the kinship system were all in this association and formed its core in the sense that they provided most of the above leaders. They also formed a significantly distinct group in each network system in which they appeared. As mentioned in the section on the kinship system, Group 7 had always been the politically and economically ruling entity of Belatung.

Other members of this association were mostly from Groups 5 or 6 of the kinship system, which also included important families in the village.

This association was quite independent, with the second highest proportion of interactions contained within itself (after Association 1, Table 3-9). It also had superior relations with all other associations. It may thus be justifiably labelled as the village elite association (Table 3-10).

Seven members of Association 4 had distinct prominence (Table 3-12), and five villagers had many contacts with villagers of other associations. Villager 130, the village head, had the best contacts with all others except Association 1. Villagers 84, 71 and 92 had many contacts with Association 2, and Villagers 37, 31 and 30 had many contacts with Association 5.

Association 4 was significantly different from all other associations in socio-economic characteristics, and this was connected with its elite status previously described. Its annual average income was the highest among all associations, although its average landholding was similar to the village average. The average age of its members was the lowest, with the shortest farming experience, but these members had the best educational

attainment, with 58 percent of them possessing radios and listening to agricultural programmes on radio about 3 times a week. The average frequency of visits to Baturaja was also the highest at 82 times a year, i.e., roughly twice a week (Table 3-13). The average cropping pattern of this association was significantly different from that of the other associations of native Belatung villagers (Associations 2, 3 and 5), with higher proportions growing cash crops, and especially coffee and citrus siam (Table 3-14). The average number of crops grown was thus the highest of all, 4.33 crops. The members of this association seem to have succeeded best in diversifying their cropping pattern, to avoid the adverse effects of fluctuations of rubber price.

3.8.4.5 Relational Association 5

This relational association consisted of members of Groups 4 and 5 of the direct agricultural information system, and of Groups 2, 3 or 4 of the kinship system (Table 3-12). Although some members also belonged to Group 5 of the direct agricultural information network, these were villagers quite different from the members of Relational Association 4; they belonged to entirely different kinship groups.

This association was more connected with Association 4 than other associations, although the connection was not particularly strong (Table 3-9). It had superior relations with Associations 1 and 2, and inferior relations with Associations 3 and 4 (Table 3-10).

Among the members of Association 5, four villagers had many contacts with other groups in the direct agricultural information network. Villager 39, 47 and 56 had good contacts with Association 4, and Villager 60 had many contacts with Association 3. However, only Villager 60 was prominent in this association (Table 3-12).

Association 5 was again very different from other associations, but had the average annual income approximately equal to the village's (Table 3-13). The proportion of agricultural income, 83 percent, was much higher than that of other associations. Except for this, this association was quite an average association in terms of age, household size, farming experience, education, and radio possession/listening to programmes. The average cropping pattern was similar to that of Association 2, although there was more of almost all crops.

This association had the largest area of land under management, but the second

highest agricultural income. Its cropping pattern was oriented to coffee, citrus siam, durian and rice, with less rubber and duku, where the latter was presently the booming fruit cash crop (Table 3-14). In particular, its citrus siam was still young and not producing at full capacity.

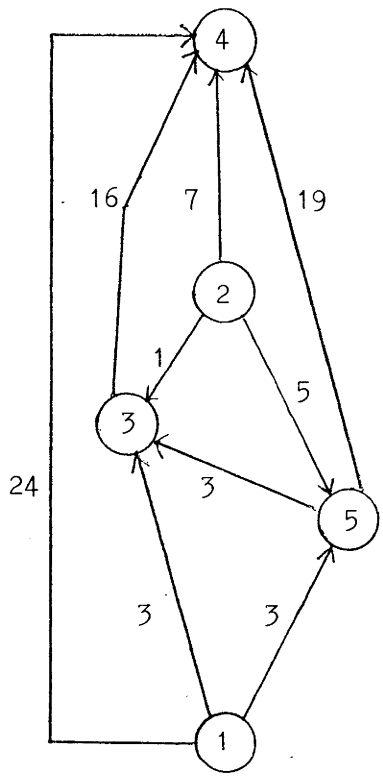
3.9 Summary

In this chapter, two approaches to identifying groups in a socio-economic interaction system were reviewed, and the procedure of eliciting groups in the village system was determined in light of the strengths and weaknesses of these approaches. Ten types of socio-economic interactions were originally selected, with a focus on the capability to transmit agricultural information among villagers. Because of the unavailability of the data, one type of interactions, i.e., exchange labour, was later excluded. In the first step using a relational approach, relational associations of villagers who were regarded as sharing almost identical information were identified. In the second step using a structural approach these relational associations were divided into basic and core associations of villagers who were considered as both sharing almost identical information and playing similar roles in disseminating information. Finally, socio-economic characteristics and cropping patterns of the relational associations were examined with use of the basic and core associations.

Figure 3-13 conceptualises the village socio-economic structure and presents some of the representative statistics of the relational associations.

According to the analyses of basic and core associations, the average socio-economic characteristics, and their hierarchical and non-hierarchical interactions, Relational Association 1 was identified as the low-class association, Relational Association 4 as the leaders' association and Relational Associations 2, 3 and 5 as the middle-class associations. The associations can be labelled similarly from the point of view of villagers' interdependence. Again, the associations' adoption rates of citrus siam gave a similar ordering.

Figure 3-13: Socio-Economic Structure of the Village



Annual Income (Rp)	Average Independence Coefficient	Average Net Relation	Citrus Siam Adoption Rate
1380000	0.105952	2.45	74%
1050000	0.064181	-0.62	38%
1030000	0.042272	-0.50	40%
980000	0.046476	-0.46	50%
680000	0.037213	-1.50	40%

Notes:
(a) Arrows indicate relations from inferior to superior, with figures showing their magnitude.
(b) A positive average net relation indicates that members of an association are superior to others on average, and a negative net relation denotes the opposite.
(c) Numbers in circles denote relational associations.

Sources:
Annual Income from Table 3-13,
Independence coefficients from Table 3-12,
Average Net Relations from Table 3-10,
Citrus Siam Adoption Rate from Table 3-14.

CHAPTER 4

Citrus Siam Adoption Process

4.1 Introduction

In Belatung and the surrounding areas, there were several relatively new crops, the adoption of which, villagers hoped, may improve their agricultural economic situation, which had been and was highly dependent on rubber production. Historically, villagers had tried various new crops. Coffee seems to have been the first alternative, followed by several types of citrus, including citrus siam. Cloves, pepper, pineapple, and rambutan had come after that. Except for coffee and citrus siam, these alternative crops had been either unsuitable for the climate or were still too recent in adoption for any conclusions to be reached.

In this chapter, firstly, the aggregate adoption processes of citrus siam in South Sumatra and in Belatung are described, and the aggregate adoption process in Belatung is explained by the relative prices of major crops. Since the purpose of this study is an explanation of intra-firm diffusion process and individual adoption behaviour, results here will not be detailedly pursued. Secondly, citrus siam adopters and non-adopters are compared from the point of view of their individual socio-economic characteristics. Thirdly, these adopters and non-adopters are examined in the light of their interdependence in the village socio-economic structure, to see whether interdependence is an important factor in explaining differences between villagers' times of adoption.

4.2 History of Adoption Process

4.2.1 South Sumatra

Citrus siam (Citrus Nobilis Microcarpa Hoslk (A.A.K. 1980)) is a type of mandarin orange with a green or orange skin and orange flesh. The name suggests its origin, but no confirmation is available. There seems to have been little varietal improvement, as each sac contains several seeds. A fruit trader from Lahat reported that a project in Riau province (Figure 2-1) had adopted a Japanese seedless variety of mandarin orange, but this information could not be confirmed.

4.2.1.1 Prehistory

The planting of citrus siam in South Sumatra can be traced back to the 1950's, according to elders of the village. It is said that citrus siam was even exported to Singapore through Palembang or nearby islands such as Bangka. Kabupaten Ogan Komering Ilir (O.K.I.), which is adjacent to Palembang and Kabupaten Bangka, was the main production area.

The elders also recall that a disease attacked citrus siam in O.K.I. in the late 1960's or early 1970's, exterminating citrus siam in the area. While the story of the extermination is certainly exaggerated, the disease, identified as C.V.P.D. (Citrus Vein Phloem Degeneration), damaged citrus siam production in the area extensively.

4.2.1.2 First Boom and C.V.P.D.

Official data on citrus siam in South Sumatra first became available in 1969. Figure 4-1 shows the harvested area, production and yields in South Sumatra after 1969. Table 4-1 gives the statistics for both South Sumatra and the five Kabupatens mainly involved. Price data first became available in 1967, when an officer of the Food Crops Agency (Dinas Pertanian dan Tanaman Pangan) in Baturaja started privately collecting price data on various commodities traded in Baturaja markets (Matroni n.d.). Figure 4-2 presents the real prices of citrus siam and major crops based on this set of data.

The official data does not give any major indication of the effect of C.V.P.D. in O.K.I. However, a small decline in the total harvested area in South Sumatra (Figure 4-1), followed by an expansion in 1970-1971 and a surge in the price of citrus siam (Figure 4-2), suggest that extensive damage occurred and which initially led to a price rise. This was followed by an expansion in area which probably included Baturaja and other

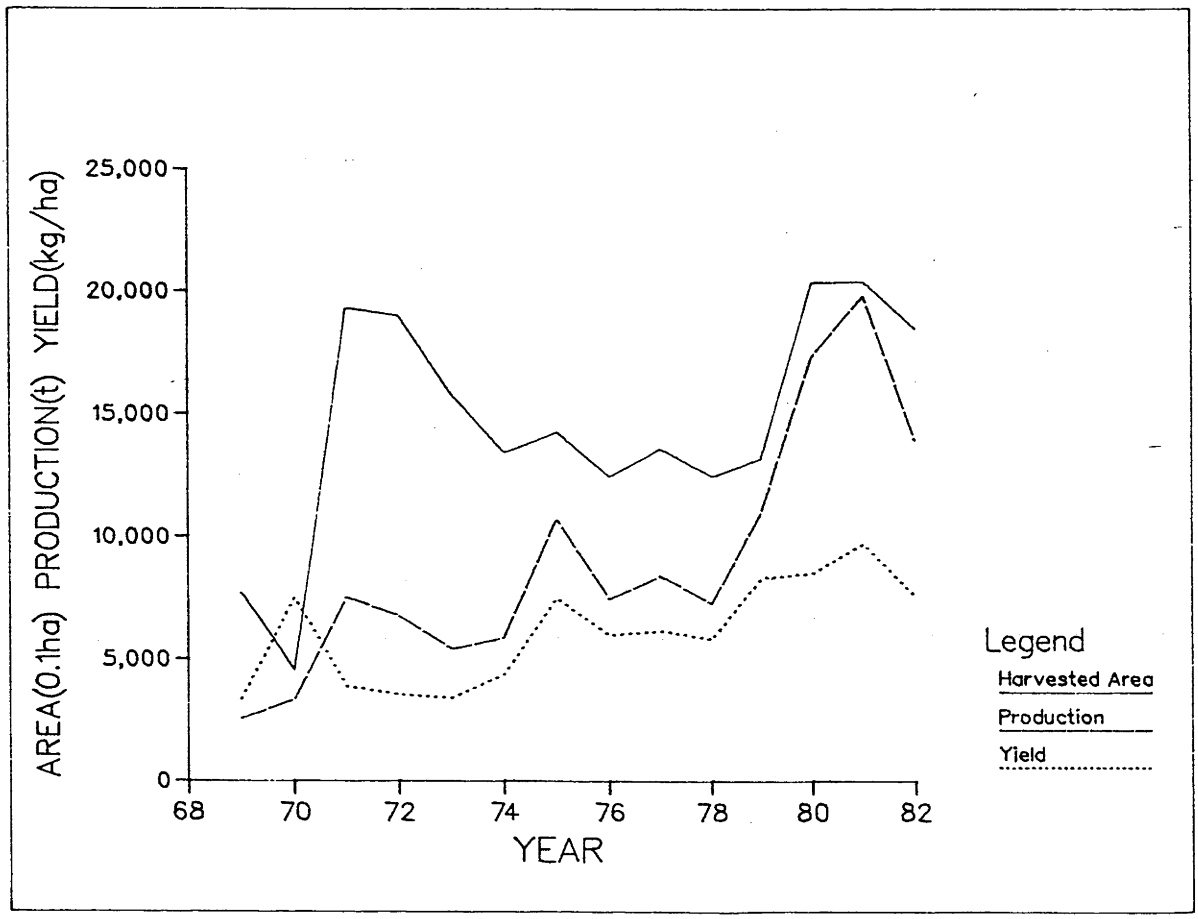
Table 4-1: Citrus Siam Production in South Sumatra 1969-1982

Year	South Sumatra Total	K A B P A T E N					
		O.K.I.	O.K.U.	Muara Enim	Lahat	Bangka	
	ton (ha.)	ton (ha.)	ton (ha.)	ton (ha.)	ton (ha.)	ton (ha.)	
1969	2574 (769)						
1970	3375 (450)						
1971	7500 (1931)						
1972	6750 (1899)						
1973	5407 (1580)						
1974	5900 (1345)						
1975	10717 (1429)						
1976	7476 (1246)						
1977	8412 (1363)						
1978	7258 (1246)	3384 (600)	550 (100)	390 (105)	321 (50)	2050 (343)	
1979	11043?(1325)	3984 (636)	750 (125)	392 (115)	322 (50)	2250 (350)	
1980	17351 (2038)	4750 (673)	7544 (757)	1520 (178)	648 (75)	2500 (300)	
1981	19823 (2040)	6770 (758)	6041 (511)	6011 (629)	431 (33)	175 (17)	
1982	13933 (1845)	5770 (544)	1419 (473)	3015 (450)	1760 (160)	1500 (150)	

Sources:
BAPPEDA Propinsi Daerah Tingkat I, Sumatera Selatan (1971-80)
Dinas Pertanian dan Tanaman Pangan Sumatera Selatan (1970-82)

Note:
(?) South Sumatran total production in 1979 is doubtful judging from Kabupaten level productions.

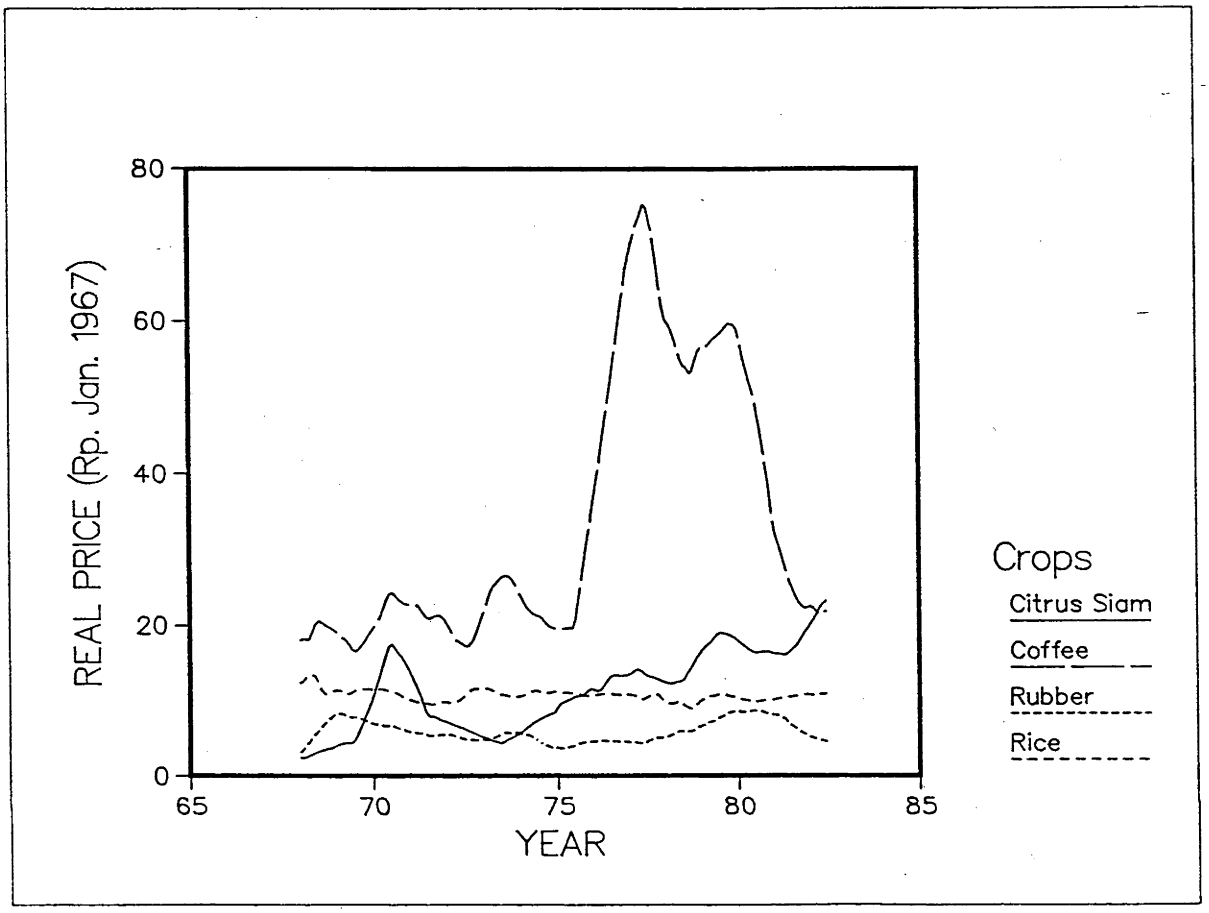
Figure 4-1: Citrus Siam Production in South Sumatra 1969-1982



Sources:

BAPPEDA Propinsi Daerah Tingkat I, Sumatera Selatan (1971-80).
Dinas Pertanian dan Tanaman Pangan Sumatera Selatan (1970-82).
Table 4-1.

Figure 4-2: Real Price of Major Crops in Baturaja 1967-1982



Notes:

(a) January 1967 Price (Rp/Kg).
(b) Consumer Price Index shown in Figure D-2 is used. For detail, see Appendix D.2.

Sources:

Matroni (n.d.).
Dinas Perdagangan Baturaja (1980-1983).
Figure D-2.

surrounding producing areas. However, since an expansion in harvested area requires an expansion in planted area three or four years earlier,[1] thus the attack of the C.V.P.D. may have occurred during the period of 1967-1970. Considering the paucity of available information, the above period is taken as the estimated time of attack.

The occurrence of an attack of C.V.P.D. in O.K.I. is also supported by the imposition of a local government prohibition on the export of citrus siam grafts from O.K.I., which was imposed in the early 1970's. This type of prohibition also occurs in Java. But owing to the eagerness of Outer Islands farmers to obtain grafts of this profitable crop, the prohibition has not been very successful (Kompas 1983b).

In South Sumatra, the C.V.P.D. is gradually spreading in areas other than O.K.I., following the expansion of citrus siam, and it has resulted in considerable damages. Declines in harvested areas and production in O.K.I. (1982) and Bangka (1981) were caused by this disease. The Ministry of Agriculture and its Food Crops Agency (Dinas Pertanian dan Tanaman Pangan) have been very slow in responding to the disease and to farmers' demands for a cure. Thus, while Kompas (1983a) printed a news release from the Food Crops Agency about a method for curing citrus siam trees attacked by the C.V.P.D., it turned out that the method was extremely costly and that the antibiotics required were not available to farmers.

4.2.1.3 Second Boom

After the first boom in 1970-1971, the price of citrus siam dropped gradually in real terms reflecting the steady increase in supply of citrus siam up to the end of 1973. It rose up to around 1980, but has subsequently fallen again.

A second surge of harvested area took place in O.K.U. in 1980 implying a planting boom in 1976-77 (Table 4-1). In 1976-1977 there was reportedly also a surge in coffee prices due to the Brazilian coffee disaster. In Ranau, a higher altitude area in O.K.U., coffee farmers suddenly became rich, and many of them built new houses and bought motor vehicles. The increase in coffee prices strongly stimulated business activity in Baturaja, the closest marketing centre, and this town visibly showed its new prosperity.

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[1]Citrus siam's gestation period is about three to four years.

The non-coffee producing areas were not directly affected because the prices of basic consumer goods were not influenced much. There was an obvious psychological effect, however, and Belatung villagers often told the author that their relatives in Ranau had suddenly become rich owing to coffee, and that they contemplated what to do to "catch up". Some planted coffee, even though they knew that it was not suitable for the climate of Belatung. Some tried pepper or cloves, only to find them failing several years later. Many others must have tried citrus siam, and these probably caused a planting boom in 1976-77. This boom appears to have spread to the neighbouring areas, Muara Enim (1977-78) and Lahat (1978-79) (Table 4-1).

These increases in production grew to a peak for South Sumatra of almost 20,000 tonnes in 1981, somewhat depressing prices in Baturaja from the heights of 1979 (Figure 4-2). Subsequently, however, as supplies fell, reflecting the considerable attacks of C.V.P.D. in the lower-altitude area of O.K.U., the price began increasing again.

The yield of citrus siam steadily increased over the whole period after 1969. The yield nearly tripled in 12 years, from 3.35 ton/ha in 1969 to 9.72 ton/ha in 1981.

The author was told by fruit traders that their estimate of yield was 40-70 kg/tree without fertiliser, and a maximum of 200 kg/tree with fertiliser. As villagers generally believe that trees should be planted six meters apart, these estimates convert to yields of 10-21 ton/ha without fertiliser and 50-60 ton/ha with fertiliser. Thus, there is a wide discrepancy between actual average yields and the yields which, the traders feel, can be achieved. This discrepancy suggests a very low level of fertiliser application or even virtually no fertiliser application in the citrus siam cultivation in South Sumatra.

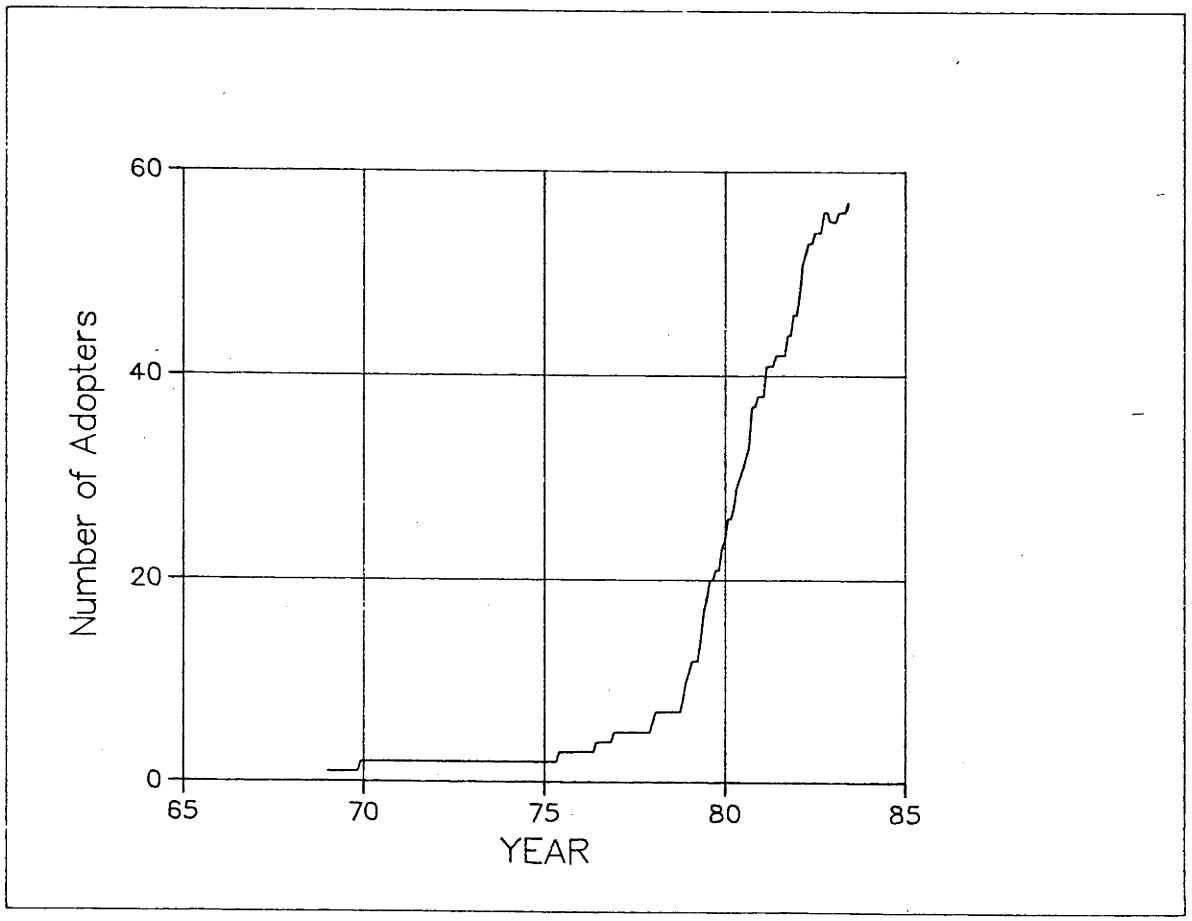
4.2.2 Belatung

In Belatung, citrus siam was first planted around 1950 by Villager 29 and Villager 86's late father. Their trees seem to have died or stopped producing by the mid-1960's,[2] and other villagers did not plant citrus siam until about 15 years later.

The current adoption process is thought to have started in 1969, when the then newly-appointed village head planted 200 grafts. A planting of this size was

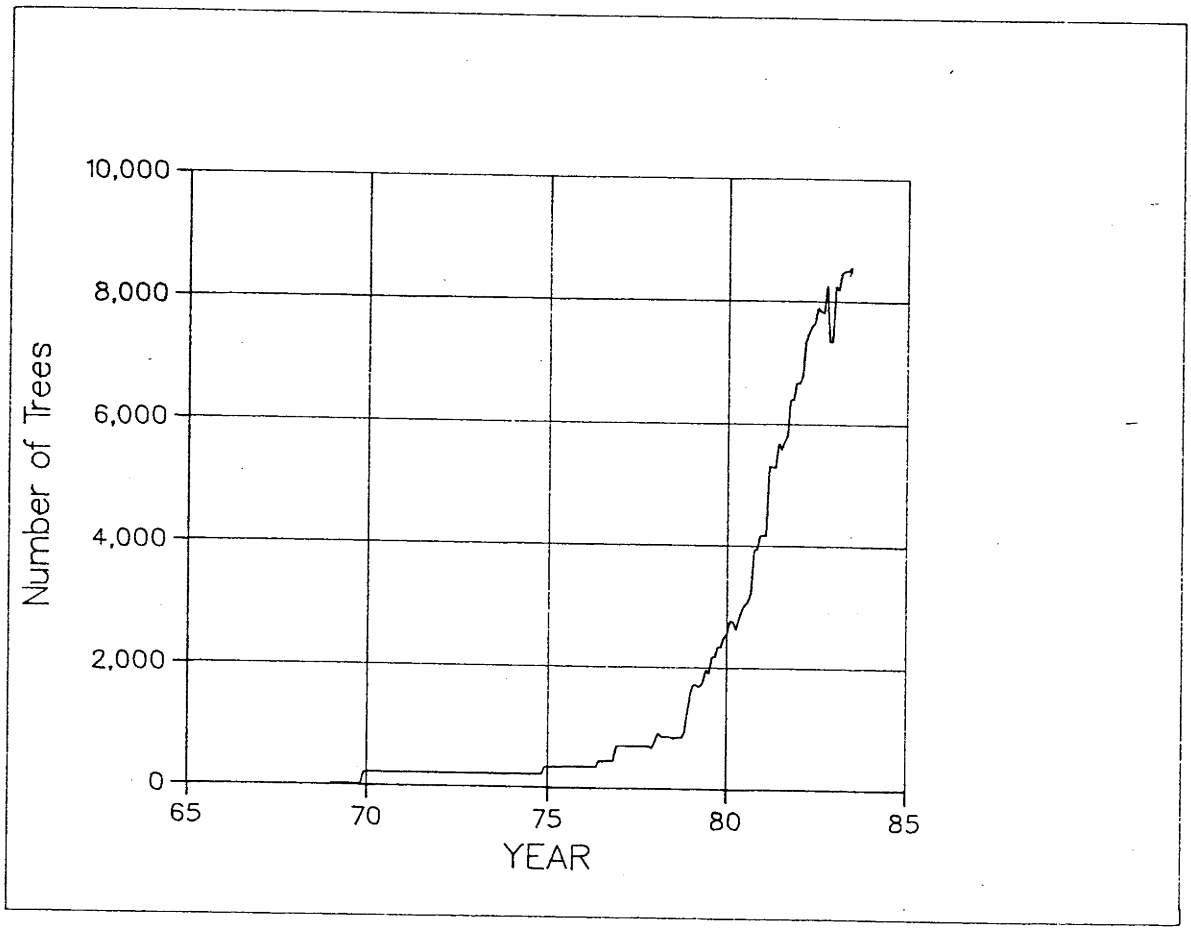
[2]Citrus siam's length of productive life is about 15 years.

Figure 4-3: Citrus Siam Adopters in Belatung 1969-1983 (monthly)



Source: **Fieldwork**

Figure 4-4: Number of Citrus Siam Trees in Belatung 1969-1983 (monthly)



Source: Fieldwork

unprecedented, and, since then the growth in number of adopters and of citrus siam trees planted in Belatung has not declined, except due to diseases or other natural causes (Figures 4-3 and 4-4).

In 1979, the number of adopters reached 10 out of 118 households in Belatung, and started to increase very rapidly. In general, as Rogers (1983) pointed out, the time when 10 to 25 percent of potential adopters have adopted an innovation may be considered as the "take-off" point in its adoption process. This rapid increase in adoption continued until 1982, after which it slowed down. The number of trees, too, grew rapidly with the number of adopters until 1982. In June 1983, the number of adopters had reached 59 (two villagers discontinued temporarily), half of the village households, and the number of citrus siam trees planted totalled 8579.

The initial plantings in 1969 and the "take-off" in 1979 correspond closely to the first and second boom periods in South Sumatra. Thus in 1969, when the C.V.P.D. attacked citrus siam in O.K.I., the prices rose sharply, and the diffusion to areas other than O.K.I. then began. Only the village head in Belatung responded to this change with his large planting, reflecting his knowledge as a fruit trader and his strong initiative. After a successful first harvest, he responded to the price increase in 1974 by increasing his number of trees. Other villagers observed his success, and followed his lead. By the second boom in 1979, the foundations of citrus siam adoption had been laid for other villagers. This second boom increased the citrus siam production of O.K.U. ten-fold, and also seems to have stimulated villagers in Belatung.

The growth of the cumulative number of adopters and the cumulative number of trees planted peaked in mid-1980. After mid-1980, the growth of both adopters and plantings slowed down. Hence, in a manner analogous to the generalised sigmoidal diffusion curve, the citrus siam adoption process in Belatung seems to have passed through its mid-point at this stage.

However, this boom continued until 1982 in Belatung, when the areas around Belatung were invaded by the C.V.P.D. from the lower-stream O.K.U. areas around Peninjauan. The local government's prohibition on the exportation of grafts from O.K.I. was apparently ignored, for traders openly brought grafts to Baturaja and other villages,

selling them to villagers who were unaware of the prohibition. The other cause of the slow-down in adoption was a drought in the dry season of 1982, in which many adopters lost their newly planted grafts.

4.2.3 Citrus Siam and Alternative Crops

As seen in Chapter 2, the major crops in Belatung are citrus siam, rice, coffee and rubber. Rice is the subsistence crop and rubber the dominant cash crop. Coffee was the initial alternative crop to rubber, and now competes with citrus siam. However, villagers know that coffee is not ideally suited for the climate and other natural conditions of Belatung, though many of them still grow coffee.

Figure 4-2 on page 169 shows the real prices of these four crops after 1968, in terms of January 1967 Rupiahs (Appendix D.2). The price of rice was the most stable during the period partly because the weighting of rice price in the consumer price index was the highest at about 35 percent.[3] The rubber price was also stable, and appears to have followed international price trends.

Coffee prices changed dramatically during the period 1975 to 1982. In 1977 the price peaked, following international price hikes in the wake of the Brazilian coffee disaster, but by 1982 it had returned to the pre-boom level.

Citrus siam prices also changed considerably, with the trends already described in Section 4.2.1.

Table 4-2 shows how changes in prices of three other major crops relative to citrus siam prices are statistically related to changes in citrus siam adoption process in Belatung.

In examining the effects of prices of citrus siam relative to major crops on the citrus siam adoption process, the coefficients in the following equation were estimated:

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[3]See Appendix D.2 for the derivation of the consumer price index.

Table 4-2: Citrus Siam Adoption in Belatung and Relative Prices of Major Crops

12 Month Lag - Best Results

Changes in Relative Prices(a)	Year	Changes in No. of Trees Planted coeff. (t-ratio)	Changes in No. of Adopters coeff. (t-ratio)
C	74	36.57967(2.735)	0.19554(2.534)
O	75	-76.73858(-0.484)	-0.61922(-0.677)
F	76	-82.70555(-0.496)	-0.43337(-0.450)
F	77	-156.99367(-0.892)	-0.91087(-0.897)
E	78	-409.48330(-3.240)	-2.77479(-3.806)
E	79	32.81286(0.145)	3.47445(2.663)
	80	-825.66534(-1.383)	3.08731(0.896)
	81	7333.05977(7.750)	12.76905(2.339)
	82	1596.47565(0.506)	19.81611(1.090)
R	74	-126.63243(-4.728)	-0.63018(-4.079)
U	75	123.61482(0.086)	5.45315(0.661)
B	76	-1774.07561(-1.872)	-2.43301(-0.445)
B	77	-7283.64306(-1.529)	-36.17833(-1.317)
E	78	-9111.17333(-4.120)	-60.04993(-4.707)
R	79	-6567.71019(-3.412)	-92.54779(-8.335)
	80	2481.66745(0.452)	-49.10421(-1.549)
	81	-25349.13148(-10.079)	-17.24104(-1.188)
	82	-8076.61941(-0.657)	-81.13276(-1.144)
R	74	-49.90184(-2.216)	-0.27037(-2.081)
I	75	345.32240(0.191)	-0.61322(-0.059)
C	76	1189.68204(1.495)	4.42386(0.964)
E	77	3623.79308(1.355)	15.60436(1.012)
	78	6067.80420(3.661)	40.57631(4.244)
	79	8074.76690(3.210)	86.16387(5.938)
	80	159.76019(0.037)	25.53103(1.013)
	81	60759.88601(8.930)	119.03281(3.033)
	82	7376.85196(1.109)	-1.17541(-0.031)
I	74	10.66693(0.887)	0.04355(0.628)
N	75	264.15608(0.438)	1.27250(0.366)
T	76	414.25927(1.058)	2.62025(1.160)
E	77	643.09757(1.876)	3.11955(1.578)
R	78	1085.65935(5.069)	7.34205(5.943)
C	79	2211.97671(14.420)	22.82722(25.798)
E	80	980.80166(1.762)	18.61100(5.796)
P	81	8851.21170(9.658)	24.40259(4.616)
T	82	2952.29020(3.697)	5.70516(1.238)
ADJ.R-SQ		0.99218	0.99224
D.W.		2.18102	1.62467

Notes:
(a) Changes in relative prices of crops to citrus siam prices.

(4.1)

$$\Delta PLANT_{mT} = \sum_{k=1}^{9} \alpha_{1k} YEAR_{Tk} \Delta COFFEE_{mT} + \sum_{k=1}^{9} \alpha_{2k} YEAR_{Tk} \Delta RUBBER_{mT} + \sum_{k=1}^{9} \alpha_{3k} YEAR_{Tk} \Delta RICE_{mT} + \sum_{k=1}^{9} \beta_k YEAR_{Tk} + \epsilon_{mT}$$

where $\Delta PLANT_{mT}$ indicates an increase in the number of citrus siam trees at time T since time T−m, and $\Delta COFFEE_{mT}$, $\Delta RUBBER_{mT}$ and $\Delta RICE_{mT}$ indicate increases in the prices of corresponding crops relative to citrus siam at the T-th month since the (T−m)-th month. The dummy variable $YEAR_{Tk}$ equals one if the T-th month corresponds to k+1973, but $YEAR_{T1}$ equals one if T is less than or equal to 1974. The lag, m, is 3, 6, 9, or 12 months.

For convenience, results obtained with twelve-month lags which showed the highest adjusted R-square are shown in this table.

Some coefficients are of interest. Changes in relative price of coffee were negatively correlated with changes in citrus siam adoption until 1978. After 1981, they appeared to be positively correlated in terms of both numbers of trees planted and adopters. After the coffee price fell drastically in 1979, these relationships appear to have changed.

Changes in relative price of rubber to citrus siam were negatively related to changes in citrus siam adoption process in terms of both numbers of trees planted and adopters. Rubber has, therefore, always been regarded as an alternative crop to citrus siam in the almost whole period since 1974, or rather, citrus siam has been considered as an alternative crop to rubber in this period.

Changes in relative price of rice to citrus siam were always positively related to changes in citrus siam adoption process. Although most of the villagers produced rice (Table 2-6), the amount of rice produced was much less than what they consume. They had to buy rice from local rice dealers or village grocery shops. Hence, an increase in the rice price tended to raise their cash expenditure and may have stimulated them to produce more of cash crops.

On the whole, it was found that absolute values of the coefficients of relative price changes increased almost exponentially over time as if they were directly related to the

accumulated scale of adoption or the accumulated number of adopters. This implies that although the adoption process was very well explained by relative price changes of three major crops, there was another significant determinant which was closely related to the accumulation of adoption. The accumulated total of products or adopters has been usually and simply employed to explain this situation because these accumulation variables are regarded as representing the contextual effect of the adoption process on itself in the form of cumulative information. However, as discussed in Chapter 1, this employment is too intuitive. According to the discussion of this study set out in Chapter 1, these exponentially increasing coefficients seem to imply the existence of interdependence among adopters and potential adopters, and that a further more detailed study is necessary to explain the empirically detected trends.

4.3 Individual Characteristics of Adopters and Non-adopters

Table 4-3 shows the characteristics of citrus siam adopters and non-adopters in Belatung in 1982/83. These characteristics are classified into five categories: (1) economic, (2) cropping patterns, (3) human capital, (4) media exposure and (5) other occupations, each of which have already been defined and explained in Chapter 2.

Among the economic characteristics, total annual expenditure, total annual consumption, and farm location in Kisam area were found to be significantly different between adopters and non-adopters.

Adopters also had more income than non-adopters, although the difference was not statistically significant. Since not many of citrus siam trees of most adopters had not yet started producing, this income difference indicated that villagers with higher incomes were more likely to adopt citrus siam earlier than those with lower incomes.

Adopters' average farm size was 1.4 ha which was higher than that of non-adopters, and their household size was also greater, but these differences were not statistically significant. The adopters' households had less male labour and more female labour than non-adopters'. A possible explanation may be that a household with more female labour tends to seek a crop requiring less physical labour; citrus siam needs less physical labour than rubber.

Table 4-3: Average Characteristics of Adopters & Non-Adopters 1982-3

		Adopters	Non-Adopters	T-test
HOUSEHOLD ECONOMY	TOTAL INCOME (million Rp.)	1.225 (0.849)	0.992 (0.892)	1.42
	EXPENDITURE (")	1.115 (0.578)	0.926 (0.567)	1.75*
	CONSUMPTION (") (a)	1.290 (0.697)	0.993 (0.625)	2.44**
PRODUCTION CHARACTERISTICS	FARM SITE LEKIS (b)	0.0339(0.183)	0.0508(0.222)	0.45
	KISAM (b)	0.0508(0.222)	0.0000(0.000)	1.76*
	FARM SIZE (ha.)	5.208 (6.488)	3.842 (4.775)	1.30
	HOUSEHOLD SIZE (No.)	5.814 (2.360)	5.542 (2.223)	0.64
	MALE LABOUR (No.)	1.322 (0.955)	1.407 (0.853)	0.51
	(Equiv.)(c)	1.492 (1.054)	1.606 (0.879)	0.64
	FEMALE LABOUR(No.)	1.475 (0.838)	1.271 (0.665)	1.46
	(Equiv.)(c)	1.212 (0.803)	0.991 (0.742)	1.56
CROPPING PATTERN	COFFEE (proportion)	0.5593(0.501)	0.4407(0.501)	1.29
	DUKU (")	0.5424(0.502)	0.4407(0.501)	1.10
	CITRUS SIAM (")	1.0000(0.000)	0.0000(0.000)	----**
	RICE (")	0.7966(0.406)	0.6780(0.471)	1.47
	RAMBUTAN (")	0.3390(0.477)	0.0678(0.254)	3.85**
	PINEAPPLE (")	0.1186(0.326)	0.1017(0.305)	0.29
	RUBBER (")	0.5254(0.504)	0.5085(0.504)	0.18
	CLOVES (")	0.1525(0.363)	0.1186(0.326)	0.53
	DURIAN (")	0.4237(0.498)	0.3729(0.488)	0.56
	NO. OF CROPS (No.)	4.458 (1.735)	2.729 (1.910)	5.15**
HUMAN CAPITAL	EDUCATION (d)	6.831 (4.001)	5.288 (3.723)	2.17**
	INDEPENDENCE COEFFICIENT	0.0811(0.086)	0.0408(0.014)	3.57**
	FARM EXPERIENCE (yr.)	20.44 (13.57)	16.10 (12.98)	1.77*
	AGE (yr.)	46.41 (13.28)	39.76 (13.41)	2.70**
MEDIA EXPOSURE	RADIO (proportion)	0.5763(0.498)	0.2542(0.439)	3.72**
	PROGRAM (times/week)	2.644 (2.935)	0.9661(2.059)	3.60**
	BATURAJA (times/yr.)	60.71 (98.43)	35.46 (61.55)	1.67*
	PRABUMULIH (times/yr.)	0.4068(1.763)	0.0508(0.289)	1.53
	PALEMBANG (times/yr.)	2.780 (4.672)	1.780 (4.457)	1.19
	LAMPUNG (times/yr.)	1.729 (3.050)	3.170 (13.47)	0.80
	JAKARTA (times/yr.)	0.2373(0.678)	0.1186(0.560)	1.04
OCCUPATION	TEACHER (proportion) (e)	0.0678(0.254)	0.0000(0.000)	2.05**
	SHOP OWNER (proportion)	0.0678(0.254)	0.0508(0.222)	0.39
	KERIO (proportion)	0.0508(0.222)	0.0000(0.000)	1.76*
	KHOTIB (proportion)	0.0339(0.183)	0.0000(0.000)	1.43
	TENANT (proportion)	0.0678(0.254)	0.2034(0.406)	2.18**
	SICK/RETIRED (proportion)	0.0678(0.254)	0.0339(0.183)	0.83
	NAT'L RAILWAY (proportion)	0.2373(0.429)	0.1186(0.326)	1.69*

Notes:
** significant at 5 percent level. * significant at 10 percent level.
Figures in parentheses are standard deviations.
(a) CONSUMPTION includes EXPENDITURE and home-production. Refer Figure 2-10 and Table 2-2.
(b) Proportion of villagers whose farm locates in these areas to all adopters or non-adopters.
(c) Male Adult Equivalence Scale. Refer Table B-1.
(d) Educational Attainment Proxy. Refer Table 2-3.
(e) Proportion to either all adopters or all non-adopters.
Source: Fieldwork

Among nine crops (used to identify cropping pattern groups of villagers in Section 2.4.1, Table 2-6), the only statistically significant difference between adopters and non-adopters was that adopters had more rambutan. The high correlation between citrus siam and rambutan (Table 2-5) was suggestive of this association. Rambutan was one of indigenous crops which have recently reconsidered profitable by farmers. The average number of crops grown by citrus siam adopters, 4.5, was also significantly greater than that of non-adopters, 2.7.

Statistically significant differences were also found between adopters and non-adopters in human capital variables. Adopters had more education, were twice as independent in their decision making, four years more experienced in farming, and about seven years older than non-adopters.

Amongst media exposure variables, adopters had more radios and listened to agricultural programmes three times as often. Except for Lampung, frequencies of visiting other places (regarded as proxies for villagers' extent of exposure to media) were higher for adopters, although the only significant difference was for Baturaja. As already described, Lampung was an area where some Belatung villagers grew coffee. Non-adopters were more frequent visitors to Lampung, probably to look after their coffee. Such villagers may have tended to pay less attention to farming in Belatung and this may explain their non-adoption of citrus siam.

There were some occupational differences which were statistically significant between adopters and non-adopters. Teachers and incumbent or former village heads, as leaders of the village, tended to be adopters, as were National Railway workers. These latters were part-time farmers with farming as a secondary occupation who produced some agricultural crops for their subsistence. These workers were somewhat isolated and regarded as lower-class villagers by native Belatung residents, and might thus be expected to be slow in adopting citrus siam or any new technology. However, they may have been led to adopt citrus siam to supplement their low (albeit regular) salaries. On the other hand, very few tenants adopted citrus siam and this may have been due to their low viability to decide what crops to be grown on the tenanted land.

4.4 Adopters and Non-adopters in Village Network System

Belatung's village network system was described in Chapter 3, and villagers were classified into five relational associations (See Figure 3-11). In relational associations, members frequently exchanged agricultural information through channels of direct agricultural information exchange activities, kinship ties, money borrowing/lending, household goods exchange activities and meeting-at-shops activities. The members are regarded as sharing an almost identical set of agricultural information. On the other hand, villagers were also classified into five structural associations (Figure 3-12) where members are regarded as influencing each other to the degree that they play similar roles in the village in disseminating agricultural information.

In Figure 4-5, villagers are placed in a row according to their memberships in the relational associations described in Figure 3-11, where closeness between two villagers within the same relational association indicates the degree to which they share agricultural information. In each relational association, there is one or sometimes two relatively early adopter(s). It can be seen from Figure 4-5 how the adoption process proceeded in each relational association, and how agricultural information exchange related to the adoption process.

After Villager 130[4] of Association 4 adopted citrus siam, Villager 58 of Association 3 and Villager 33 of Association 5 adopted. These two villagers may have diffused agricultural information, experience or recommendations to nearby villagers, who eventually followed. We can clearly observe the relationships between villagers' closeness to these pioneers (Figure 4-5 or 3-11) and their times of adoption.

In Association 4, Villager 130 was followed by Villager 102, and then Villagers 10, 92 and 128. Villager 102 seems to have been influenced by Villagers 130 of this association, and by Villager 58 of Association 3. Villager 128 inherited his father's citrus siam and added new trees. Other villagers of the association seem to have followed these early adopters.

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[4]In Figure 4-5, only adopters in the current adoption process are shown. The adopters in the previous adoption process can still be identified from the time of adoption listed in the third and fourth columns. The latter had been already inactive in producing citrus siam when the current adoption process was started by Villager 130, the present village head.

In Association 5, Villager 33 was followed by Villagers 60, 56 and 121, who must have planted these trees before Villager 33 commenced his successful production. The coincidence of proximity in the association with time of adoption clearly shows a diffusion of citrus siam along with the diffusion of information.

In Association 3, the influence of the pioneer of the association seems to have been less than in the associations above, while the influence from outsiders was stronger (Figure 4-5).

In Associations 1, and 2, there was no conspicuous early adopter, but proximity in the association still seems to have determined the times of adoption.

Although flows of agricultural information from adopters to non-adopters (Figure 4-5) thus seem to be an important factor affecting villagers' decisions to adopt citrus siam, the more important factor seems to be their memberships of the same basic association identified in Section 3.8.2 (Table 3-11). Members of a basic association share an almost identical set of agricultural information and play similar roles in disseminating agricultural information. Table 4-4 shows the ratios of adopters to all members of basic associations.

As to relational associations, the sole significant difference can be found for Association 4. Other associations do not have significant difference between adopters and non-adopters. In relational associations, agricultural information is supposed to diffuse step by step directly through each interaction. Therefore, in each relational association there are always some adopters and some non-adopters. As the adoption process proceeds the ratio gradually changes.

In a structural association, villager-members are regarded as playing almost identical social roles and thus influencing each other strongly. There are two structural associations almost all members of which are adopters. Differentiation in terms of adoption rate is greater than among relational associations.

Adoption rates of basic associations clearly show their strong relationships with the independence coefficients. Basic associations with more than 50 percent adoption rate have generally much greater independence coefficients than those with lower adoption rates.

Figure 4-5: Adopters and Non-adopters in Relational Associations

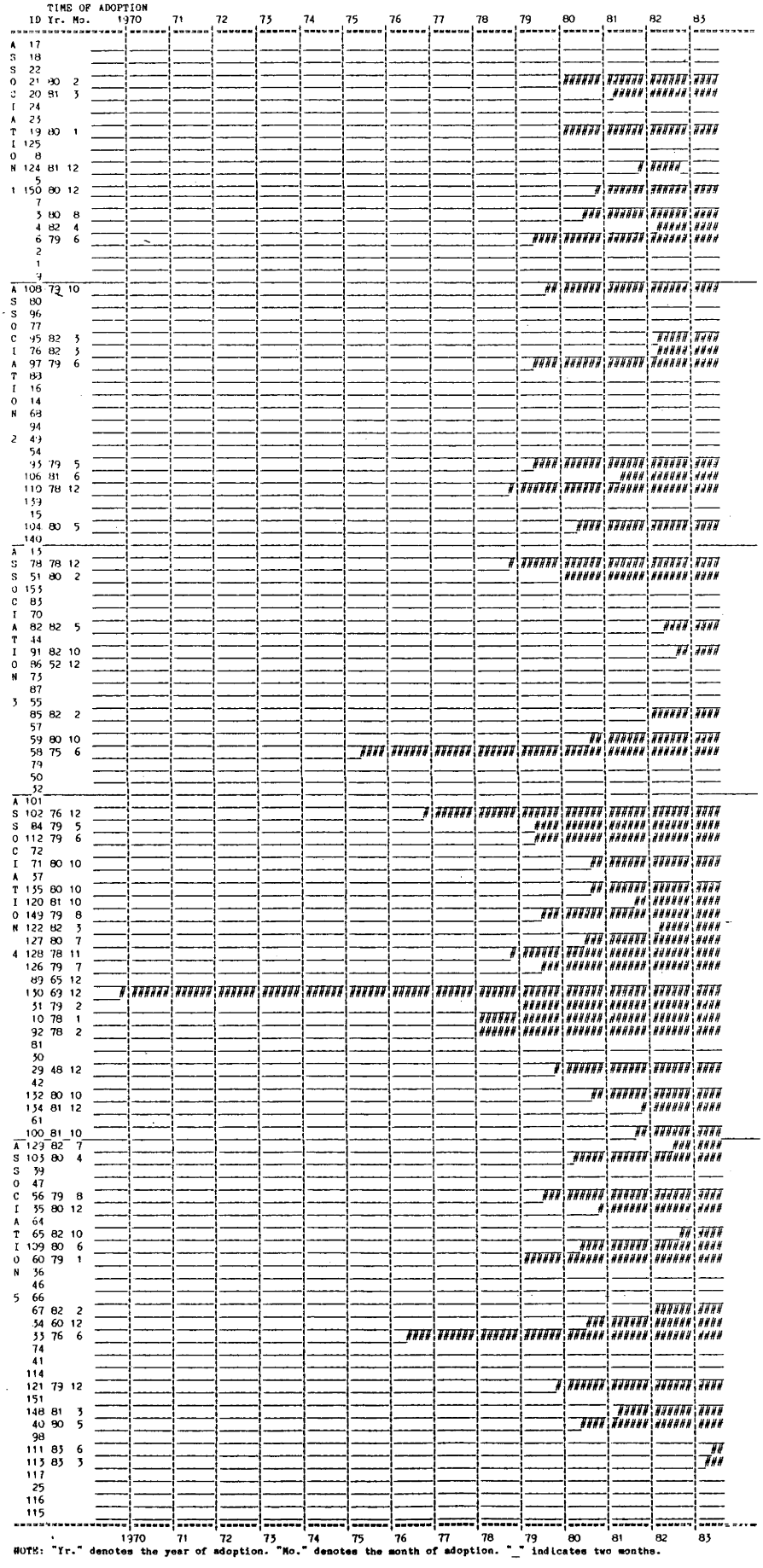

Table 4-4: Adopters in Relational, Structural and Basic Associations

RELATIONAL ASSOCIATION	NO. OF ADOPTERS	NO. OF MEMBERS	ADOPTION RATE (%)
1	8	20	40.0
2	8	21	38.1
3	8	20	40.0
4	20	27	74.1
5	15	30	50.0

STRUCTURAL ASSOCIATION	NO. OF ADOPTERS	NO. OF MEMBERS	ADOPTION RATE (%)
1	24	52	46.2
2	13	24	54.2
3	5	6	83.3
4	12	31	38.7
5	5	5	100.0

BASIC ASSOCIATION (1)	(2)	(3)	NO. OF ADOPTERS	NO. OF MEMBERS	ADOPTION RATE (%)	INDEPENDENCE COEFFICIENT(x100) MEAN	SD
14	4	5	5	5	100.0	28.018	9.147
5	2	3	1	1	100.0	31.329	0.000
9	3	3	1	1	100.0	7.079	0.000
10	4	1	9	10	90.0	4.357	1.630
13	4	3	3	4	75.0	16.338	10.660
8	3	2	4	6	66.7	5.075	1.410
17	5	2	4	7	57.1	6.953	5.246
4	2	2	4	8	50.0	7.038	2.555
15	5	1	4	8	50.0	3.306	0.208
16	5	4	7	15	46.7	4.287	1.091
11	4	4	2	5	40.0	4.426	0.824
1	1	1	8	20	40.0	3.721	0.331
3	2	4	1	3	33.3	3.763	0.292
12	4	2	1	3	33.3	4.978	0.807
7	3	4	2	8	25.0	3.497	0.377
2	2	1	2	9	22.2	3.984	0.610
6	3	1	1	5	20.0	3.807	0.594
TOTAL			59	118			

Notes:
(1) Identification numbers of basic associations.
(2) Identification numbers of relational associations.
(3) Identification numbers of structural associations.
See Tables 3-1 and 3-11 for the concept of "basic associations".

The magnitude of the influence is represented by their structural equivalence proximity, i.e., the interdependence coefficients defined in Section 3.2.5. If an earlier adopter's influence on a later adopter is greater, then the latter's time of adoption may be earlier than it would otherwise have been. Interdependence coefficients are not reciprocal. That is, Villager i's dependence on Villager j, represented by l_{ji}, is not always equal to Villager j's dependence on Villager i, represented by l_{ij}. Thus if Villager i is the later adopter, his dependence on the earlier adopter, Villager j, l_{ji}, is expected to affect the lag of their times of adoption negatively. On the other hand, the earlier adopter's dependence on the later adopter, l_{ij}, is not a determinant of the time lag between the earlier and later adopters. To illustrate, consider two adopters A and B who adopt at time TOA_A and TOA_B where $TOA_A < TOA_B$. Now, the dependence of B on A is determinant of TOA_B, but the dependence of A on B is not a determinant of TOA_A.

Furthermore, the direct representation of the interdependence by l_{ji} does not include the many types of influence the earlier adopter has. If the later adopter is dependent on the earlier adopter, who is more independent in his decision making, the influence of the earlier adopter on the later adopter is even more significant. In this case it is considered that the interdependence coefficient should be multiplied by the independence coefficient of the villager supposed to influence the other. Thus the influence of an earlier adopter on a later adopter should be represented by $l'_{ji} = l_{ji} * l_{jj}$.

The relationship between the lag between the times of adoption of two adopters and the flows of agricultural information between them, i.e., their interdependence can be statistically tested. This may be done by regression analysis[5] of the difference between two villagers' times of adoption,[6] with independent variables representing the flows of agricultural information between them, their interdependence, and differences in their socio-economic characteristics. The following equation is used:

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[5]It would have been preferable to use Tobit analysis, for reasons which will be discussed in Section 6.5.3. But the available software, SHAZAM, did not permit analysis with a large number of observations (6105). Therefore, the simpler approach of OLS in SPSS was used.

[6]Difference between two villagers' times of adoption, $DTOA_{ij}$, is defined as difference between dates of their first planting, not dates of their first knowledge.

(4.2)

$$DTOA_{ij} = TOA_i - TOA_j = \alpha_0 + \alpha_1 l_{ii} + \alpha_2 l_{jj} + \alpha_3 l_{ji} l_{jj} + \sum_{k=1}^{m} \alpha_{3+k} R_{ij}^{(k)} + \alpha_{4+m} TIME_{ij} + \alpha_{5+m} D_{1ij} + \alpha_{6+m} D_{2ij} + \sum_{k=1}^{r} \alpha_{6+m+k} (Z_{ik} - Z_{jk}) + \epsilon_{ij}$$

where Villager i and Villager j are later and earlier adopters respectively. Hence

$$TOA_i \geq TOA_j.$$

Explanatory variables are:

1. l_{ii} and l_{jj} are independence coefficients.

2. l_{ji} is Villager i's (later adopter) interdependence coefficient with respect to Villager j (earlier adopter).

3. $R_{5.\,ij}^{4.\,(k)}$ indicates the existence of an agricultural information flow between Villagers i and j through the k-th channel such as direct agricultural information exchange activity or household goods exchange activity. Since these $R_{5.\,ij}^{4.\,(k)}$'s are components of independence and interdependence coefficients, l_{ii}, l_{jj} and l_{ji}, if both are included multicollinearity should be carefully examined.

   a. R^1: Direct Agricultural Information

   b. R^2: Kinship

   c. R^3: Household Goods Exchanges

   d. R^4: Money Lend/Borrowing

   e. R^5: Meeting-at-shops

4. $TIME_{ij}$ indicates the time during which the interaction between Villager i and j takes place. This can be represented by any time between an earlier adopter's time of adoption, TOA_j, and a later adopter's time of adoption, TOA_i. To avoid statistical redundancy, the mid point of these two villagers' times of adoption, $TIME_{ij} = (TOA_i + TOA_j)/2$, is used. As the adoption process progresses, the quantity and quality of agricultural information about the innovation increases cumulatively. Hence, the lag between two villagers' times of adoption may be shortened, other things remaining equal.

5. D_{1ij} indicates that Villager i is really a non-adopter, and D_{2ij} indicates that Villager j is really a non-adopter. For convenience, 1985 has been assigned to non-adopters as their time of adoption.

6. Z_{ik} and Z_{jk} represent two villagers' k-th socio-economic characteristics.

7. ϵ_{ij} is an error term.

The coefficient of the later adopter's independence, α_1, is expected to be negative, because independence in his decision making leads to more economically optimal decisions in which others are not considered at all. Thus, when the profitability of the innovation concerned is rising, it will be adopted earlier. For the same reason, the coefficient of the earlier adopter's independence coefficient, α_2, is expected to be positive. Again, the coefficient of the later adopter's interdependence (coefficient) on the earlier adopter adopter, α_3, is expected to be negative. If the later adopter is more dependent on the earlier adopter, the lag is shorter. The coefficient of the existence of agricultural information flows through the k-th channel, α_{3+k} (k=1,2,...,m), is expected to have a negative sign. If agricultural information flows exist between the two villagers concerned, they may promote earlier adoption by the later adopter. $TIME_{ij}$ is expected to have a negative coefficient, for as the adoption process proceeds, agricultural information accumulates and the lags generally become shorter. This may be another evidence for the existence of the contextual effect.

To indicate the existence of agricultural information flows through certain activities, the groups identified with respect to these activities in Chapter 3 (summarised in Table 3-12) were used. This was a superior approach to the direct usage of original sociometric interactions as depicted in Figures 3-2, 3-3, 3-7, 3-8, and 3-9. Even though there is a flow of information or an interaction between two villagers, the fact that they are in two different groups may mean that the content is different from, and less favourable to, the promotion of agricultural innovation, than the content in the flow between two villagers of the same group.

Table 4-5 shows the results of four regressions examining independence and interdependence coefficients, channels of agricultural information flows, and a wide range of socio-economic characteristics. The first three equations were run for all villagers, and the last one only for adopters.

The results indicate that the hypotheses made above with respect to the independence coefficients, l_{ii} and l_{jj}, and to the interdependence coefficient, l_{ji}, cannot be rejected. With respect to channels of agricultural information flow, $R^{(k)}$, three channels were found to be effective in shortening lags (Regression 1). The direct agricultural

Table 4-5: Regression Analyses of Differences of Times of Adoption

Regression Variable	(1) All(a)	(2) All	(3) All	(4) Adopters(b)
l_{ii}	---	-5.09804***	-5.04482***	-3.82175***
l_{jj}	---	3.38274***	3.38182***	6.10047***
$l_{ji}*l_{jj}$	---	-388.30499***	-351.87042***	-369.13542***
R1	-0.11776**	---	-0.04923	-0.07549
R2	0.04201	---	0.07391	-0.00738
R3	-0.04265	---	-0.03532	-0.18717
R4	-0.31499***	---	-0.21080**	-0.24512
R5	-0.05808**	---	-0.01614	0.08811
TIMEij	-1.31632***	-1.25322***	-1.25631***	-0.70097***
D1	5.94429***	5.74090***	5.74414***	---
D2	-1.46515***	-1.55049***	-1.54675***	---
Income	-0.11113***	-0.13068***	-0.13019***	-0.38556***
H.H. Size	0.00691	0.01227	0.01170	-0.01117
M. Labour	-0.01128	0.01541	0.01679	0.09910*
F. Labour	0.02031	0.02577	0.02635	0.16007**
Farm Size	0.00108	-0.00097	-0.00083	0.02090*
Lekis	-0.24352***	-0.28903***	-0.28963***	-0.70216***
Kisam	-0.26996**	-0.35490***	-0.36946***	-0.69740***
Age	0.00353**	0.00416***	0.00415***	0.00120
Farm Experience	-0.00886***	-0.01059***	-0.01050***	-0.02366***
Education	-0.01459***	-0.01581***	-0.01617***	-0.06370***
Programme	-0.03099***	-0.02948***	-0.02949***	-0.04881***
Baturaja	-0.00085***	-0.00092***	-0.00090***	-0.00168***
Prabumulih	-0.02706**	-0.00166	-0.00166	-0.04033
Palembang	0.01553***	0.01501***	0.01522***	0.03875***
Lampung	0.00552***	0.00622***	0.00623***	0.08102***
Jakarta	0.05509**	-0.00828	-0.00833	0.07278
Village Head	-1.07664***	-0.58408***	-0.59338***	-1.34398***
Relig's Teacher	-0.34369***	-0.30589***	-0.30829***	-0.47934**
Nat'l Railway	-0.18202***	-0.25224***	-0.25015***	-0.72815***
Shop Owner	-0.04511	0.07101	0.07171	0.65842***
Sick/Retired	0.55076***	0.40113***	0.40076***	0.35060*
Teacher	-0.12632*	0.48565***	0.48956***	0.94091***
Tenant	-0.04508	-0.06159*	-0.06202*	0.25740*
Constant	107.50384***	102.59532***	102.84464***	57.76952***
Adj. R-square	0.87026	0.87735	0.87753	0.56691
F	1321.79	1506.58	1287.38	61.71
(D.F.)	31, 6073	29, 6075	34, 6070	32, 1452
N	6105	6105	6105	1485

Notes:
There is no serious correlation among explanatory variables.
Asterisks indicate statistical significance levels.
*** 0.1 percent level ** 1.0 percent level * 5.0 percent level
(a) All villagers including adopters and non-adopters.
(b) Adopters only.

information channel, $R^{(1)}$, the money lend/borrowing channel, $R^{(4)}$, and the meeting-at-shops channel, $R^{(5)}$, showed significantly non-zero and negative coefficients where independence and interdependence coefficients were not included.

However, since the correlations between the interdependence coefficients and the agricultural information channel variables are relatively high, the results where both these groups of variables were considered at the same time (Regression 3) showed that the interdependence coefficients were relatively more significant in explaining lags. The money lending/borrowing channel, $R^{(4)}$, still effectively shortened the time lag in this regression, however.

Among other variables, the most distinctively significant one was $TIME_{ij}$. It showed, as expected, that the progress of the adoption process promoted the process itself by increasing the quality and quantity of agricultural information transmitted through the channels of information, and by the influences transmitted via villagers' interactions and interdependence. This is another evidence for the existence of the contextual effect in the adoption process.

Among socio-economic characteristics used in the regressions (3) and (4), almost all are significant. For example, differences in income levels were significant. If a later adopter's income level was greater than that of an earlier adopter's, the lag was shortened.

Determinants which significantly shorten time lags, other than income level, are the locational factors (Lekis and Kisam), farming experience, education, radio agricultural programme listening, visits to Baturaja, and three occupation variables (village head, religious teacher, and National Railway worker). In contrast, determinants which significantly lengthen time lags are, visits to Palembang and Lampung, two occupation variable (sick or retired, and teacher). As mentioned before, frequent visits to Palembang and Lampung lead to their neglect of agriculture in the village. Visits to Lampung affect time lags more than those to Palembang, since the duration of the visits to Lampung is much longer than the latter.

CHAPTER 5

Model of Interdependence

5.1 Introduction

Recently it has been increasingly argued that income (or wealth) may yield individual satisfaction in two distinct ways. Firstly, income provides an individual with control over consumables. An increase in income increases the size of an individual's consumption choice bundle and thus increases his welfare. Secondly, and this is the novel element in the interdependence approach, income relative to others provides a social ranking. An increase in an individual's income has the additional effect of increasing his social ranking and this, it is argued, is an additional source of utility.

In this chapter, an interdependence utility function is formulated on three assumptions. Firstly, higher-order interdependence is absent. Secondly, a person derives his satisfaction from his relative income level as well as his own income level. Thirdly, a person is "envious" of all others outside of his household. His relative income level is a ratio of his income level to his subjectively perceived system average income level. The concept of the "reference group" is incorporated to derive such a system average-income level. To derive a measure of this person's risk-attitude, the Arrow-Pratt type risk-premium has to be modified in considering his ability to expect others' income changes even if he cannot control these others' income levels. Application of this interdependence risk-premium is made to give an explanation towards the Cancian Dip in sociological studies of rural adoption process.

5.2 Interdependence Utility Function

An interdependence utility function has been studied by few scholars. Duesenberry (1949) applied an interdependence utility function to an analysis of the choice between consumption and saving, and to an analysis of demand growth. Leibenstein (1950) introduced the concepts of "bandwagon effect", "snob effect", and "Veblen effect". Johnson (1952) used an interdependence utility function in an analysis of the effects of income distribution on aggregate consumption. Pollak (1976) incorporated the idea of "interdependent preferences" into demand analysis with a linear demand system. Hayakawa and Venieris (1977), Kapteyn et al.(1978, 1980) and Van Praag et al. (1979) introduced a sociological concept of "reference groups (space)" into their study of consumer interdependence.

Person i's interdependence utility function is generally defined as follows:

$$U^i = W^i(X_1, X_2, \ldots, X_n) \tag{5.1}$$

where X_k (k = 1,2,...,n) is Person k's income level. Variables inside the utility function can be amounts of commodities Person i and other persons consume, or their utility levels.[1]

Person i's marginal utility with respect to another person, for example, Person j (j $\neq$ i), is

$$U^i_j = \frac{\partial W^i}{\partial X_j}. \tag{5.2}$$

If this marginal utility is negative, Person i is regarded as being envious to Person j's condition, in this case, his income level. An increase in Person j's income level decreases Person i's utility. On the contrary, if it is positive, Person i is considered as being benevolent to Person j. An increase in Person j's income level causes an increase in Person i's utility. Hence, a person's first-order marginal utility with respect to Person j's income level can be termed as his interdependence coefficient with respect to Person j, if the

[1]Ng (1983) classifies types of the interdependence utility function into various categories according to the variables inside of the function.

marginal utility is constant. However, the marginal utility is generally considered to change depending on the income levels of persons involved, and can be written as follows:

$$U^i_j = f(X_1, X_2, \ldots, X_n). \tag{5.3}$$

Since Person i's marginal utility with respect to Person j above includes all others' income levels, this indicates there are higher orders of interdependence between these two persons. That is, for example,

$$U^i_{jk} \neq 0 \quad (k \neq i, j, \text{ and } j \neq i). \tag{5.4}$$

The interdependence between Persons i and j is affected by a third person's (Person k) income level. Since the existence of the higher-order interdependence seems certainly to complicate the further analysis, the absence of the higher-order interdependence is assumed in this study, and Person i's first-order interdependence with respect to Person j is thus defined as follows:

$$U^i_j = f(X_i, X_j). \tag{5.5}$$

Person i's interdependence with respect to Person j is a function of solely these two persons' income levels, and hence third person's income level does not affect these two persons' interdependence.

$$U^i_{jk} = 0 \quad (k \neq i, j, \text{ and } j \neq i) \tag{5.6}$$

5.3 Relative Income Utility Function

In another set of literature, a utility function which includes a person's relative income level together with his own (absolute) income level has been considered. Pigou (1962) noted that " ... the satisfaction which a man derives from the possession of a given income depends not only on the absolute amount of income, but also on the relation subsisting between it and the incomes of other people". Duesenberry (1949) stated that "Our theory ... depends upon the validity of a single hypothesis, viz.: that the utility index is a function of relative rather than absolute consumption expenditure", and

developed his relative income hypothesis. And Galbraith (1958) more dramatically argued that "people are poverty stricken when their income ... falls markedly behind that of the community". Hirsch (1976) introduced the concept of the "positional goods". Thus, economists have known the existence and importance of the contextual effects[2] on persons, but rarely constructed a formal model of the contextual effects following such statements.

Only recently, formal models of contextual effects in the above framework have started emerging. Boskin and Sheshinski (1978) considered the optimal redistributive taxation system using a utility function which includes a person's relative income level as well as his absolute income level. This contributed to solve Mirrlees' problem of the regressivity of marginal tax-rates (Ng 1983).[3] Layard (1980), without referring to the Boskin-Sheshinski model, developed a utility function model which includes the relative income level as well as the absolute income level. This model was stimulated by the study of relative deprivation by Runciman (1966). The concept of "relative deprivation" indicates that a person's satisfaction decreases if others' satisfaction, or characteristics from which satisfaction is derived, increases or is expected to increase.

Person i's relative income utility function is generally defined as follows:

$$U^i = V^i(X_i, S_i) \tag{5.7}$$

where X_i represents Person i's income level, and S_i, Person i's subjective relative income level.

Person i's marginal utility functions with respect to both his income, X_i, and his subjective relative income level, S_i, are, of course, positive. The utility function, V^i, is also assumed to be strictly concave. Hence,

$$V_1^i > 0, \tag{5.8}$$

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[2]Hamaguchi (1982) recognises a man as a "contextual", rather than as an individual by emphasising that he is not an atomistic, independent and astructural being in a social system. In sociology, there are an increasing number of its formal models and statistical methods for testing.

[3]Mirrlees (1971) derived an optimal tax scheme which has a progressive tax-rate but a regressive marginal tax-rate. Various forms of utility functions and social welfare functions are used in later studies (Atkinson 1973, Helpman 1974), but still the regressive marginal tax-rate is present.

$$V_2^i > 0, \tag{5.9}$$

$$V_{11}^i < 0, \tag{5.10}$$

$$V_{22}^i < 0, \tag{5.11}$$

and

$$V_{11}^i V_{22}^i - (V_{12}^i)^2 > 0. \tag{5.12}$$

Person i's subjective relative income level is defined cardinally as the ratio of his income to his subjective system average income.

$$S_i = \frac{X_i}{\tilde{X}_i} \tag{5.13}$$

and

$$\tilde{X}_i = \sum_{k=1}^{n} l_{ki} X_k \tag{5.14}$$

$$\sum_{k=1}^{n} l_{ki} = 1. \tag{5.15}$$

His subjective relative income level is thus higher when S_i is greater. Person i's subjective system average income, $\tilde{X}_i$, is a weighted average of all persons' incomes (Equation (5.14)). l_{ki} (k = 1,2,...,n) is Person i's weight on Person k's income level. This will be called Person i's interdependence coefficient with respect to Person k later. n is the number of persons in the system. A person has his own "small world" or "reference group", which consists of a particular subset of all persons in the whole system.[4] Persons who are outside his reference group are given weights of zero.

In place of the subjective relative income level, Layard introduced a person's

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[4]From the reference group viewpoint, Hayakawa and Venieris (1977) studied consumer interdependence, and Kapteyn et al. (1978, 1980) and Van Praag et al. (1979) studied utility functions. If one considers equally all members of the system he belongs to, including himself, his subjective relative income level is always equivalent to the system average income level (objective not subjective like above), and there is no point in including these coefficients in the model.

percentile rank-order in the earnings distribution into the utility function as a continuous variable. This presents a major problem. Although he had recognised a person's differentiated suffering on account of different persons' income levels, he did not account for this by merely transferring the relative income into a rank order. Thus it seems that Layard misunderstood what Runciman meant. What Runciman really implied in his book is the importance of the reference group to which a person belongs. A person's relative income level should be derived in reference to the income levels of members of his reference group. The concept of social rank does not represent this at all. For example, if Person B whose social rank is just one rank above Person A swaps his social rank with Person C whose social rank is two ranks above Person A, Person A is not affected at all, because his social rank is unchanged. If Person B belongs to Person A's reference group and Person C does not, a change in Person A's utility can be expected. In order to introduce this aspect, Layard should have first identified a person's reference group, and then calculated the person's relative, rather, subjectively relative, income level by, for example, putting different weights to the reference group's members' income levels as well as non-members' income levels.

This relative income utility function can be regarded as an interdependence utility function because Person i's subjective relative income level (Equations (5.13) and (5.14)) includes income levels of all persons in the system.

$$U^i = V^i(X_i, S_i) = W^i(X_1, X_2, \ldots, X_n) \tag{5.16}$$

Hence, Person i's marginal utility with respect to Person j's income level is

$$\frac{\partial W^i}{\partial X_j} = V_2^i \frac{\partial S_i}{\partial X_j} = -V_2^i \frac{X_i l_{ji}}{(\sum_{k=1}^{n} l_{ki} X_k)^2} \quad (j \neq i). \tag{5.17}$$

Therefore, the ratio of Person i's marginal utility with respect to two different persons' income levels equals the ratio of the weights, l_{ji} and l_{ki}.

$$\frac{\partial W^i}{\partial X_j} : \frac{\partial W^i}{\partial X_k} = l_{ji} : l_{ki} \quad (k \neq i, j, \text{and } j \neq i) \tag{5.18}$$

Simultaneously, the sign of the marginal utility with respect to Person j is determined by the sign of the weight, l_{ji}. If the weight is positive, as it is usually assumed, the marginal utility is negative (Equation (5.9)), and this indicates that Person i is envious of an increase in Person j's income, and that he welcomes a decrease in Person j's income. In this sense, Person i can be regarded as being "envious" of Person j. Contrarily, if the weight is negative, the marginal utility is positive, and this indicates that he welcomes an increase in Person j's income and that when Person j's income decreases, his utility decreases as if he sympathises to Person j's misfortune. In this sense, Person i can be regarded as being "benevolent" to Person j.

For these reasons, weights in Person i's subjective relative income level can be termed as Person i's interdependence coefficients with respect to others.

A "benevolent" person may be observed within a household, like a father of a "rotten kid" in Becker's (1974) social interaction model. However, among households it may be rarely observed. There are charity activities among households, but they are often regulated by religious codes, or they are not between specific households, and often through an institution specifically established for the charity purpose. In this study, hence, all persons are assumed to be "envious" of others, like a Hobbesian being, and all interdependence coefficients are thus positive.

Further, from Equations (5.15) and (5.17), the ratio of the sum of Person i's marginal utility levels with respect to all others' income levels to his marginal utility with respect to Person j's income level equals the ratio of the sum of Person i's all interdependence coefficients to his interdependence coefficient with respect to Person j. The former is, by definition, equivalent to one minus Person i's weight on his own income level in his subjective system average income level.

$$\sum_{k \neq i} \frac{\partial W^i}{\partial X_k} : \frac{\partial W^i}{\partial X_j} = \sum_{k \neq i} l_{ki} : l_{ji} = 1 - l_{ii} : l_{ji} \tag{5.19}$$

Therefore, the weight on his own income level may well be termed as his independence

coefficient.[5]

If Person i is "completely independent", his independence coefficient equals one, $l_{ii} = 1$, and all interdependence coefficients are zero, $l_{ki} = 0$ $(k \neq i)$. In this case, his subjective system average income to equal his own income over the whole range of income. This makes his subjective relative income level, S_i, always equals one, and thus his interdependent utility depends only on his income level, i.e., his utility function is an independent utility function.

A completely independent person is thus at the end of the scale. However, since a person who never appreciates his own income in his consideration of his subjective system average income cannot be imagined, the independence coefficient, l_{ii}, cannot be zero nor negative. Hence, the independence coefficient and interdependence coefficient respectively satisfy

$$0 < l_{ii} \leq 1, \tag{5.20}$$

and

$$0 \leq l_{ki} < 1, \quad (k \neq i). \tag{5.21}$$

The relative income utility is, as seen above, a type of interdependence utility functions. As discussed in the last section, if the absence of higher-order interdependence is assumed, the following condition should be satisfied by the relative income utility

[5]There are three ways to empirically derive these coefficients: (1) categorical approach by Kapteyn et al. (1978, 1980) and Van Praag et al. (1979), (2) relational approach by Rogers and Kincaid (1981), and (3) structural approach by Burt (1980, 1982). The last two approaches belong to sociological network analysis, and particularly Burt's structural approach was combined with an interdependence utility function which can be interpreted as a relative income utility function. For the interpretation, see Section 1.4.6.

function:[6]

$$V^i_{22}S_i + 2V^i_2 = 0. \tag{5.22}$$

The general solution of the above partial differential equation is

$$V^i(\ X_i,\ S_i\ ) = -\frac{exp(f(X_i))}{S_i} + g(X_i). \tag{5.23}$$

Although there are many forms of mathematical functions for the above two functions which satisfy Equations (5.8) to (5.12), it is difficult to interpret them reasonably without further complicacy and unnecessary arbitrariness.

A start is made with the marginal utility function with respect to a person's own income level. A person's marginal utility function with respect to his own income level is assumed to consist of two parts and to be multiplicatively separable.[7] Therefore, Person i's marginal utility function with respect to his own income level, which embodies the above properties, can be formulated as follows:

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[6]Differentiating Person i's marginal utility with respect to Person j's income level (X_j, $j \neq i$), Equation (5.17), with respect to Person k's income (X_k, $k \neq i, j$),

$$\frac{\partial^2 W^i}{\partial X_k \partial X_j} = \frac{X_i l_{ji} l_{ki}}{(\sum_{q=1}^{n} l_{qi} X_q)^3} (V^i_{22}S_i + 2V^i_2)$$

is obtained. Since the assumption of the absence of higher-order interdependence means

$$\frac{\partial^2 W^i}{\partial X_k \partial X_j} = 0 \quad (k \neq i,\ j,\ and\ j \neq i),$$

the following condition can be obtained:

$$V^i_{22}S_i + 2V^i_2 = 0$$

where subscripts of the function V indicate arguments in the function V by which the function V is differentiated.

[7]An additive form requires an arbitrary constant and restricts the range of income levels.

$$\frac{\partial W^i}{\partial X_i} = \frac{u'(X_i)}{S_i} \tag{5.24}$$

where

$$u_i' = u'(X_i) > 0, \tag{5.25}$$

and

$$u_i'' = u''(X_i) < 0. \tag{5.26}$$

The numerator is his independent marginal utility function, which is equivalent to the conventional marginal utility function. This function is assumed to be positive and decreasing. The denominator is his subjective relative income level. The addition of the denominator to the conventional marginal utility function represents the fact that a person's subjective value of $1 is greater if he becomes poorer in absolute money terms, and/or if he falls in terms of the subjective relative income level. As discussed above, a completely independent person, who has the independence coefficient which equals one ($l_{ii} = 1$), has a subjective relative income level which equals one ($S_i = 1$). Therefore, the first part indicates the marginal utility function of his income, and is called his independent marginal utility function.

This formulation of a person's marginal utility function is equivalent to the

following formulation of his utility function.[8]

$$U^i = V^i(\, X_i,\, S_i\,) = l_{ii}\,\{\, u(X_i) - X_i F_i\,\} + \frac{X_i F_i}{S_i} \tag{5.27}$$

where, for notational convenience, F_i is defined as

$$F_i = \int \frac{u'(X_i)}{X_i}\, dX_i. \tag{5.28}$$

If, again, Person i is completely independent having his independence coefficient which equals one, this utility function yields,

$$U^i = u(X_i) \tag{5.29}$$

Hence, $u(X_i)$ can be called his independent utility function.

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[8]Integrating both sides of

$$\frac{\partial U^i}{\partial X_i} = u_i' \frac{\tilde{X}_i}{X_i}$$

with respect to X_i,

$$U^i = l_{ii} u(X_i) + \int \frac{u'(X_i)}{X_i}\, dX_i \sum_{k \neq i} l_{ki} X_k + f(X_1,\ldots,X_{i-1},X_{i+1},\ldots,X_n)$$

is obtained. Assuming $f(X_1,\ldots,X_{i-1},X_{i+1},\ldots,X_n) = 0$,

$$U^i = l_{ii} u(X_i) + \int \frac{u'(X_i)}{X_i}\, dX_i \sum_{k \neq i} l_{ki} X_k$$

is obtained. Since

$$\sum_{k \neq i} l_{ki} X_k = X_i\,(\,\frac{1}{S_i} - l_{ii}\,),$$

Person i's utility function is

$$U^i = V^i(X_i, S_i) = l_{ii}\,\{\, u(X_i) - X_i F_i\,\} + \frac{X_i F_i}{S_i}$$

where

$$F_i = \int \frac{u'(X_i)}{X_i}\, dX_i.$$

When this utility function, Equation (5.27), is corresponded to the generally admissible form, Equation (5.23),

$$f(X_i) = log_e(\ -\ X_i F_i\ ) \tag{5.30}$$

and

$$g(X_i) = l_{ii}\{\ u(X_i) - X_i F_i\ \} \tag{5.31}$$

are obtained.

With this form of a person's utility function, the conditions above, Equations (5.8) to (5.12), can be rewritten as follows:

$$V_1^i = -\ l_{ii} F_i + \frac{u_i' + F_i}{S_i} > 0, \tag{5.32}$$

$$V_2^i = -\ \frac{X_i F_i}{S_i^2} > 0, \tag{5.33}$$

$$V_{11}^i = \frac{u_i'}{X_i}\left(\frac{1 - \rho_i^R}{S_i} - l_{ii}\right) < 0, \tag{5.34}$$

$$V_{22}^i = \frac{2X_i F_i}{S_i^3} < 0, \tag{5.35}$$

$$V_{11}^i V_{22}^i - (V_{12}^i)^2 = \frac{2u_i' F_i(1 - \rho_i^R - l_{ii} S_i) - (u_i' + F_i)^2}{S_i^4} > 0. \tag{5.36}$$

where ρ_i^R is the Arrow-Pratt relative risk-aversion index of Person i's independent utility function, $u(X_i)$.

$$\rho_i^R = -\ X_i \frac{u_i''}{u_i'} \tag{5.37}$$

The elementary algebraic function which satisfies the conditions, Equations (5.25), (5.26) and (5.32) to (5.36), to be Person i's independent utility function, $u(X_i)$, is the natural log of income

$$u(X_i) = log_e X_i \tag{5.38}$$

or

$$u(X_i) = -\frac{1}{X^{\alpha}}, \quad \alpha > 0. \tag{5.39}$$

These two types of functions both yield a constant Arrow-Pratt relative risk aversion index. The Arrow-Pratt relative risk-aversion index for the former function is:

$$\rho_i^R = 1, \tag{5.40}$$

and for the latter

$$\rho_i^R = 1 + \alpha, \quad \alpha > 0. \tag{5.41}$$

This indicates that, a completely independent person's relative Arrow-Pratt risk-aversion index should be constant and greater than or equal to one in the framework of the relative income utility function. This theoretical finding matches empirical findings of distribution of the Arrow-Pratt relative risk aversion index, if farmers in the empirical studies can be regarded as independent person in an experimental environment. Hamal and Anderson (1982) found almost all farmers have relative risk aversion index greater than or equal to one.

Intuition suggests that a person's risk-aversion decreases as his income level increases (Deaton and Muellbauer 1980:399, Anderson, Dillon and Hardaker 1977:90), and experiments by Binswanger (1980) and others in several developing countries reinforce this intuition. It is not specified whether it is his independent absolute risk-aversion as derived from u_i, or his interdependence absolute risk-aversion as derived from U^i, that decreases. However, psychological experiments in isolated or confined spaces like laboratories support the intuition that a person's independent absolute risk-aversion decreases as his income level increases (Stevens 1957). The person's independent absolute risk-aversion index is thus regarded here as being determined by his income level alone, along with its negative derivative. The independent utility functions identified above give a constant Arrow-Pratt relative risk-aversion index which is greater than or equal to one ($\rho_i^R = 1 + \alpha \geq 1$).

A person's utility function, Equation (5.27), implicitly consists of all persons'

income levels, according to the definition of a person's subjective system average income, Equations (5.13) and (5.14). Properties of the utility function with respect to each person's income level can be examined.

$$W_i^i = \frac{u'(X_i)}{S_i} = u'(X_i)\frac{\sum_{k=1}^{n} l_{ki}X_k}{X_i} > 0, \tag{5.42}$$

$$W_{ii}^i = \frac{u''(X_i)}{X_i}\sum_{k=1}^{n} l_{ki}X_k - \frac{u'(X_i)}{X_i^2}\sum_{k\neq i} l_{ki}X_k < 0, \tag{5.43}$$

$$W_j^i = l_{ji}F_i \leq 0 \quad (j\neq i), \tag{5.44}$$

$$W_{jj}^i = 0 \quad (j\neq i), \tag{5.45}$$

$$W_{ij}^i = W_{ji}^i = l_{ji}\frac{u'(X_i)}{X_i} \geq 0 \quad (j\neq i), \tag{5.46}$$

and hence

$$W_{ii}^i W_{jj}^i - (W_{ij}^i)^2 = -(W_{ij}^i)^2 \leq 0. \tag{5.47}$$

Person i's marginal utility of his own income is positive and decreasing, and depends on other persons' income levels (Equation (5.42)). As Person j's income level increases, Person i's marginal utility of his own income increases (Equation (5.46)). As has been implied by the definition of his marginal utility of his own income, his valuation of an additional $1 increases when he becomes poorer in his subjective relative income level. Since an increase in Person j's income is equivalent to a decrease in his subjective relative income level, the above implication is quite natural.

Person i's marginal utility with respect to another person's (Person j's) income is negative (Equation (5.44)), and it is constant with respect to that person's income (Equation (5.45)). No matter how high Person j's income may be, an increase in Person j's income has the same effect on Person i's utility. The magnitude of this marginal utility

depends on Person i's interdependence coefficient with respect to Person j and on Person i's income level (Equation (5.46)). As Person i's interdependence with Person j increases, the absolute magnitude of this marginal utility increases. The more interdependent a person is with others, the more affected he is by others. As Person i's income increases, the absolute magnitude of this marginal utility decreases.

The last equation (Equation (5.47)) indicates that the indifference curves of Person i with respect to Person i and Person j's income levels are not concave. If Person i is not dependent on Person j, $l_{ji} = 0$, then his indifference curves are a set of straight vertical lines. But if not, his indifference curves are a set of curves with an increasing positive slope.

5.4 Attitudes towards Risk

5.4.1 Derivation of Interdependence Risk-Premium

As shown in Equation (5.16), Person i's utility function can be rewritten as an interdependent utility function which includes all persons' income levels.

$$U^i = V^i(X_i, S_i) = W^i(X_1, X_2, \ldots, X_n) \tag{5.48}$$

This form of the utility function resembles a multi-commodity utility function in an algebraic form. However, the multi-person interdependence utility function has properties radically different from a multi-commodity utility function in terms of expectations.

For deriving Person i's risk-premium, it is considered that Person i has his own particular expectation of his personal income level, of its variance, of others' income levels, and of the covariances between the distributions of his expected income level and others' expected income levels. His own expected income level is

$$\bar{X}_i^i = E^i(X_i), \tag{5.49}$$

and his expected income level for Person k, $\bar{X}_k^i$, is

$$\bar{X}_k^i = E^i(X_k). \tag{5.50}$$

The variance of his expected income level, σ^{i}_{ii}, is[9]

$$\sigma^{i}_{ii} = VAR^{i}(X_i), \tag{5.51}$$

and the covariance between his own expected income level and what he expects to be the level of Person k's income, σ^{i}_{ik}, is

$$\sigma^{i}_{ik} = COV^{i}(\, X_i, X_k \,). \tag{5.52}$$

Person i's certainty equivalent is defined as the certain income which gives the same utility as the utility expected from the risky situation. In a single variate utility function case, a single level of the variable as the certainty equivalent can be selected, but in a multi-variate utility function case, either in multi-commodity or in multi-person situation, it is not possible to derive a single point without a constraint. There is a set of certainty equivalents.

Algebraically, Person i's set of certainty equivalents, $\mathbf{C}^{i}$, is

$$\mathbf{C}^{i} = [\, \mathbf{Y} \mid E^{i}\{W^{i}(\mathbf{X})\} = W^{i}(\mathbf{Y}) \,], \tag{5.53}$$

i.e., a set of income levels of all persons which give the same utility level as the utility level expected from the risky situation.

By Taylor's expansion around all persons' present income level vector:[10]

$$\mathbf{X}^{0} = (X^{0}_{1}, X^{0}_{2}, \ldots, X^{0}_{n})^{t}$$

Person i's expected utility in the risky situation is:

$$\begin{aligned} & E^{i}\{W^{i}(\mathbf{X})\} \\ & \quad \approx W^{i}(\mathbf{X}^{0}) + \{E^{i}(\mathbf{X}) - \mathbf{X}^{0}\}^{t}\, grad\{W^{i}(\mathbf{X}^{0})\} \\ & \qquad + \frac{1}{2}\, trace(\mathbf{Z}^{i}\, \Sigma^{i}) + \frac{1}{2}\, \{E^{i}(\mathbf{X}) - \mathbf{X}^{0}\}^{t}\, \mathbf{Z}^{i}\, \{E^{i}(\mathbf{X}) - \mathbf{X}^{0}\} \end{aligned}$$

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[9]To avoid more superscripts, the order of power, 2, is omitted, and instead, the subscript, i, is repeated. Therefore, this does not indicate the standard deviation, and in the further analysis, the standard deviation does not appear at all.

[10]Refer to Malinvaud (1971), page 290-292.

where $\mathbf{Z}^i$ is the Hessian matrix of Person i's multi-person interdependence utility function $W^i(\mathbf{X})$ at $\mathbf{X} = \mathbf{X}^0$, and Σ^i is a variance-covariance matrix of Person i's expectation of all members' income levels.

On the assumption that the difference between the certainty equivalent and his present income level is negligible at its second order, his utility at the certainty equivalent $\mathbf{Y}$ can be expanded as

$$W^i(\mathbf{Y}) = W^i(\mathbf{X}^0 + (\mathbf{Y} - \mathbf{X}^0))$$
$$\approx W^i(\mathbf{X}^0) + (\mathbf{Y} - \mathbf{X}^0)^t \, grad\{W^i(\mathbf{X}^0)\}.$$

Therefore, any certainty equivalent, $\mathbf{Y}$, satisfies

$$\frac{1}{2} trace(\mathbf{Z}^i \, \Sigma^i) + \frac{1}{2} \{E^i(\mathbf{X}) - \mathbf{X}^0\}^t \, \mathbf{Z}^i \, \{E^i(\mathbf{X}) - \mathbf{X}^0\} = (\mathbf{Y} - \mathbf{X}^0)^t \, grad\{W^i(\mathbf{X}^0)\}. \tag{5.54}$$

If Person i's expected income level vector, $\mathrm{E}^i(\mathbf{X})$, equals the present income level vector, $\mathbf{X}^0$,

$$\frac{1}{2} trace(\mathbf{Z}^i \, \Sigma^i) = (\mathbf{Y} - \mathbf{X}^0)^t \, grad\{W^i(\mathbf{X}^0)\} \tag{5.55}$$

is obtained.

So long as another constraint is not provided, a single certainty equivalent cannot be derived. In the multi-person interdependence utility case, any one certainty equivalent cannot be dominant over others. A plausible assumption is needed to obtain one certainty equivalent in the multi-person interdependence utility function case.

Person i can expect others' income levels, but cannot control their income levels. In the framework of the multi-person interdependence utility function, Person i's certainty equivalent can be defined as the amount of income he can obtain with certainty while he expects some amount of income increase happens to others with certainty. However, in the framework of a relative income utility function in this study, a plausible scenario should also be based on a person's "envy" or "malevolence".

Consider a risky situation which is expected by Person i. Suppose he can obtain a

certain windfall gain with certainty while nobody else gets such a windfall. Now if he is indifferent between this situation and the risky situation, the amount of this windfall is defined as his certainty equivalent to the risky situation he expects, and the difference between this certainty equivalent and the expected income level is defined as his risk-premium, which represents the degree of his risk-aversion.

Algebraically, this definition of the certainty equivalent vector is

$$\mathbf{Y} = (\bar{X}^i_1, \ldots, \bar{X}^i_{i-1}, c_i, \bar{X}^i_{i+1}, \ldots, \bar{X}^i_n)^t \tag{5.56}$$

where c_i is Person i's certainty equivalent (scalar). This scenario is obviously based on a person's "envy" or "malevolence" for he does not think others are as lucky as he is.[11]

Therefore, Equation (5.55) can be modified according to the scenario as

$$\frac{1}{2} trace(\mathbf{Z}^i \, \Sigma^i) = (c_i - X^0_i) \frac{\partial}{\partial X_i} W^i(\mathbf{X}^0). \tag{5.57}$$

Hence, Person i's interdependence risk-premium is

$$PREMIUM_i = X^0_i - c_i = - \frac{trace(\mathbf{Z}^i \, \Sigma^i)}{2 \dfrac{\partial}{\partial X_i} W^i(\mathbf{X}^0)}. \tag{5.58}$$

The particular form of the relative income utility function formulated in Equation (5.27) yields the following interdependence risk-premiums:[12]

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[11] If a person's interdependence utility function is not based on relative income levels, and based both on "benevolence" or "altruism", two other scenarios can be plausible. Details are in Appendix E.2.

[12] Components of the Hessian matrix, $\mathbf{Z}^i$, for the relative income utility function, Equation (5.27), are

$$W^i_{ii} = - \frac{u'_i}{S_i X_i} (1 + \rho^R_i - w_{ii})$$

$$W^i_{ij} = W^i_{ji} = l_{ji} \frac{u'_i}{X_i} \quad (j \neq i)$$

$$W^i_{jk} = W^i_{kj} = 0 \quad (k \neq i \text{ and } j \neq i).$$

(5.59)

$$PREMIUM_i = (1 + \rho_i^R - \omega_{ii}) \frac{\sigma_{ii}^i}{2X_i^0} - \sum_{k \neq i} \omega_{ik} \frac{\sigma_{ik}^i}{X_k^0}.$$

where ρ_i^R is the Arrow-Pratt relative risk-aversion index of Person i's independent utility function, $u(X_i)$, and

(5.60)

$$\omega_{ik} = \frac{l_{ki} X_k^0}{\sum_{q=1}^{n} l_{qi} X_q^0} \quad (k=1,2,...,n)$$

is an interdependence weight indicating Person i's interdependence with Person k, derived from the combination of Person i's all interdependence coefficients and all persons' income levels. If k = i, then this weight is especially called Person i's independence weight following the convention of the naming of the interdependence and independence coefficients. They can also be interpreted as the proportion of Person k's income in Person i's subjective system average income (Equation (5.14)). The signs of these two types of risk-premium are identical because the independence weight, ω_{ii}, is less than or equal to one, the functions F_i and u_i' are respectively negative and positive for any $X_i > 0$, and they satisfy Equation (5.32). The above interdependence risk premium includes a completely independent person's, i.e., $l_{ii} = 1$, risk-premium as a special case.[13]

The first part of the interdependence risk-premium, Equation (5.59), is actually the risk-premium given by the Arrow-Pratt risk-aversion indices. It is based on the first- and second-order partial derivatives of Person i's interdependence utility function (Equation (5.27)) with respect to his own income level. If the covariances in the second part is ignored on some assumption, the Arrow-Pratt risk-aversion indices can be also used for the interdependence utility function. The simplest assumption which enables this may be that Person i considers that the distributions of all others' income levels are independent of the distribution of his own income level. All the covariances, therefore, equal zero. However, this assumption will not be made in this study.

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[13] A "completely" independent person's independence coefficient, l_{ii}, equals 1 by definition. Hence, $\omega_{ii} = 1$ and $\omega_{ik} = 0$ ($k \neq i$).

The second part of the numerator of the interdependence risk-premium thus plays a crucial role. Where the first part together with interdependence weights, ω_{ik} (k=1,2,...,n), and income levels, X_k^0 (k=1,2,...,n), are positive, the covariances are important in determining the sign of Person i's risk-premium.

Let this second part be called the interdependence expectation effect on a person's risk-premium, because this part aggregates the person's expectation of other persons' income changes.

5.4.2 Interdependence Expectation Effect

If Person i expects that Person k's income level is positively correlated with his income level, i.e., σ_{ik}^i is positive, Person i's risk-premium can be pulled down towards zero, and further into the negative range. He may thus be a risk-taker when he expects that others' income levels are positively correlated with his own in this way. The others' income levels are in his utility function as sources of relative deprivation (decreasing his utility level); the belief that his income level is thus positively correlated with those of others means that the expectation of an increase of his own income has simultaneously both a positive and a negative effect on his utility. Due to its effect on others' incomes, his utility will decrease while it increases his independent utility, $u(X_i)$. A person of this type may have a low degree of risk aversion or even be a risk-taker.

On the other hand, if Person i expects that Person k's income level is negatively correlated with his, i.e., σ_{ik}^i is negative, his risk-premium is pushed up and he becomes more risk-averse. His utility is increased by both an increase in his income level and associated decreases in those of others.

The second part of the numerator of the interdependence risk-premium only includes covariances between Person i's income levels and those of all others. It does not include the variances of these income levels (σ_{kk}^i, $k \neq i$), or their covariances (σ_{jk}^i, $j, k \neq i, j \neq k$) as expected by him. This reflects the assumption of the absence of the higher-order interdependence, i.e., a third person's income level (Person k) does not influence Person i's marginal utility with respect to a second person's (Person j's) income level, Equation (5.6). Person i is not required to have expectations regarding all the variances and covariances of all other persons' expected income levels. For a measure of the risk

premium to be derived, he is only required to have expectations about the levels and covariances between his own income and those of others. In other words, his density function of the risky situation is not necessarily complete.

The covariance between Person i's and Person k's income levels expected by Person i, σ^{i}_{ik}, is not observable. Person i may plausibly construct this expected covariance on the basis of the variance of his own income level and his relationship with Person k. This is because the variance, σ^{i}_{ii}, is the sole variable which Person i is sure of. Therefore, it is assumed that

$$\sigma^{i}_{ik} = Q_{ik}\,\sigma^{i}_{ii} \tag{5.61}$$

where Q_{ik} is an index indicating Person i's relationship with Person k. If Person i thinks that his expected income is negatively correlated with that of Person k, Q_{ik} is negative, and if he thinks that his expected income is positively correlated with Person k's, Q_{ik} is positive. This new index may be a function of their interdependence coefficients, l_{ki} and l_{ik}, or of their interdependence weights, ω_{ik} and ω_{ki}, Equation (5.60), or of other completely different indices. Because the interdependence coefficients are the most fundamental measures of interdependence in this study, it is assumed that Person i's aggregate relationship with all other persons in terms of his expectation can be represented by the following weighted average of Q_{ik}'s:

$$Q_i = \frac{\sum_{k\neq i} l_{ki}Q_{ik}}{1-l_{ii}} = \frac{1}{1-l_{ii}}\sum_{k\neq i} l_{ki}\frac{\sigma^{i}_{ik}}{\sigma^{i}_{ii}} \quad (l_{ii}\neq 1) \tag{5.62}$$

If this weighted average is positive, Person i is regarded as forming his expectation on the basis that all other persons' income levels are, on the whole, positively correlated with his income level. On the other hand, if Q_i is negative, Person i is regarded as forming his expectation on the basis that all other persons' income levels are, on the whole, negatively correlated with his own. This new index is termed Person i's interdependence expectation index from now on, and the "interdependence expectation effect" and "interdependence expectation index" are, hereafter in this chapter, abbreviated to the "IE effect" and "IE index".

With this IE index, Person i's interdependence risk-premium, Equation (5.59), is modified as follows:

$$PREMIUM_i = \{1 + \rho_i^R - \omega_{ii} - 2(1 - l_{ii})Q_i S_i\} \frac{\sigma_{ii}^i}{2X_i^0} \tag{5.63}$$

If Person i considers that all others' income levels are distributed independently of his own income level, then $Q_{ik} = 0$ $(k \neq i)$, and further $Q_i = 0$. This gives the Arrow-Pratt risk-premium of his interdependence utility function. Again, if positive and negative Q_{ik}'s happen to cancel each other in the process of the summation with weights, Q_i can be zero. If, however, statistical testing shows Q_i to be significantly non-zero, these two cases are rejected and the existence of a kind of interdependence among persons in terms of expectations is supported, i.e., an IE effect.

5.5 Properties of the Interdependence Risk-Premium

Since it was found that elementary algebraic functional forms of a person's independent utility function, $u(X_i)$, which satisfy Equations (5.32) to (5.36) are

$$u(X_i) = log_e X_i \tag{5.64}$$

and

$$u(X_i) = -\frac{1}{X_i^{\alpha}}, \ \alpha > 0, \tag{5.65}$$

these forms are used for investigation of the properties of risk-premium. Thus, the Arrow-Pratt relative risk-aversion index of Person i's independent utility function, ρ_i^R, is equal to or greater than one. Person i's interdependence risk-premium treated from here on is:

$$PREMIUM_i = P_i = \{2 + \alpha - \omega_{ii} - 2(1 - l_{ii})Q_i S_i\} \frac{\sigma_{ii}^i}{2X_i^0} \tag{5.66}$$

where

$\alpha \geq 0$.

5.5.1 Risk-Averse or Risk-Taking

Person i can either be risk-averse or risk-taking, depending on his IE index, Q_i, his present income level, X_i^0, and his independence coefficient, l_{ii}. If he is completely independent, $l_{ii} = 1$, then there is no possibility for him to be risk-taking. Or if he is not completely independent and his IE index, Q_i, is less than or equal to B_1^i, there is no such possibility either. Person i is thus always risk-averse, no matter what the levels of his present income and his independence coefficient may be. But if his IE index, Q_i, is greater than B_1^i, his attitude towards risk changes depending on his present income level and his independent coefficient. His attitude changes from risk-averse to risk-taking as his present income level, X_i^0, increases and surpasses a certain person-specific point, A_1^i. From now on, X_i is simply used to represent Person i's present income level, instead of X_i^0.

$$P_i \begin{cases} > 0 & if\ l_{ii} = 1 \\ & if\ l_{ii} \neq 1\ and\ Q_i \leq B_1^i \\ & if\ l_{ii} \neq 1\ and\ Q_i > B_1^i\ and\ X_i < A_1^i \\ = 0 & if\ l_{ii} \neq 1\ and\ Q_i > B_1^i\ and\ X_i = A_1^i \\ < 0 & if\ l_{ii} \neq 1\ and\ Q_i > B_1^i\ and\ X_i > A_1^i \end{cases} \tag{5.67}$$

where

$$A_1^i = \frac{(2+\alpha)\sum_{k \neq i} l_{ki} X_k}{2(1-l_{ii})Q_i - (1+\alpha)l_{ii}} \tag{5.68}$$

and

$$B_1^i = \frac{(1+\alpha)l_{ii}}{2\,(1-l_{ii})} > 0. \tag{5.69}$$

5.5.2 Income Effect on Risk-Premium

The magnitude of Person i's risk-premium changes as his income level increases. The first-order partial derivative of his risk-premium with respect to his income level is[14]

$$\frac{\partial P_i}{\partial X_i} = -\{2+\alpha-\omega^2-2(1-l_{ii})\omega_{ii}Q_iS_i\}\frac{\sigma^i_{ii}}{2X_i^2} \tag{5.70}$$

$$\begin{cases} <0 & if\ l_{ii}=1 \\ & if\ l_{ii}\neq 1\ and\ Q_i \leq B_1^i \\ & if\ l_{ii}\neq 1\ and\ Q_i > B_1^i\ and\ X_i < A_2^i \\ =0 & if\ l_{ii}\neq 1\ and\ Q_i > B_1^i\ and\ X_i = A_2^i \\ >0 & if\ l_{ii}\neq 1\ and\ Q_i > B_1^i\ and\ X_i > A_2^i \end{cases}$$

where

$$A_2^i = A_1^i[1+\{\frac{l_{ii}+2(1-l_{ii})Q_i}{(2+\alpha)l_{ii}}\}^{1/2}]. \tag{5.71}$$

In examining the possibility of a person being risk-taking and higher order derivatives, it appears that if Person i's IE index, Q_i, is less than or equal to B_1^i, or if he is independent, $l_{ii} = 1$, then the effect of his income level, X_i, on his risk-premium, P_i, is monotonic. As his income level increases, his risk-premium decreases a decreasing rate, and converges to zero. Figure 5-1-a shows the relationship between his income level and risk-premium if his IE index is less than or equal to B_1^i.

If Person i's IE index, Q_i, is greater than B_1^i, the effect of his income level on his risk-premium is not monotonic. As his income level increases from zero, his risk-premium decreases, and after it passes A_1^i, he becomes risk-taking. His risk-premium continues decreasing until his income level reaches A_2^i. Beyond A_2^i, his risk-premium starts increasing and converges to zero (Figure 5-1-b).

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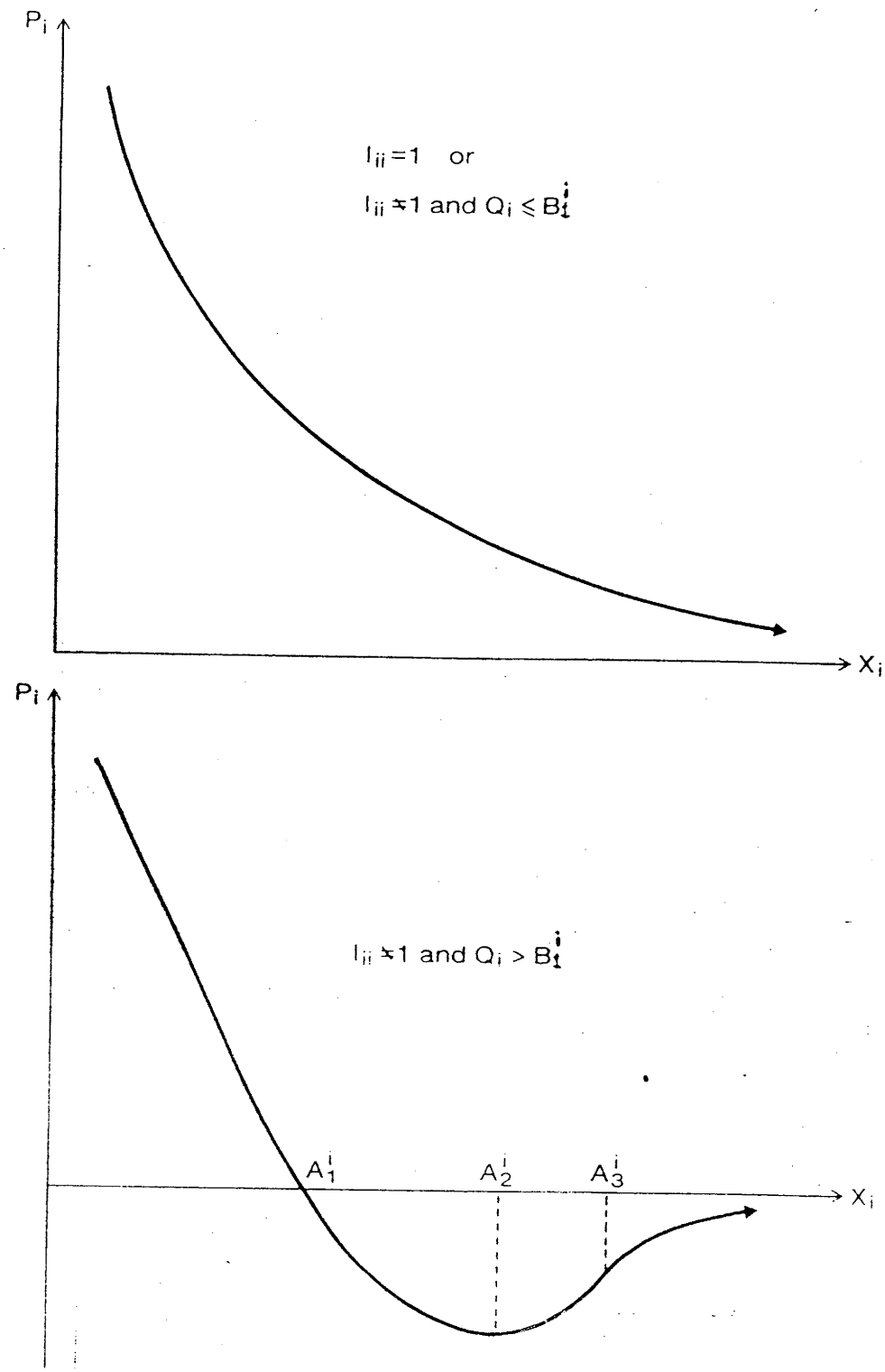
[14]Note that ω_{ij}'s (j=1,2,...,n) include X_i.

Figure 5-1: Risk-Premium and Income



Appelbaum and Katz (1981) and Katz (1983) studied a person's utility function, consisting of his own wealth level and the rank of his wealth level in the society in which he is located. Katz (1983) assumed that a person's attitude towards risk with respect to these two variables is risk-averse in terms of the Arrow-Pratt partial absolute risk-aversion index, and showed that this person's attitude towards risk with respect to his wealth level as a whole could not be determined because of the combined effect of these two variables. Or possibly his utility function corresponds to a Friedman-Savage utility function.[15] This person can be either risk-taking or risk-averse despite these assumptions depending on the wealth distribution within the society. The result shown above coincides with Katz's findings.

5.5.3 Independence Coefficient Effect on Risk-Premium

The magnitude of a person's risk premium changes as his independence coefficient changes. The effect can be represented by the derivative of Person i's risk premium with respect to his independence coefficient. Person i's independence in his decision-making is assumed to change independently, under the constraint that all interdependence coefficients add up to one. Thus, Person i's interdependence coefficient with respect to Person k, differentiated by Person i's independence coefficient is

$$\frac{\partial l_{ki}}{\partial l_{ii}} = \frac{-l_{ki}}{1 - l_{ii}} \quad (\forall k \neq i). \tag{5.72}$$

With this relationship, the first-order partial derivative is:

$$\frac{\partial P_i}{\partial l_{ii}} = \{Q_i - \frac{l_{ii}(1-\omega_{ii})}{2\,\omega_{ii}(1-l_{ii})}\} \frac{\sigma^i_{ii} X_i}{\tilde{X}^2} \tag{5.73}$$

$$\begin{cases} > 0 & if\ Q_i > B_2^i \\ = 0 & if\ Q_i = B_2^i \\ < 0 & if\ Q_i < B_2^i \end{cases}$$

where

[15] Friedman and Savage 1948. See also Section 1.4.3.3.

(5.74)

$$B_2^i = \frac{l_{ii}(1-\omega_{ii})}{2\,\omega_{ii}(1-l_{ii})}$$

The second- and third-order partial derivatives are:

(5.75)

$$\frac{\partial^2 P_i}{\partial l_{ii}^{\,2}} = -\{Q_i - \frac{l_{ii}(1-\omega_{ii})}{2\,\omega_{ii}(1-l_{ii})}\}\frac{\sigma_{ii}^i X_i}{\bar{X}^4}$$

(5.76)

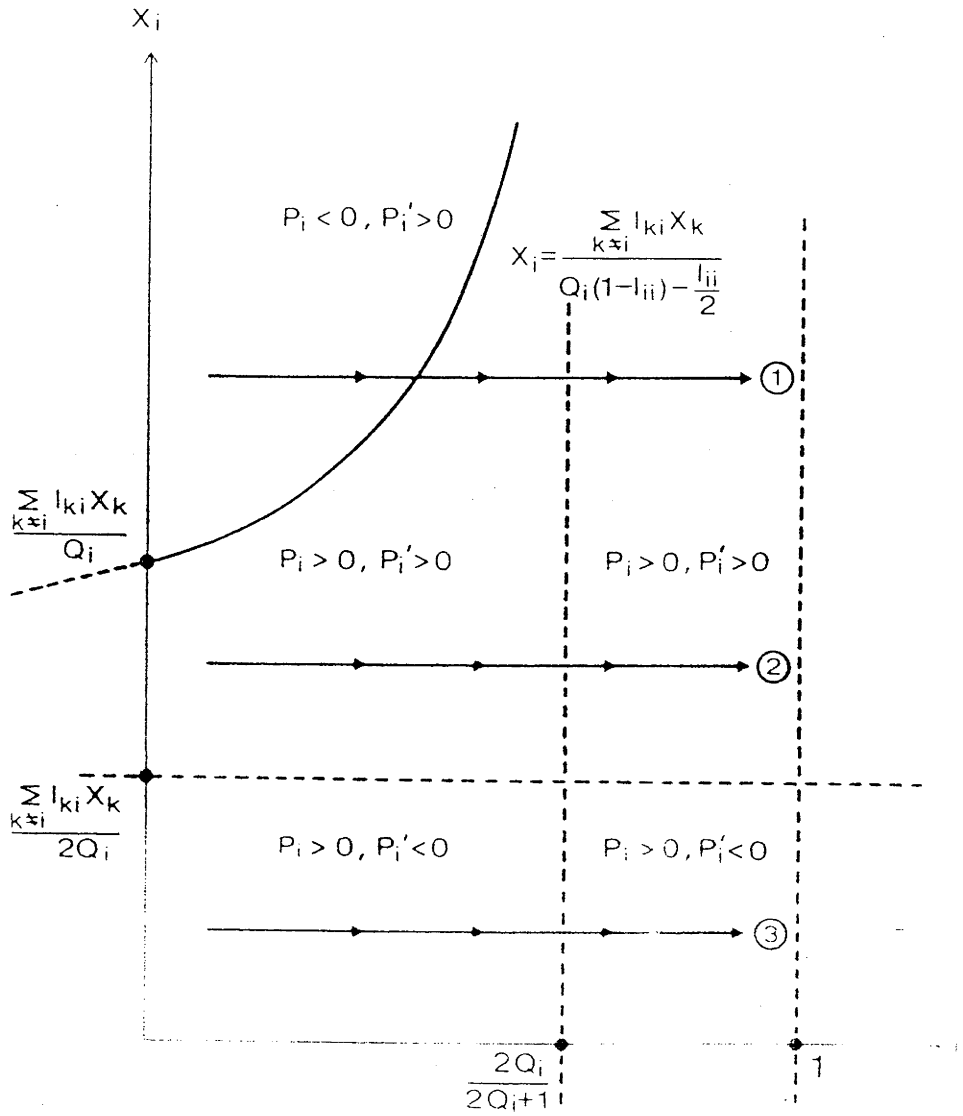
$$\frac{\partial^3 P_i}{\partial l_{ii}^{\,3}} = \{Q_i - \frac{l_{ii}(1-\omega_{ii})}{2\,\omega_{ii}(1-l_{ii})}\}\frac{\sigma_{ii}^i X_i}{\bar{X}^8}$$

These three partial derivatives change their signs according to the same condition as the condition for the first-order partial derivative. Therefore, the relationship between the risk premium and the independence coefficient is monotonic.

The effect of a person's independence coefficient on his risk-premium changes as the relation between his IE index, Q_i, and B_2^i changes. If his IE index, Q_i, is smaller than B_2^i, the effect is negative. On the other hand, if Q_i is greater than B_2^i, the effect is positive. If B_2^i happens to be a very small positive number, this can be interpreted as follows. If the person thinks that others' income levels are on the whole negatively correlated with his, an increase in the independence of his decision making, which is represented by his independence coefficient, leads to a decreased risk-premium, i.e., leads him to become less risk-averse. That is, as the influence from others decreases, the portion of risk-premium determined by others' influence, or his concerns with others, decreases. On the other hand, for a person with a positive IE index, an increase in his independence in decision making increases his risk-averseness, because the portion which reduces his risk-premium due to his optimistic concern with others' income levels decreases. He is thus pushed back to the more risk-averse attitude.

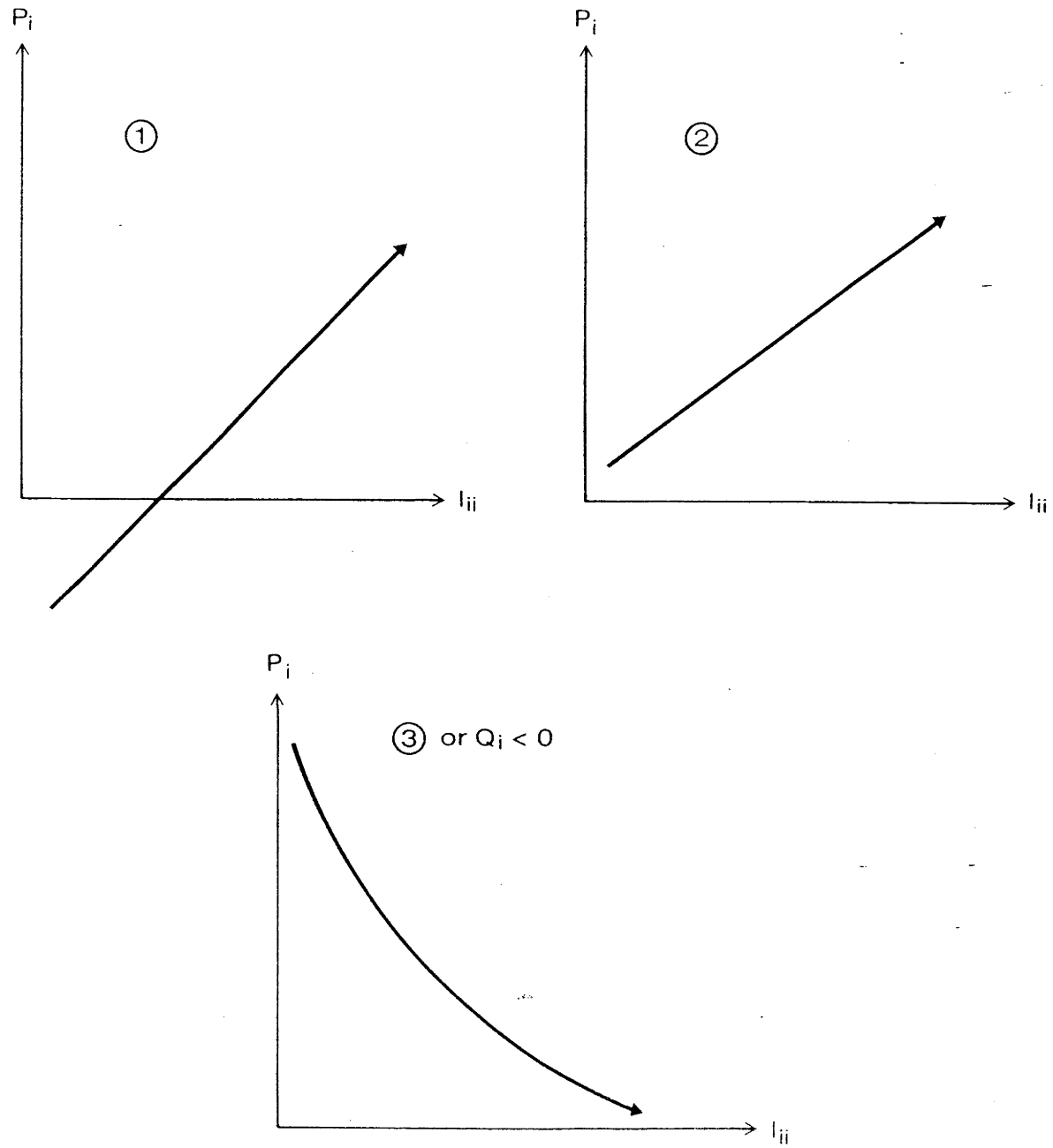
To examine the effect as the person's independence coefficient changes, especially when his IE index is positive, Equations (5.67) and (5.73) are used, and Figure 5-2 is drawn. The half plane constructed with his income level and his independence coefficient is divided into five areas by curves and lines in the two equations. Horizontal lines with arrows represent patterns of changes in the effect of the independence coefficient as it

Figure 5-2: Effect of Independence Coefficient on Risk-Premium (when $Q_i > 0$)



Note: P_i' denotes $\partial P_i / \partial l_{ii}$.

Figure 5-3: Patterns of Effect of Independence Coefficient on Risk-Premium



Note: (1), (2) and (3) respectively correspond to the same signs in Figure 5-2.

moves from zero to one. These patterns are shown in Figure 5-3. If the person's IE index, Q_i, is negative, the effect is simply positive and decreasing, as shown in the last part of Figure 5-3.

5.5.4 Effect of Variance of Expected Income Distribution on Risk-Premium

The effect of the variance of the distribution of the person's expected income on his risk-premium can be examined using the derivatives of his risk-premium with respect to the variance.

$$\frac{\partial P_i}{\partial \sigma_{ii}^i} = \frac{P_i}{\sigma_{ii}^i} = \{2 + \alpha - \omega_{ii} - 2(1 - l_{ii})Q_i S_i\} \frac{1}{2X_i} \tag{5.77}$$

$$\begin{cases} > 0 & if\ l_{ii} = 1 \\ & if\ l_{ii} \neq 1\ and\ Q_i \leq B_1^i \\ & if\ l_{ii} \neq 1\ and\ Q_i > B_1^i\ and\ X_i < A_1^i \\ = 0 & if\ l_{ii} \neq 1\ and\ Q_i > B_1^i\ and\ X_i = A_1^i \\ < 0 & if\ l_{ii} \neq 1\ and\ Q_i > B_1^i\ and\ X_i > A_1^i \end{cases}$$

The effect of the variance on Person i's risk-premium is completely dependent on whether he is actually risk-averse or risk-taking, because the variance merely functions as a multiplier in the risk-premium. Therefore, the effect is identical with Equation (5.67), which indicates whether Person i is risk-averse or risk-taking. If he is independent, $l_{ii} = 1$, then the effect is always positive. Or, if his IE index, Q_i, is less than or equal to B_1^i, the effect is also always positive. Otherwise, the effect depends on the relation between his income level A_1^i defined in Equation (5.68).

5.5.5 Effect of Interdependence Expectation Index on Risk-Premium

The effect of Person i's IE index, Q_i, on his risk-premium is represented by the partial derivative of his risk-premium with respect to Q_i.

(5.78)

$$\frac{\partial P_i}{\partial Q_i} = -(1 - l_{ii}) \frac{\sigma^i_{ii}}{\tilde{X}_i} < 0$$

The effect is always negative. If he thinks that other persons' income levels are, on the whole, more highly positively correlated with his income level than before, his risk-premium is decreased. He should be less risk-averse (or more risk-taking) to obtain a certain level of utility. If, on the contrary, he thinks that other persons' income levels are more negatively correlated with his income level than before, his risk-premium is increased. He does not need to act in a risk-taking way to obtain a certain level of utility, rather he can act in a more risk-averse way.

5.6 Application: Adoption of Innovations and Risk-Premium

In the literature on the adoption of new agricultural technology, it is widely acknowledged that a person's risk-aversion is a positive determinant of his time of adoption and a negative determinant of his scale of adoption. That is, if he is highly risk-averse, he is slow to adopt and adopts less, and if he is less risk-averse he is quick to adopt and adopts more.

In a formal framework, Feder (1978, 1980), as reviewed in Section 1.4.1.3, formulated an expected utility maximising model and determined that a person's Arrow-Pratt risk aversion index is a negative determinant of the scale of adoption. As to the time of adoption, Lindner and Fischer (1982), as reviewed in Section 1.4.1.4, formulated a Bayesian model and showed the time of adoption is partly determined by a person's attitude towards risk.

In this study, it is assumed that the adoption behaviour, I_i, such as time and scale of adoption, is a function of a person's risk-premium, P_i, and other individual socio-economic characteristics, Z_{ik} (k=1,2,...,m), already identified as important to adoption. These characteristics are educational attainment, labour constraints, tenure status, age, farming experience, etc.

$$I_i = f(\, P_i, Z_{i1}, Z_{i2}, \ldots, Z_{im}\,) \tag{5.79}$$

where

$$f_1 = \frac{\partial f}{\partial P_i} < 0, \quad f_{11} = \frac{\partial^2 f}{\partial P_i^2} \leq 0, \quad and \quad f_{111} = \frac{\partial^3 f}{\partial P_i^3} \leq 0 \quad if\ I_i > 0 \tag{5.80}$$

are assumed.

The first assumption in Equation (5.80) obviously indicates that if a person becomes less risk-averse, he adopts more. The second and third assumptions indicate rapid progress at the initial adoption stage. Figure 5-4 illustrates the relation between the risk-premium and the adoption scale. Once a person's risk-aversion has decreased and surpassed the threshold level, he suddenly starts adopting the innovation by a relatively large amount. The marginal increase of adoption scale decreases, however, as his risk-aversion decreases further.

From the definition of the risk-premium, P_i (Equation (5.66)), this functional relation yields

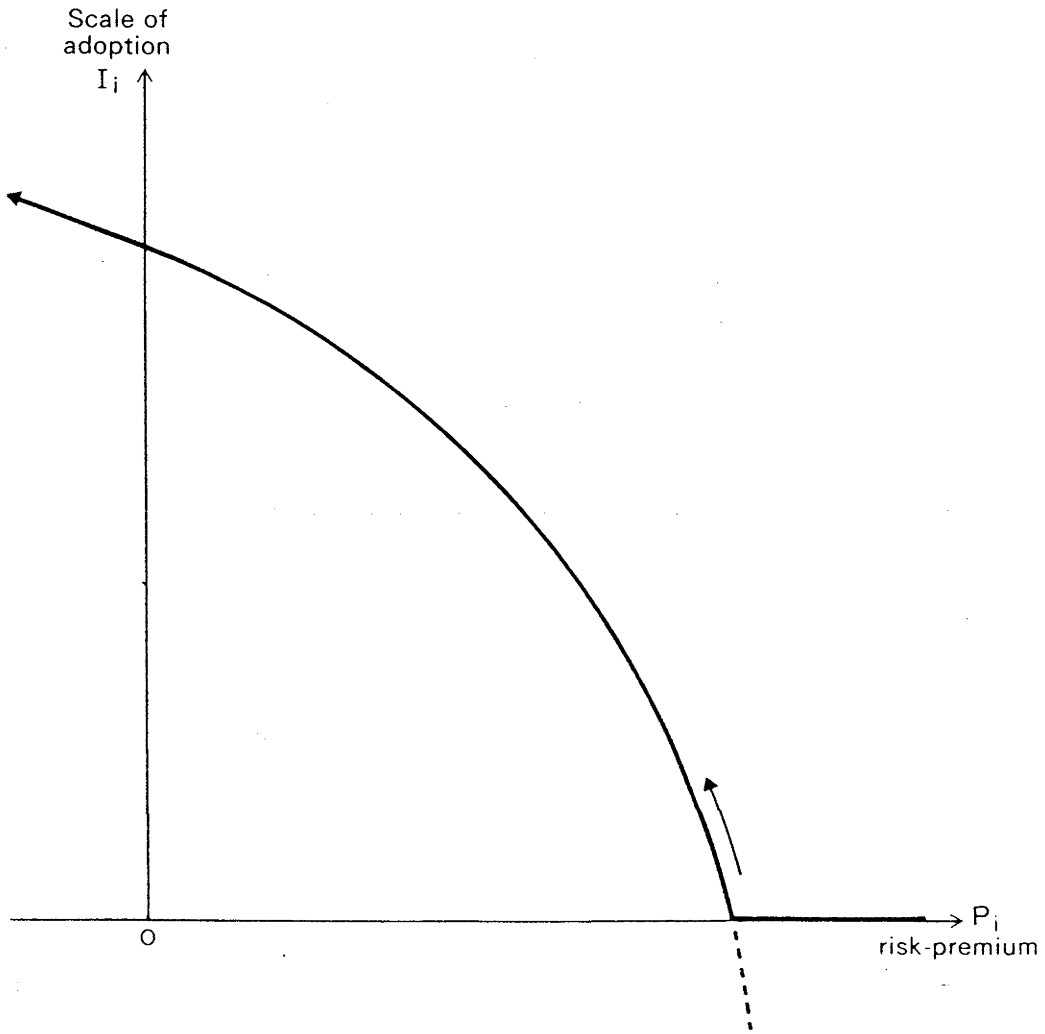
$$I_i = f(\, \{2 + \alpha - \omega_{ii} - 2(1 - l_{ii})Q_i S_i\} \frac{\sigma^i_{ii}}{2X_i}, Z_{i1}, Z_{i2}, \ldots, Z_{im}\,) \tag{5.81}$$

5.6.1 Income Effects on the Scale of Adoption

Income level, either expected or present, has been regarded as an important determinant of adoption behaviour. Yet, as will be reviewed later in Section 6.2.2, income level is a surrogate of many other characteristics which affect adoption behaviour. Thus, income level is excluded from the socio-economic characteristics, Z_{ik} (k=1,2,...,n), and is regarded solely as the determinant of risk-premium. This is on the assumption that these other socio-economic characteristics together cover the characteristics for which income level is a surrogate. Thus, the effect of expected income level on adoption behaviour works only through the risk-premium, P_i.

If the latter is not the case, then income level must be included as one of the socio-economic characteristics independently of the risk-premium. While the need to include income level is tested later in the next chapter, it is assumed, in this section, that income level can be excluded from the set of socio-economic characteristics.

Figure 5-4: Relation between Risk-Premium and Adoption Scale



The first-order partial derivative of the scale of adoption with respect to income level is

(5.82)

$$\frac{\partial I_i}{\partial X_i} = f_1 \frac{\partial P_i}{\partial X_i} = -\{2 + \alpha - \omega^2 - 2(1-l_{ii})\omega_{ii}Q_iS_i\} \frac{\sigma^i_{ii}}{2X_i^2}$$

$$\begin{cases} > 0 & if\ l_{ii} = 1 \\ & if\ l_{ii} \neq 1\ and\ Q_i \leq B_1^i \\ & if\ l_{ii} \neq 1\ and\ Q_i > B_1^i\ and\ X_i < A_2^i \\ = 0 & if\ l_{ii} \neq 1\ and\ Q_i > B_1^i\ and\ X_i = A_2^i \\ < 0 & if\ l_{ii} \neq 1\ and\ Q_i > B_1^i\ and\ X_i > A_2^i \end{cases}$$

where A_2^i and B_1^i are respectively as defined in Equations (5.71) and (5.69).

If Person i is independent, or with an IE index less than or equal to B_1^i, then the effect of his income level is always negative. As his income level increases, his scale of adoption increases and converges towards a certain level. However, if Person i is not independent, and his IE index is greater than B_1^i, his scale of adoption first increases upto A_2^i, and thus decreases beyond this point (Figure 5-6).

Higher-order derivatives suggest that the inflexion point in the relation between the risk-premium and the income level is moved to right, if the IE index is greater than B_i^1. Otherwise, there is no maximum point or inflexion point at all as depicted as Curve-3 in Figure 5-6, since these partial derivatives are respectively always negative and positive over the whole range of income level.

5.6.2 Independence Coefficient and the Scale of Adoption

The effect of the independence coefficient on the scale of adoption changes as the relation between a person's IE index and B_2^i changes.

(5.83)

$$\frac{\partial I_i}{\partial l_{ii}} = f_1 \{Q_i - \frac{l_{ii}(1-\omega_{ii})}{2\,\omega_{ii}(1-l_{ii})}\} \frac{\sigma^i_{ii}X_i}{\tilde{X}^2}$$

$$\begin{cases} < 0 & if\ Q_i > B_2^i \\ = 0 & if\ Q_i = B_2^i \\ > 0 & if\ Q_i < B_2^i \end{cases}$$

where B_2^i is as defined in Equation (5.74).

As discussed in Section 5.5.3, the effect of a person's independence coefficient on his risk-premium captures the relationship that others have on his decision making, including his belief regarding the relation between his income level and that of others. The effect of a person's independence coefficient on his scale of adoption also captures this relationship. If the person's IE index is greater than B_2^i, that is, his income level is on the whole highly positively correlated with others' income levels, his scale of adoption decreases with his growing independence in decision making. On the contrary, if the person's IE index is less than B_2^i, he increases his scale of adoption as he becomes more independent in decision making.

5.6.3 Variance of Expected Income Distribution and the Scale of Adoption

The effect of the variance of Person i's prospect of his own income changes is shown by the following derivative:

$$\frac{\partial I_i}{\partial \sigma_{ii}^i} = f_1 \frac{P_i}{\sigma_{ii}^i} = f_1\{2 + \alpha - \omega_{ii} - 2(1 - l_{ii})Q_i S_i\} \frac{1}{2X_i} \tag{5.84}$$

$$\begin{cases} < 0 & if\ l_{ii} = 1 \\ & if\ l_{ii} \neq 1\ and\ Q_i \leq B_1^i \\ & if\ l_{ii} \neq 1\ and\ Q_i > B_1^i\ and\ X_i < A_1^i \\ = 0 & if\ l_{ii} \neq 1\ and\ Q_i > B_1^i\ and\ X_i = A_1^i \\ > 0 & if\ l_{ii} \neq 1\ and\ Q_i > B_1^i\ and\ X_i > A_1^i \end{cases}$$

where A_1^i and B_1^i are as defined in Equations (5.68) and (5.69).

The effect of the variance of Person i's expected income on his scale of adoption is always negative if he is independent, or if his IE index is less than or equal to B_1^i, because he is risk-averse and the variance is a multiplier of his risk-premium. On the other hand, if he is risk-taking, the effect of the variance of expected income is positive. That is, if the variance increases he becomes more risk-taking and his scale of adoption increases.

5.6.4 Interdependence Expectation Index and the Scale of Adoption

As examined in Section 5.5.5, the effect of a person's IE index, Q_i, on his risk-premium, P_i, is always negative. Therefore, its effect on the scale of adoption is always positive.

$$\frac{\partial I_i}{\partial Q_i} = - f_1 (1 - l_{ii}) \frac{\sigma_{ii}^i}{\bar{X}_i} > 0 \tag{5.85}$$

As his IE index increases, his scale of adoption increases. That is, if he thinks that his income is more positively correlated with other persons' income levels than before, his scale of adoption is greater.

5.6.5 Individual Socio-Economic Characteristics and the Scale of Adoption

The effects of individual socio-economic characteristics on scale of adoption are shown by the derivative with respect to individual socio-economic characteristics, Z_{ik} (k=1,2,...,m).

$$\frac{\partial I_i}{\partial Z_{ik}} = f_{1+k} \quad (k=1,2,...,m) \tag{5.86}$$

The signs of these derivatives cannot be determined in this model, and will be discussed in the next chapter in relation to empirical studies.

5.6.6 An Interpretation of Cancian Dip

Cancian's argument for his two hypotheses[16] does not really explain these hypotheses and empirical findings of the existence of the Cancian Dip in areas of various types of agriculture. It seems, on the other hand, that the relationship between a person's

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[16]Refer Section 1.4.4.3.

interdependence risk-premium and his income level matches to the Cancian Dip. If his IE index is less than or equal to the certain positive value, the relationship is monotonically decreasing. However, if it is greater than that value, there is a dip (Figure 5-1, and Equations (5.67) to (5.71)). Further, an investigation towards conditions which determine the sign of his interdependence expectation index seems to lead to the explanation of the divided empirical findings of the existence of the Cancian Dip.

Suppose there is the following relationship between a person's innovativeness, I_i, risk-premium, P_i, and income level, X_i:

$$I_i = - aP_i + bX_i + \sum_{k=1} c_k Z_{ik} \tag{5.87}$$

where a and b are both positive coefficients. The second term represents that there is an income-related factor which directly affects his innovativeness, not via his risk-premium. For example, a person's income level may represent his accessibility to capital market.

Hence, the relationship between a person's income level and his innovativeness is

$$\frac{\partial I_i}{\partial X_i} = - a \frac{\partial P_i}{\partial X_i} + b. \tag{5.88}$$

Figure 5-5 shows this relationship when

$$b < a \underset{X_i}{Max} \left(\frac{\partial P_i}{\partial X_i}\right). \tag{5.89}$$

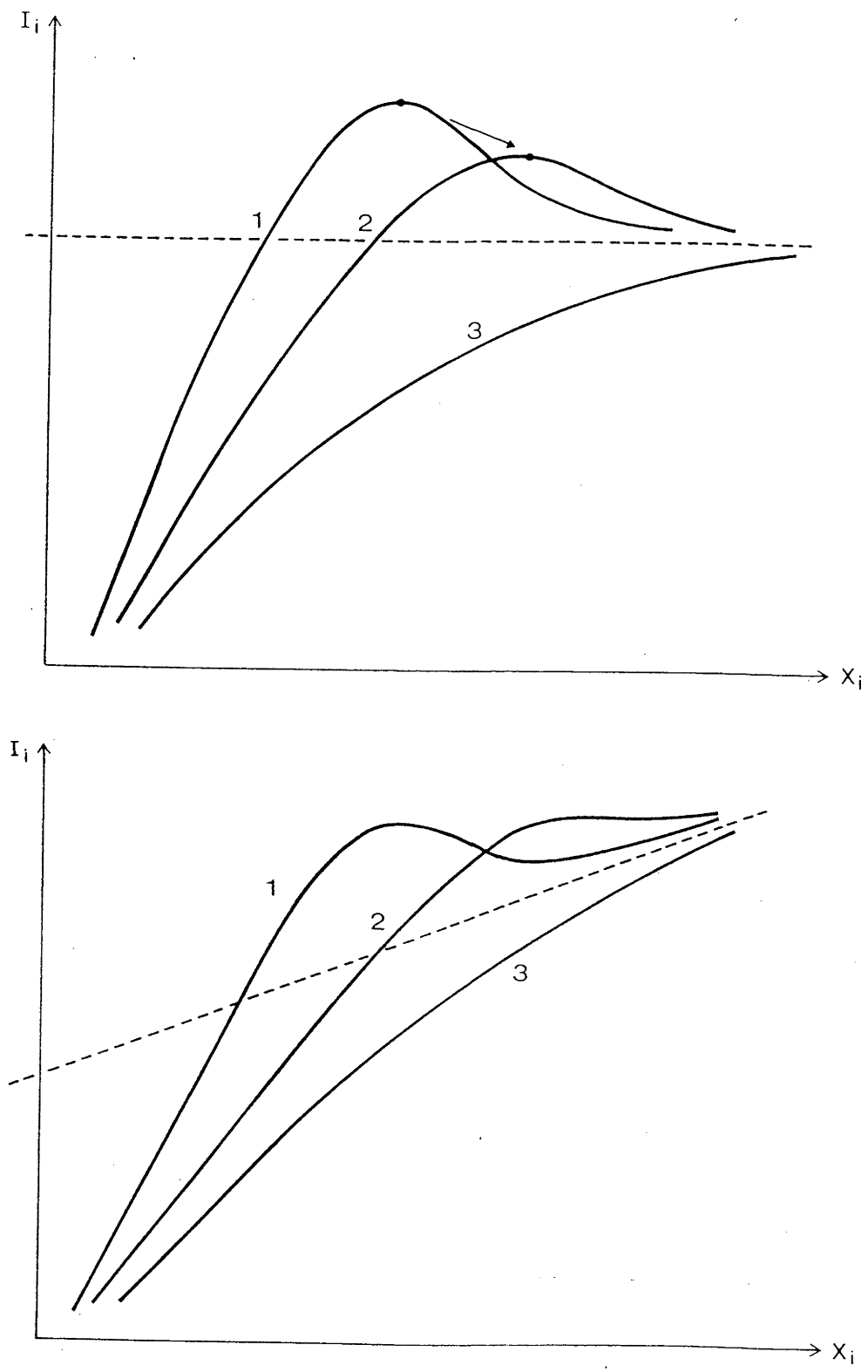
This indicates that as the direct effect of his income level on his innovativeness increases, the probability of the existence of the Cancian Dip decreases.

The second hypothesis can be explained by the following relationship derived from Equation (5.70) differentiated by another person's income level, X_j.

$$\frac{\partial^2 I_i}{\partial X_j \partial X_i} = - a \frac{\partial^2 P_i}{\partial X_j \partial X_i} > 0 \text{ for all } X_i > 0. \tag{5.90}$$

As the diffusion process proceeds and others' income levels increase, the negative portion

Figure 5-5: Innovativeness and Income Level



of $\partial I_i/\partial X_i$ gradually disappears, and hence the Cancian Dip also disappears.[17]

The relation just described is shown in Figure 5-6, for a situation where Person i's IE index is greater than B_1^i. As the adoption process proceeds and others' income levels increase, Curve-1 shifts towards Curve-2, being stretched and straightened, and further converges towards Curve-3. If income level is included in the functional relation of Equation (5.79) independently of the risk-premium, the horizontal line should be replaced with a straight line with a positive slope or an increasing curve.[18]

Cancian (1967, 1979) classified persons into quartiles according to measures of their socio-economic status, such as income level, and found a curvilinearity in the relationship between (1) persons' innovativeness (expressed in such measures as time and scale of adoption) and (2) their socio-economic status. A cubic curve with a hump and a trough

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[17]This can also be shown when the relation between the switching point, A_2^i, and others' income levels is examined.

$$\frac{\partial A_2^i}{\partial X_j} = \frac{l_{ji}}{\sum_{k \neq i} l_{ki} X_k} A_2^i > 0 \quad (j \neq i, if\ Q_i > B_1^i).$$

As others' income levels increase, the switching point also increases, and the non-monotonicity becomes more stretched and straightened over the range of income levels.

The minimum risk-premium, $P_i^* = P_i(X_i = A_2^1)$, also increases together with the switching point, A_2^i, as others' income levels increase. The scale of adoption associated with this minimum risk-premium point therefore declines.

$$P_i^* = -\frac{(2+\alpha)\sigma_{ii} l_{ii}}{2\sum_{k \neq i} l_{ki} X_k} \{ 1 - (\frac{l_{ii}+2(1-l_{ii})Q_i}{l_{ii}(2+\alpha)})^{1/2} \}^2 < 0.$$

and

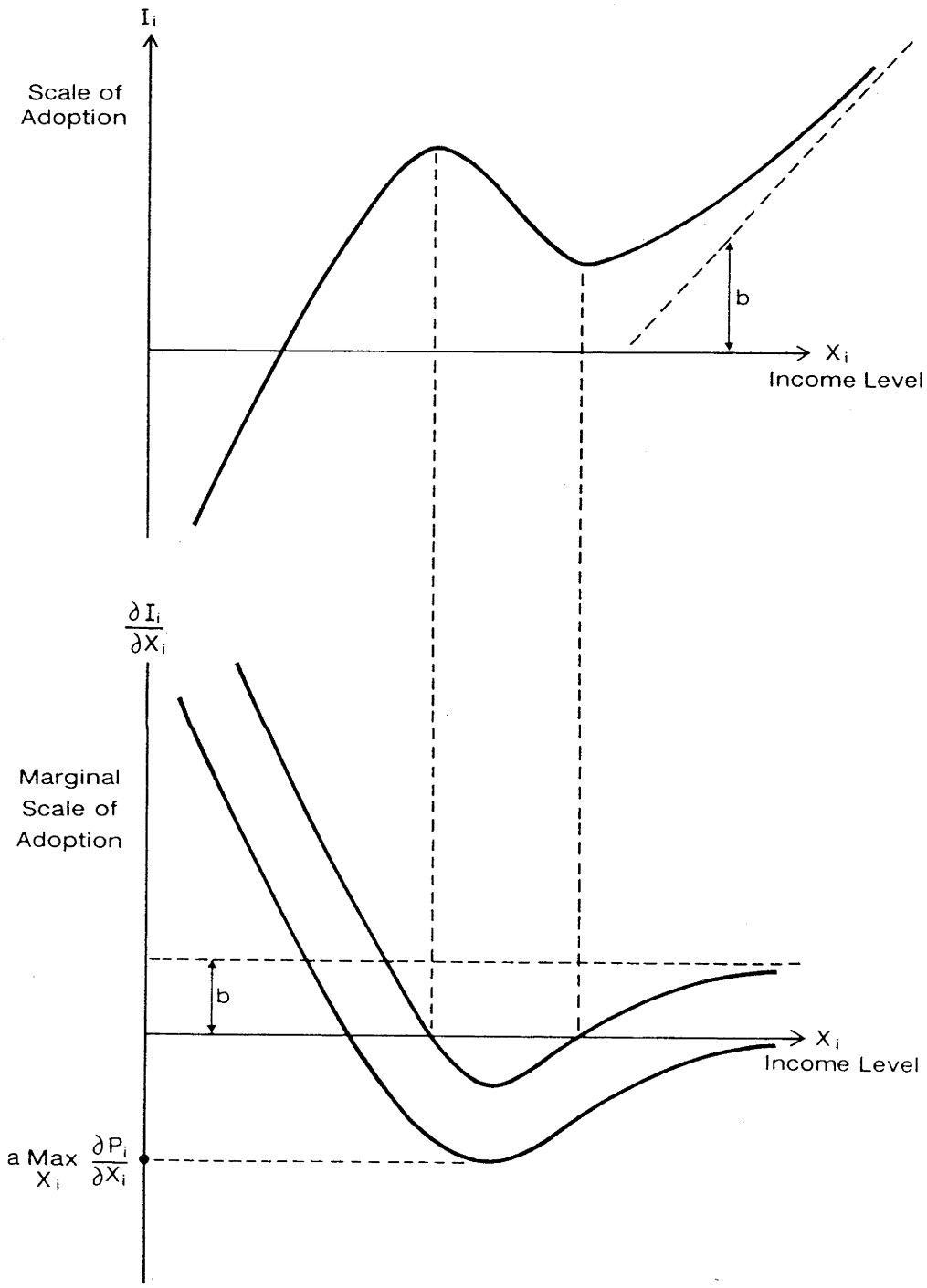
$$\frac{\partial P_i^*}{\partial X_j} = \frac{(2+\alpha)\sigma_{ii} l_{ji} l_{ii}}{2(\sum_{k \neq i} l_{ki} X_k)^2} \{ 1 - (\frac{l_{ii}+2(1-l_{ii})Q_i}{l_{ii}(2+\alpha)})^{1/2} \}^2 > 0.$$

therefore

$$\frac{\partial I_i^*}{\partial X_j} = f_1 \frac{\partial P_i^*}{\partial X_j} < 0.$$

[18]The slope of the line or the curve depends on the function assumed. A non-negative slope is more plausible, and matches with observations in the literature.

Figure 5-6: Relationship between Scale of Adoption and Income



was used to fit this relation (Boyd 1980).[19]

While the interdependence utility function approach without the income level being included independently of the risk-premium, and with other determinants held equal, does not denote any such relationship, this approach with the income level included independently of risk-premium does confirm the use of a cubic curve relationship. The interdependence utility function approach thus covers the empirically found relation between socio-economic status and innovativeness. The simplest "lower-class conservatism" is covered by the case in which a person's IE index is less than or equal to B_1^i, or where he is (completely) independent, i.e., $l_{ii} = 1$. Cancian's "upper-middle-class conservatism" is demonstrated by the case in which a person's IE index is greater than B_1^i and income level is included in the functional relation independently of his risk-premium. Further, the possibility of the "upper-class conservatism" is derived from the case in which a person's IE index is greater than B_1^i and income level is excluded from the functional relation, as shown in the above analysis.

The Cancian Dip hypotheses are thus related to the interdependence risk-premium. However, the divided empirical findings discussed above are still left unexplained. For the answer to the question of the conditions of the Cancian Dip, the interdependence expectation index should be investigated. Conditions which determine the sign of the interdependence expectation index should be identified.

Person i's IE index, Q_i, indicates a weighted average of the ratio of the covariance between his income changes and the others' income changes to the variance of his income changes. If the index is positive, he generally expects that others' income changes are similar to his own income changes. If his income increases, others' income levels increase, and if his income decreases, others' income levels decrease. On the other hand, if the index is negative, he anticipates that others' income changes are towards the opposite direction to his income changes. If his income increases, others' income levels generally decrease, and if his income level decreases, others' income levels increase.

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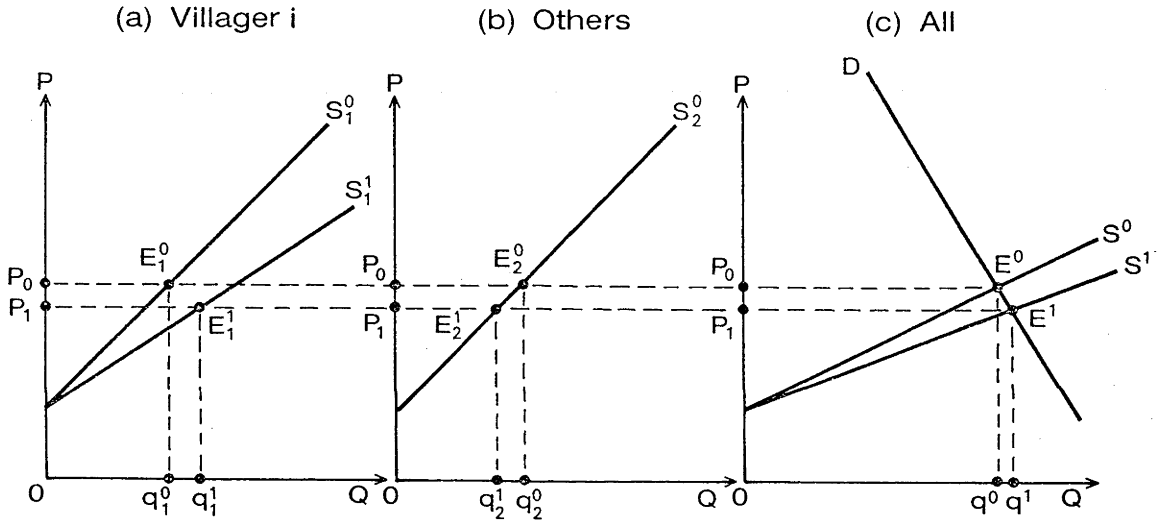
[19]Boyd proposed a statistical method to examine the significance of the hump. But this method is not statistically justifiable, because the ratio of two variables which have t-distributions does not have a t-distribution; it actually has a Cauchy distribution, which has no moment of any order at all.

These situations can be simply explained by Figure 5-7. Suppose there are two groups of persons: Group 1 consists of Person i alone and Group 2 consists of all other persons. They have their supply functions under existing technology of respectively, $S_1^0(P)$ (Figure 5-7-a) and $S_2^0(P)$ (Figure 5-7-b). The supply function of all persons is thus indicated by $S^0(P)$ (Figure 5-7-c), which is the sum of two supply functions, $S_1^0(P)$ and $S_2^0(P)$.

Figure 5-7: Supply-Demand Diagrams for Interdependence Expectation



The demand function is illustrated as D(P) in the diagram, and the equilibrium price determined under the existing technology is P_0. Areas $Oq_1^0E_1^0P_0$ and $Oq_2^0E_2^0P_0$ respectively indicate income levels of (1) Person i and (2) others as a whole.

Suppose Person i adopts a new technology and his supply function shifts rightwards to S_1^1 (Figure 5-7-a), the total supply function also shifts rightwards to the same degree to S^1 (Figure 5-7-c). Then, a new equilibrium price is determined as P_1. At this new price Person i supplies q_1^1, and others supply q_2^1. It is not certain that Person i's income, represented by the rectangle $Oq_1^1E_1^1P_1$ is more or less than his initial income, but others' income level certainly decreases (Figure 5-7-b).

The conditions for Person i's income to increase can be derived from the following mathematical analysis:

Supply-Demand Equality $$D(P) = t\, S_1(P) + S_2(P) \tag{5.91}$$

where t indicates the technological level of Person i's supply function, and initially equals one.

The income levels of the two groups are:

Person i $$I_1 = P\, t\, S_1(P) \tag{5.92}$$

Others $$I_2 = P\, S_2(P) \tag{5.93}$$

By totally differentiating Equation (5.91) with respect to P and t, the technological change effect on the equilibrium price is obtained.

$$\frac{dP}{dt} = \frac{S_1}{D' - t\, S_1' - S_2'} < 0 \tag{5.94}$$

because

$$D' < 0, \quad S_1' > 0, \quad and \quad S_2' > 0.$$

The effect is always negative under the usual conditions of demand and supply functions such as above.

The technological change effect on income levels is obtained by totally differentiating Equations (5.92) and (5.93) with respect to P and t.

$$\frac{dI_1}{dt} = t\, S_1 \left(1 + \frac{P\, S_1'}{S_1} \right) \frac{dP}{dt} + P\, S_1 \lessgtr 0 \tag{5.95}$$

$$\frac{dI_2}{dt} = S_2 \left(1 + \frac{P\, S_2'}{S_2} \right) \frac{dP}{dt} < 0 \tag{5.96}$$

As Person i's supply curve shifts rightwards, his income level changes, but the direction of change is indeterminate. The other persons' income level, on the other hand, always decreases as Person i shifts his supply curve in this direction.

Thus, the relation between Person i's income change and others' income change when Person i changes his supply function by increasing the index, t, is:

$$\frac{dI_2}{dI_1} = \frac{\frac{dI_2}{dt}}{\frac{dI_1}{dt}} \tag{5.97}$$

The sign of this derivative depends on the sign of the technological change effect on Person i's income level shown in Equation (5.95). Since the sign of the technological change effect on others' income level shown in Equation (5.96) is always negative, the sign of the derivative above is opposite to the sign of Equation (5.95).

The condition for this derivative to be positive is:

$$\epsilon_{DP} > (1 - \gamma)(1 + \epsilon_{2P}) - 1, \tag{5.98}$$

where ϵ_{DP} is the price elasticity of demand, ϵ_{2P} is the price elasticity of others' supply, and γ is the ratio of Person i's income to the total income which is the sum of Person i's income and others' incomes. This condition clearly indicates two aspects of the IE effect.

Firstly, this condition indicates the relationship between (1) the probability that the IE index is positive and (2) the crop produced. Generally, it is agreed that the price elasticity of demand for locally-traded subsistence crops or highly perishable crops is closer to zero than that of widely-traded cash crops such as rubber, coffee and citrus. That is, demand for the former is less elastic than demand for the latter with respect to price. Hence, the probability that the above condition is violated is greater for widely-traded cash crops than for locally-traded subsistence crops. In other words, the probability that the IE index is negative is greater for farmers who grow widely-traded cash crops than for those who grow locally-traded subsistence crops.

Secondly, this condition indicates the relationship between (1) the probability that the IE index is positive and, (2) the ratio of a person's income level to the system total income level. As described above, γ indicates the ratio of Person i's income level to the system total income level. Therefore, the probability that the IE index is positive is greater for a person with the greater γ. In other words, the correlation between the IE index and the ratio, γ, is positive.

A person who grows a subsistence crop with relatively inelastic demand, and/or

who subjectively feels he has a large share in the total system income, tends to have a positive IE index. He generally thinks that when his income level from such a crop decreases, others' incomes also decrease. However, he does not think that when his income increases due to a shift of his supply curve, others' incomes also increase. Hence, in a community where there are many persons of this kind, the Cancian Dip is expected.

In contrast, a person who grows a cash crop, and/or who subjectively feels he has a smaller share in the total system income, tends to have a negative IE index. He generally thinks that when his income level increases, others' incomes decrease. He does not, however, think that when his income decreases, others' incomes increase. Whatever the technology adopted by this one person may be, others' income level has to decline. This indicates that the Cancian Dip seldom appears in a community where there are many person of this kind.

5.7 Conclusion

Generally, studies of an interdependence utility function have been halted because of the complicated nature of the interdependence among persons. In this study, firstly it is assumed that there is no higher-order interdependence among persons. Secondly, it is taken that a person's interdependence utility function has the form of a function which includes the absolute level of a person's income and the subjectively perceived relative level of his income. Finally, a person is assumed to be "envious" to others outside his household. By assuming as above, the interdependence utility function study can be conducted with much less complication. In this particular study, it was thus found that only two types of elementary algebraic functions are suitable for formulating an relative income (interdependence) utility function.

The risk attitude of a person who has the above interdependence utility function was then analysed. One scenario was considered, then the relationship between the interdependence risk-premium and a person's income level was studied. It was found that a person can be risk-averse and risk-taking according to his interdependence characteristics and his income level, as having been expressed in a Friedman-Savage utility function.

Finally, the sociological findings of the "Cancian Dip" was theoretically analysed from the above viewpoint. It turned out that the interdependence risk-premium can explain not only the original two hypotheses of the "Cancian Dip" but also the empirical findings that the "Cancian Dip" can appear more often in areas where locally traded crops are grown.

CHAPTER 6

Empirical Analysis of the Citrus Siam Adoption Process

6.1 Introduction

In this chapter, the theoretical derivations of hypotheses from the model of the interdependence approach are tested, using data on the villagers' citrus siam adoption behaviour. In examining villagers' adoption behaviour, the primary interest is in the continuous variables of scale and time of adoption.

A villager's scale of adoption is measured in terms of the number of citrus siam trees planted, and his time of adoption is measured by length of years since his first planting of citrus siam. Earlier adopters have greater values of the latter variable.

In Section 6.2, individual socio-economic characteristics which the agricultural technology adoption literature has identified as determinants of adoption behaviour are discussed. In Section 6.3, memberships of basic associations in the village socio-economic structure are examined as respectively representing sets of agricultural information received, and villagers' roles in disseminating agricultural information in the village. Villager's memberships of basic associations are thus included as the aggregated form of the contextual effects.

In Section 6.4, the "objective" risk of citrus siam production in the village is calculated. As already indicated, villagers have experienced the risk of the citrus siam production, through their own production and observations of others' production. In the interdependence approach, every element of information is evaluated in accordance to the relation between its source villager and its recipient villager. Villager's subjective average risk and their subjective variance of risk, in relation to citrus siam production, are calculated using the interdependence coefficients elicited in Chapter 3. A villager's subjective variance of risk is incorporated into the regression analysis as one of his individual socio-economic characteristics.

In Section 6.5, the structure of statistical procedures is set out, and the suitability of the statistical methods required for the analysis of adoption behaviour is discussed.

In Section 6.6, the results of statistical analysis on the scale of adoption and time of adoption are presented. Finally, in Section 6.7, the various results are interpreted as a whole, in the light of the comparison between the models with and without variables associated with the interdependence approach. Some individual socio-economic characteristics are given further interpretation.

6.2 Individual Socio-Economic Characteristics

Literature on the process of adopting agricultural innovations has identified many socio-economic characteristics which are important explanatory variables.

6.2.1 Farm Size

While farm size has been found to be a positive determinant of adoption in some empirical studies, it has also been identified as a negative or non-determinant in others. These conflicting findings suggest that "(farm)size is a surrogate for a large number of potentially important factors such as access to credit, capacity to bear risks, access to scarce inputs, wealth, access to information, etc." (Feder, Just and Zilberman 1981, p.8). It is also seen as a surrogate for "the effectiveness of on-farm use of improved technology" (Schutjer and Van der Veen 1977, quoted from Feder et al. 1981).

In this study, because of the incorporation of a villager's risk-premium as the focal determinant of his adoption behaviour, farm size can only be regarded as a surrogate for access to scarce inputs and wealth. Access to credit in this village, as described in Chapter 2, is almost nil. Access to informal information is represented by villagers' membership of relational associations (See Chapter 3 and Section 6.3 in Chapter 6.), and access to formal information can be represented by access to extension services, but as seen in Chapter 2 it is again nil.

6.2.2 Income

A villager's income can also be viewed as a proxy for his accumulated wealth, and can further be regarded as his living standard. This variable is also one determinant of his risk premium, as theoretically derived by the interdependence approach. It should therefore be incorporated in the regression analysis (1) as one of his individual socio-economic characteristics, excluding variables associated with the interdependence approach, and (2) as the determinant of his risk-premium in the regression analysis, including the variables of the interdependence approach.

Another element of the income level is the ratio of the agricultural income to the total income level, which reflects a villager's dependency on agriculture. It may be postulated that if the ratio is zero, the villager will be very slow to start adopting the innovation; as the ratio increases, he may be quicker to adopt. Even if the villager is a completely subsistence farmer, he may regard the adoption of the innovation as an opportunity to become a commercial farmer. This ratio, therefore, may be a good determinant for explaining the adoption behaviour, together with other socio-economic characteristics which indicate villagers' primary or secondary occupations.

6.2.3 Labour Availability

Labour availability has very often been listed as a significant determinant of farmers' adoption behaviour. Thus when a new technology is labour-saving, its adoption is promoted by labour shortages. For example, ox cultivation is labour-saving compared with man-power cultivation, and its adoption is promoted by labour shortage in some areas (Weil 1970). On the other hand, if a new technology requires more labour input, a labour shortage prevents farmers from its adoption. The high yielding variety (HYV) cereal technology particularly in its early period generally corresponded to this case, especially it often increased the seasonal demand for labour. It may consequently be regarded as less attractive for farmers with limited family labour or those with bad access to labour markets.

Another important aspect of labour availability is the sexual differentiation of labour. In Islamic societies, the sexual differentiation of labour is often marked, for women tend to be kept in the vicinity of their houses and men work outside. In

smallholding rubber production, however, a couple usually works together, where the husband taps rubber trees and later his wife collects the latex in bowls. Yet, if a more profitable opportunity arises, the husband tends to take this opportunity, leaving the wife behind to maintain rubber production often at a lower level. This reduces the risks associated with the new opportunity. In Belatung, rubber production has recently been declining, because of falling output prices and the age of the trees (See Chapter 4). Citrus siam production gives opportunities for the differentiation of sex-roles; the wives would look after citrus production, while the men looked for other economic opportunities. Therefore, family labour availability is divided into male labour and female labour, and are separately incorporated into the regression analysis in addition to household size.

Hired labour is another source to be considered. As mentioned in Chapters 2 and 3, hired labour is little utilised and often comes from within the village. It is thus not considered to be an important factor in explaining adoption behaviour in this village.

6.2.4 Tenure Status

In Belatung, a small proportion of villagers are sharecroppers or penumpang (See Section 2.4.2.2.). They do not have power to select which crops to grow on the land they look after. Landowners decide what to grow and how to grow it, and lessees have to follow such directions.

In a number of studies, tenure status has been considered as a negative determinant of adoption scale and production efficiency. However, this effect will only operate if lessees have control of what is grown on the land.[1]

In Belatung, however, the lessees also have their own small parcels, and lease in other parcels of land if their own parcels are insufficient for household subsistence. Therefore, tenure status as sharecroppers or penumpang is incorporated into the regression analysis as a dummy variable, indicating whether a villager partially or fully controls his parcels of land.

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[1]Neoclassical sharecropping theories are abundant in recent literature. Some recent models utilise game theory, in which relations between a landlord and lessees are regarded as a game.

6.2.5 Human Capital

Educational attainment has been viewed as a strong positive determinant of a villager's allocative ability, and thus his scale of adoption. Schultz (1964) demonstrated the importance of human capital in the situation of disequilibrium resulting from the introduction or adoption of new technology. This work inspired many studies on the role of education in developing agriculture. Most of these studies also found that educational attainment is a strong determinant of the scale of adoption of new technology in agricultural development.

A monotonic or linear relationship between scale and time of adoption and educational attainment is most plausible however.[2] Higher educational attainment tends to lead a villager to emigrate and seek out other opportunities, and to shorten his farming experience. Even if he stays in the village or returns to it subsequently, he may prefer other jobs to farming and may become a part-time farmer. The relationship between scale of adoption and educational attainment may thus be found to be linear with these other factors above being considered in the regression analysis.

Other sources of human capital are villagers' age and farming experience, measured in years. These two factors are expected to be highly correlated, and to represent aspects negatively correlated with modern or formal education, which has only begun in recent years, as described in Section 2.3.4. Traditional informal education which has taken place within the village, such as learning-by-doing, and other experiences which help to better villagers' economic or production decisions, are represented by these two factors.

Interestingly, Rogers and Shoemaker (1971) who examined 228 empirical studies, found that 48% showed that there is no relationship between a villager's age and time of adoption, 19% showed that earlier adopters were younger and 33% showed that earlier adopters were older. Hence, it is not possible to generalise the relationship between age and time of adoption, or between age and scale of adoption. However, it is believed that these two factors should be included in the regression analysis as individual socio-economic characteristics.

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[2]Rogers and Kincaid (1971) showed 74 percent of studies they surveyed supported the linear relation between time of adoption and educational attainment.

6.2.6 Media Exposure

Various types of information from outside the village have been used as explanatory variables for adoption behaviour in the literature. Frequency of visits to cities and of listening to agricultural programmes on radio are used in this study to represent villagers' media exposure. Visits to extension service personnel and visits by them are not important, as described in Section 2.4.7. Extension services are not active in the Belatung area, although extension officers are stationed in the village.

Visits to four cities, Baturaja, Prabumulih, Palembang and Jakarta, and to one province, Lampung, were selected as being likely to influence adoption behaviour. The characteristics of these places were described in Section 2.3.5.

Listening to agricultural programmes is a measure of a villager's desire to obtain agricultural information.

6.2.7 Locational Factors

Belatung's villagers' citrus siam farms are situated in several distinct areas within the village. The most distinct areas are Lekis and Kisam (See Figures 2-2 and C-1). The Lekis area is located on the other side of the Ogan river and about an hour's walk from the river, and this area is more easily approached from the neighbouring village (Lebuk Batang Lama). Villagers there have good contacts with Javanese migrants who grow citrus siam quite independently of them, bringing budgrafts directly from Java. The Kisam area is also far away from the Ogan river but on the same side as the village residential area, and is located in the middle of the rubber growing area.

These two locational factors are regarded as influencing information and techniques of citrus siam production, and accordingly adoption behaviour.

6.2.8 Primary and Secondary Occupation

Villagers of Belatung are basically farmers, but as seen in Table 2-1 they have several sources of income other than agriculture. These are accordingly included amongst the individual socio-economic characteristics as likely to affect adoption behaviour (as well as attitudes towards agriculture in general). The dummy variables included are for shop-owners, sick or semi-retired household heads, National Railway workers, school teachers, present and ex-villager heads, present and ex-religious teachers, and sharecroppers or penumpangs.

6.3 Associations in Village Structure

In Chapter 3, the village structure was examined and five relational and structural associations of villagers were drawn out.

As already indicated, relational associations are based on the villagers' direct socio-economic interactions which transmit agricultural information among the villagers. A relational association can therefore be regarded as a set of villagers who shares almost identical agricultural information. Two villagers in different relational associations may receive different agricultural information.

Structural associations are based on villagers' positions in the village structure, i.e., their roles in the village system. Two villagers who belong to two different structural associations may react to an identical set of agricultural information differently, according to their respective roles in the village, even if they belong to the same relational associations.

As Table 3-11 shows, villagers can be classified into 17 basic associations,[3] according to the quality of agricultural information they receive, and to their roles in disseminating such information in the village. These basic associations can be considered as villagers' reference groups. Thus the average adoption behaviour of a reference group such as its average adoption scale is considered to affect the decisions of its members on adoption behaviour.

The group averages for basic associations are shown in Table 6-1.

6.4 Expected Loss in Citrus Siam Production

6.4.1 Objective Loss in Citrus Siam Production

Objective loss in physical citrus siam production (as opposed to income) can be represented by the "loss ratio" of the number of trees lost after being planted, to the number of all trees actually planted. Figure 6-1 shows the distribution of this measure among 55 adopters. The distribution has a maximum of 100%, a minimum of 0% and a mean of 22.4%. There are 14 adopters who have not lost any trees so far, and 2 adopters

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[3]Theoretically 25 (5 x 5) categories are possible.

Table 6-1: Averages of Dependent Variables for Basic Associations

Basic Association	No. of Villagers	Average(a) PLANT1	Average(b) TIMEPASS	Proportion(c) Adopters(%)
1	20	20.0	1.183	40.0
2	8	35.0	0.906	25.0
3	3	6.7	1.694	33.3
4, 5	9 (8+1)	79.1	1.407	55.6
6	5	35.0	0.906	20.0
7	7	17.7	1.643	28.6
8	6	51.7	1.542	66.7
9	0	---	---	---
10	6	168.7	2.722	100.0
11	5	144.4	2.067	40.0
12	3	20.0	1.806	33.3
13	4	177.5	2.708	75.0
14	5	237.8	6.450	100.0
15	7	77.9	0.310	57.1
16	15	60.8	1.683	46.7
17	7	118.4	1.857	57.1

Note:
Due to missing observations, 110 observations are used.
Because there is only one member of Basic Association 5, whose data are available, this association is combined with Basic Association 4.

(a) PLANT1: Total number of existing citrus trees including non-adopters

(b) TIMEPASS: Length of years from a villager's initial adoption until June, 1983 (including non-adopters).

(c) Figures are different from Table 4-4 due to missing observations.

who have lost almost all trees planted. The distribution is centred around the range of 15% to 20%, and is skewed towards zero.

A villager's objective loss can be regarded as information based on his own experiences. This is villager's "direct information" (Lindner et al. 1982).

Figure 6-1: Objective Loss Ratio in Citrus Siam Production

```
OBJECTIVE
LOSS RATIO(a)        0         5         10        15        20
  RANGE      N    %  :.........:.........:.........:.........:
0.00        14 25.5 ****************************
0.00-0.05    4  7.3 ********
0.05-0.10    5  9.1 **********
0.10-0.15    3  5.5 ******
0.15-0.20    7 12.7 **************
0.20-0.25    7 12.7 **************
0.25-0.30    5  9.1 **********
0.30-0.35    1  1.8 **
0.35-0.40    2  3.6 ****
0.40-0.45    1  1.8 **
0.45-0.50    2  3.6 ****
0.50-0.55    0  0.0
0.55-0.60    1  1.8 **                    Mean = 0.230
0.60-0.65    1  1.8 **                    SD   = 0.224
0.65-0.70    0  0.0                       Max. = 1.000
0.70-0.75    0  0.0                       Min. = 0.000
0.75-0.80    0  0.0
0.80-0.85    0  0.0
0.85-0.90    0  0.0
0.90-0.95    1  1.8 **
0.95-1.00    1  1.8 **
          ---------
            55  100.
             (b)
```

Note:
(a) The ratio of the number of trees lost (damaged, died, etc) to the number of trees actually planted.
(b) Citrus siam adopters.

6.4.2 Subjective Loss in Citrus Siam Production

Figure 6-2: Subjective Average Loss Ratio in Citrus Siam Production

```
SUBJECTIVE  (a)
AVERAGE LOSS RATIO          10         20         30         40         50
 RANGE      N    %  .........:.........:.........:.........:.........:
0.13-0.14   2   1.8 **
0.14-0.15   0   0.0
0.15-0.16   0   0.0
0.16-0.17   1   0.9 *
0.17-0.18   0   0.0
0.18-0.19   1   0.9 *
0.19-0.20   1   0.9 *
0.20-0.21   3   2.7 ***
0.21-0.22  10   9.1 **********
0.22-0.23  33  30.0 **********************************
0.23-0.24  42  38.2 ******************************************
0.24-0.25   9   8.2 *********
0.25-0.26   1   0.9 *
0.26-0.27   3   2.7 ***                  Mean = 0.231
0.27-0.28   2   1.8 **                   SD   = 0.023
0.28-0.29   0   0.0                      Max. = 0.325
0.29-0.30   0   0.0                      Min. = 0.132
0.30-0.31   0   0.0
0.31-0.32   1   0.9 *
0.32-0.33   1   0.9 *
          --------
          110  100.
           (b)
```

Note:
(a) As defined in Equation (6.1).
(b) All villagers (except for those with missing data).

Although a villager may be aware of the widely spread distribution of objective loss in citrus siam production, he may not believe that the worst will happen to him. It is quite plausible to assume that he has his own subjectively weighted average loss ratio because particular villagers differentially weigh information of other villagers' losses in citrus siam production.

As the degrees of a villager's interdependence on others are represented by his interdependence coefficients, the weighted average loss, in which his interdependence coefficients are used as weights, may be regarded as his subjective average loss. Non-adopters are, of course, excluded in the calculation of his subjective loss, but these non-

adopters can have their own subjective average loss. A villager's subjective average loss ratio may thus be defined as follows:

$$\mu_i = \frac{\sum_{k=1}^{n} l_{ki} LOSS_k D_k}{\sum_{k=1}^{n} l_{ki} D_k} \tag{6.1}$$

where $LOSS_k$ indicates Villager k's objective loss ratio, shown in Figure 6-1, and where D_k indicates whether Villager k has adopted or not.

The distribution of subjective average loss ratio pertaining to all villagers[4] is shown in Figure 6-2. It is significantly concentrated around the mean, 23.1%, and has a much narrower distribution than the objective loss ratio. Its maximum is 32.5% and its minimum is 13.2%. This subjective average loss ratio can be regarded as a villager's aggregate for both "direct" and "indirect" information about losses in citrus siam production.

A villager's risk premium (Equation (5.66)) includes the variance of his prospects for his own income changes. This can be separated into two components, (1) production risk and (2) price risk, if these components can be assumed to be independent of each other.

The first component can be detected by examining a villager's subjective variance of loss ratios. This is the weighted sum of squared deviations of all adopters' loss ratios from his subjective average loss ratio, μ_i. The second component can be assumed to be universal among all villagers, because prices associated with citrus siam are known to all villagers, and are taken as exogenously given parameters.

Therefore, the variance of the income prospects can be represented by the first component. Thus,

---

[4]Because of missing data, 110 villagers were treated here.

(6.2)

$$\sigma_i^2 = \frac{\sum_{k=1}^{n} l_{ki} D_k (LOSS_k - \mu_i)^2}{\sum_{k=1}^{n} l_{ki} D_k}$$

Figure 6-3: Subjective Variance of Loss Ratio in Citrus Siam Production

```
SUBJECTIVE VARIANCE
OF LOSS RATIO(a)              10        20        30        40        50
 RANGE        N   %   .....:.....:.....:.....:.....:.....:.....:.....:
0.000-0.005   0  0.0
0.005-0.010   0  0.0
0.010-0.015   0  0.0
0.015-0.020   0  0.0              Mean = 0.060
0.020-0.025   2  1.8 **           SD   = 0.009
0.025-0.030   0  0.0              Max. = 0.098
0.030-0.035   1  0.9 *            Min. = 0.022
0.035-0.040   1  0.9 *
0.040-0.045   1  0.9 *
0.045-0.050   1  0.9 *
0.050-0.055  13 11.8 ************
0.055-0.060  30 27.3 ******************************
0.060-0.065  50 45.5 **************************************************
0.065-0.070   8  7.3 ********
0.070-0.075   0  0.0
0.075-0.080   1  0.9 *
0.080-0.085   1  0.9 *
0.085-0.090   0  0.0
0.090-0.095   0  0.0
0.095-0.100   1  0.9 *
            --------
            110 100.
Note:
(a) As defined in Equation (6.2).
```

The distribution of the subjective variance of loss ratio is shown in Figure 6-3. It is quite a concentrated distribution about the mean of 0.060, with a standard deviation of 0.009. More than 90% of villagers have their subjective variance of loss ratio between 0.05 and 0.07.

6.5 Statistical Inference Method

Statistical testing of hypotheses derived from the interdependence approach has to be made carefully, owing to the special characteristics of the model. The dependent variable of this model is limited (or truncated). For example, a non-adopter's scale of adoption is always zero and it should not be estimated to be negative. Negative estimates cannot be sensibly interpreted.

In the next section, the statistical inference procedures are set out, and appropriate techniques to deal with the special trait of the model are selected.

6.5.1 Structure of Statistical Inferences

The structure of statistical inferences is set out here in three steps.

Step A

Simple correlation coefficients between any two among dependent and independent variables are checked to find significant determinants of dependent variables and sources of multi-collinearity among independent variables.[5] An attempt is made to explain each dependent variable by individual socio-economic characteristics, without using variables associated with the interdependence approach. Income is included, as it simply represents villagers' economic status. Results at this level are regarded as the basis for the comparison at the succeeding levels of statistical analysis.

Step B

There are four basic assumptions in the analysis conducted above, namely,

---

[5]Multicollinearity can be detected by checking (1) simple correlations among explanatory variables, (2) determinant or eigen values of data product sum matrix, X'X, where X is a data matrix of explanatory variables, (3) auxiliary regression or (4) the matrix decomposition of the data product sum matrix, X'X (Judge et al. 1982).

1. a person's independent Arrow-Pratt relative risk-aversion index, ρ^{R}_{i}, is greater than or equal to one,[6]

2. a person's IE index, Q_i, is significantly non-zero,[7] a person's IE index is correlated positively with his interdependence weight, ω_{ii},[8]

3. a person's income level determines his adoption behaviour, only in conjunction with his risk-premium.[9]

By expanding Equation (5.79) with only first-order derivatives, and replacing the risk-premium with Equation (5.63) and the first socio-economic characteristics, Z_{i1}, with his income level, X_i, the following equation is obtained for statistical testing.

$$I_i = \beta_0 + \beta_1\{(1 + \rho_i^R - \omega_{ii})\frac{\overset{i}{\sigma}_{ii}}{2\,X_i} - (1 - l_{ii})Q_i\frac{\overset{i}{\sigma}_{ii}}{\tilde{X}_i}\} + \beta_2 X_i + \sum_{k=2}^{m}\beta_{1+k}Z_{ik} + \epsilon_i \tag{6.3}$$

As ρ^{R}_{i} and Q_i are not known, this equation is non-linear with respect to parameters to be estimated, β_k's, ρ^{R}_{i} and Q_i. For testing the basic three hypotheses mentioned above, this equation is expanded as follows:

$$I_i = \beta_0 + \beta_{11}(-\frac{\omega_{ii}\overset{i}{\sigma}_{ii}}{2\,X_i}) + \beta_{12}\frac{\overset{i}{\sigma}_{ii}}{2\,X_i} + \beta_{13}\{-(1 - l_{ii})\frac{\overset{i}{\sigma}_{ii}}{\tilde{X}_i}\} + \beta_2 X_i + \sum_{k=2}^{m}\beta_{1+k}Z_{ik} + \epsilon_i \tag{6.4}$$

It can be expected that the IE index, Q_i, and Arrow-Pratt relative risk-aversion index, ρ^{R}_{i}, vary over individual persons. But, because of the limited data, the IE effect is examined group by group instead. This is done in the following equation using dummy variables which represent groups of persons:

---

[6]See Equations (5.37), (5.38), (5.63) and (5.66).

[7]Refer to Section 5.4.1 on page 209.

[8]Refer to Section 5.6.6.

[9]Refer to Section 5.6.1.

(6.5)

$$I_i = \beta_0 + \beta_{11}(-\frac{\omega_{ii}\overset{i}{\sigma_{ii}}}{2\,X_i}) + \beta_{12}\frac{\overset{i}{\sigma_{ii}}}{2\,X_i} + \sum_{k=1}^{r}\beta_{13k}D_k^i\{-(1-l_{ii})\frac{\overset{i}{\sigma_{ii}}}{\tilde{X}_i}\} + \beta_2 X_i + \sum_{k=2}^{m}\beta_{1+k}Z_{ik} + \epsilon_i$$

where

(6.6)

$$D_k^i = \begin{cases} 1 & \text{if } \textit{Person } i \textit{ belongs to Group } k \quad (k = 1,2,...,r) \\ 0 & \text{otherwise.} \end{cases}$$

Regression analysis of this equation gives

(6.7)

$$I_i = b_0 + b_{11}(-\frac{\omega_{ii}\overset{i}{\sigma_{ii}}}{2\,X_i}) + b_{12}\frac{\overset{i}{\sigma_{ii}}}{2\,X_i} + \sum_{k=1}^{r}b_{13k}D_k^i\{-(1-l_{ii})\frac{\overset{i}{\sigma_{ii}}}{\tilde{X}_i}\} + b_2 X_i + \sum_{k=2}^{m}b_{1+k}Z_{ik}$$

where b_k's are estimated coefficients in Equation (6.5). the resulting equation, it is possible to test

1. $b_{12} / b_{11} \geq 2$ for $\rho^R{}_i \geq 1$,
2. $b_{13k} / b_{11} \neq 0$ (k=1,2,...r) for the existence of IE effect,
3. positive correlation between Q_i and ω_{ii},
4. $b_2 = 0$ for the exclusion of income level.

Statistical significance levels of (1) and (2) should be calculated with the Month-Carlo methods because divisions involved with these hypotheses produce Cauchy distributions which have no finite moments but a finite average. With knowledge of variances and averages of the numerator and denominator, and covariance, distributions of these divisions can be produced by the Monte-Carlo method and proportions in certain ranges can be calculated as significant levels.

The IE index for persons of Basic Association k, $Q_i^{(k)}$, can be estimated from

(6.8)

$$Q_i^{(k)} = \frac{b_{13k}}{b_{11}} \quad (k=1,2,...,r)$$

With these estimated IE indices, the following regression can be run for testing the effects on adoption behaviour of income level, independence coefficient, variance of uncertainty and IE indices:

(6.9)

$$I_i = \beta_0 + \beta_1 X_i + \beta_2 l_{ii} + \beta_3 \sigma_{ii}^i + \beta_4 Q_i + \sum_{k=2}^{m} \beta_{3+k} Z_{ik} + \epsilon_i$$

If the estimated IE indices are negative, coefficients in the above regression equation are as follows:

$\beta_1 > 0, \quad \beta_2 > 0, \quad \beta_3 < 0, \quad and \quad \beta_4 > 0.$

In the following equation, the higher order derivatives and the non-monotonicity can be tested.

(6.10)

$$I_i = \beta_0 + \beta_{11} X_i + \beta_{12} X_i^2 + \beta_{13} X_i^3 + \beta_{21} l_{ii} + \beta_{22} l_{ii}^2 + \beta_{23} l_{ii}^3 + \beta_3 \sigma_{ii}^i + \beta_4 Q_i + \sum_{k=2}^{m} \beta_{3+k} Z_{ik} + \epsilon_i$$

If the estimated IE indices are all negative, the expected signs of coefficients are:

$\beta_{11} > 0, \quad \beta_{12} < 0, \quad \beta_{13} > 0,$

$\beta_{21} > 0, \quad \beta_{22} > 0, \quad \beta_{23} > 0,$

$\beta_3 < 0, \quad \beta_4 > 0.$

The statistical significance test for the existence of a hump and trough is quite complicated. Boyd (1980) proposed a testing method, but it is not statistically acceptable. A Monte Carlo method to check the statistical significance of the existence of a hump and trough has been developed by the author, and details are given in Appendix F.2.

Step C

The curvilinear relationship between villagers' innovativeness and socio-economic status that Cancian (1967, 1979) and others proposed has been investigated basically in a

one-dependent-one-independent-variable framework (Section 1.4.4.3). They do not consider villagers' other characteristics as explanatory variables for innovativeness. On the other hand, in the interdependence approach above, many other characteristics are considered, and even then curvilinearity may be found.

In this step, curvilinearity is investigated firstly by constructing an income-quartiles table, and secondly, by Tobit regression analyses with only polynomials of a socio-economic status variable as explanatory variables. The following socio-economic variables are used:

1. Income, X_i
2. Rank of Income, R_i (Ascending order: the poorest person gets $R_i = 1$)
3. Subjective Relative Income,[10] $S_i = X_i/\tilde{X}_i$
4. Independence Coefficient, l_{ii}
5. Independence Weight, $\omega_{ii} = l_{ii}S_i$

The results of this step are compared with those of Step B and interpretations are given.

6.5.2 Tobit Analysis

As pointed out by Feder, Just and Zilberman (1981), adoption process studies have only concentrated on the dichotomous dependent variable, that is, whether an individual has adopted an innovation or not. In these studies, a limited dependent variable, such as the scale of adoption or time of adoption, has not been treated rigorously. This dependent variable has a specific characteristic which makes it unsuitable to apply a simple multiple regression analysis with OLS, because it is limited or truncated (censored) at either or both ends of its distribution.

A statistical method for the explanation of these types of dependent variables corresponds with a multiple regression model which Maddala (1977) described as follows:

---

[10] $\tilde{X}_i$ denotes Villager i's subjective average village income level. Refer Equation (5.14).

Sometimes in multiple regression models we do not observe the dependent variable over the entire range. For instance, suppose the regression model is

$$Y = \beta X + u \tag{6.11}$$

and we observe Y only if Y > 0. Thus our model is

$$Y = \begin{cases} \beta X + u & \text{if } \beta X + u > 0 \text{ or } u > -\beta X \\ 0 & \text{otherwise} \end{cases} \tag{6.12}$$

Here we cannot use just the observations for which Y > 0 to estimate the regression equation by ordinary least squares because the residuals do not satisfy the condition E(u) = 0 if we consider only those residuals such that u > − βX. If we make some specific assumption about the distribution of u, we can use the ML (maximum likelihood) method to estimate the parameters. For instance, if we assume that u has a normal distribution with mean zero and variance σ^2, the joint distribution of the observation is ...

$$L = \prod_1 \frac{1}{\sigma} f\left(\frac{Y_i - \beta X_i}{\sigma}\right) \prod_2 F\left(\frac{-\beta X_j}{\sigma}\right) \tag{6.13}$$

where f( ) is the standard normal density and F( ) is the cumulative normal density (...where the first term corresponds to those observations for which we observe Y_i and the second term corresponds to these observations for which all we know is that Y_j is less than or equal to zero). The ML estimates are obtained by maximizing L with respect to β and σ. [pp.162-163]

This model is called Tobin's normit model, in short, the Tobit model (Johnston 1984). Tobin (1958) first used this model for explaining the relationship between the expenditure on automobiles and income.[11] As Olsen (1978) proved that the Tobit model's log-likelihood function is globally concave if normalised coefficients (β_k/σ) are estimated, it is not necessary to worry about convergence to a local maximum. Moreover, the Tobit estimators have specific relationships with the OLS estimators with samples whose dependent variables are non-zero (Fair 1977). Using this property, the calculation of the model can be made to converge more quickly.

For limited dependent variable maximum likelihood regression models, Amemiya (1980, 1981) compared the following scalar criteria for selecting the optimal model and optimal model size for small-size sample cases:

---

[11]See Amemiya (1984) for the survey of the use of the Tobit model.

1. Number of wrong predictions (for dichotomous dependent variables)
2. Sum of squared errors (SSE)
3. Efron's R^2
4. Theil's adjusted R^2
5. SSE weighted by estimated probabilities
6. Squared correlation coefficient
7. Log-likelihood function
8. Akaike Information Criterion (AIC)
9. McFadden's R^2
10. Amemiya's Prediction Criterion (PC)

and preferred the Akaike Information Criterion, for its simplicity and its ability to adjust for the degrees of freedom, although no single criterion dominates the others. The Akaike Information Criterion (AIC) has the following form:

$$AIC = \frac{2}{n} \{ -(log\text{-}likelihood) + p + 1 \} \tag{6.14}$$

where "n" is the number of samples, "p+1" is the number of coefficients to be estimated. If the intercept should be suppressed, "1" is excluded. Because of the non-dominance of the above criteria over each other, results of regression analysis with the A.I.C., adjusted R-square and Likelihood Ratio test are compared. R-square is most often used in the following study for convenience, if the evaluation of two criteria are not contradictry.

6.5.3 Methods to Detect Contextual Effect

Statistical inference procedures usually assume the independence of samples. Since a matrix of interdependence coefficients of villagers was elicited in the interdependence approach, their interdependence upon each other has to be considered in relation to statistical inferences. This problem of interdependence among variables, either dependent or independent, has been called the contextual effect, and it has been treated in two frameworks (Erbring and Young 1979). The first framework is the "social telepathy" and

the second is the "endogenous feedback". For each framework, specific statistical methods have been developed.

In the first framework, it is assumed that an individual's behaviour is influenced directly by the others' behaviours he witnesses. Hence, "group averages" of a dependent variable are incorporated for the separate detection of individual effects of individual characteristics and contextual effects.[12] In the second framework, the contextual effect is assumed to be mediated by interactions among individuals, and the network autoregression model[13] has been developed in which a contiguity matrix represents their interactions.

The latter framework is quite relevant to the interdependence approach in which a matrix of interdependence coefficients is utilised and can be regarded as the contiguity matrix. However, it seems that it is not always necessary to use the network autocorrelation model. There are three reasons for this. Firstly, the elicited independence coefficient and other variables which constitute villagers' risk-premium represent contextual as well as individual effects. For instance, if a villager's independence coefficient is low, it is implied that he is greatly affected by others, and vice versa. Secondly, the incorporation of "group averages" of a dependent variable into the regression analysis as an explanatory variable is technically much more straightforward than the network autocorrelation model. Estimated coefficients of the group average of the dependent variable may be interpreted as the proportionate effect of group membership in an individual's decision making. However, it is very obvious that, as groups become smaller, correlation between the dependent variable and the group average becomes higher. Hence, there is no point to include other variables into regression analysis. In other words, causal relations among explanatory variables become obscured. Thirdly, ranges of dependent variables in this study are limited. As discussed in Section 6.5.2, the distribution of a dependent variable is truncated at zero or a certain level, and thus negative values for these variables are not allowed to exist. If such a limited

---

[12]For detailed discussions, see Blalock (1984) and Boyd & Iversen (1979).

[13]Details are given in Appendix F.1.

distribution of dependent variables is incorporated into the network autocorrelation model, computation procedure becomes much more complicated. In fact, there is no available computer programme for this revised network autocorrelation model.

For these reasons, it was decided that only the variables associated with the risk-premium are included in regression analysis.

6.6 Statistical Results

In this section, statistical results according to the procedure set out in the last section are presented. Since there is no time element in the theoretical framework, the results of the scale of adoption are discussed first, and those of the time of adoption second. Variables which appear in this section are listed in Table 6-2.

6.6.1 Step A

6.6.1.1 Simple Correlations

The dependent variables of adoption behaviour, PLANT1 (the existing number of citrus siam trees), and TIMEPASS (the period since adoption) (Table 6-2) are highly correlated with each other, and have high correlations with almost identical sets of independent variables which are themselves highly correlated (Figure 6-4). The independent variables, INDEPEND (independence coefficient), VARLOSS (subjective variance of loss ratio in citrus siam production), PROG (frequency of listening to agricultural programmes on radio) and KERIO (incumbent or ex-village head), appear to be primary candidates as the determinants of the dependent variables. As seen in Equation (5.66), there are four major components of the risk-premium, i.e., INDEPEND, VARLOSS, INCOME (income level), and Q (interdependence expectation index). Interestingly, the third component, INCOME, is found to be an insignificant variable in terms of the simple correlation coefficient. PROG is found to have a strongly positive correlation with adoption behaviour. There are no significantly negative determinants, except for VARLOSS, which is obvious from the definition of risk-premium.[14]

Among other explanatory variables, there are several notable relations. VARLOSS

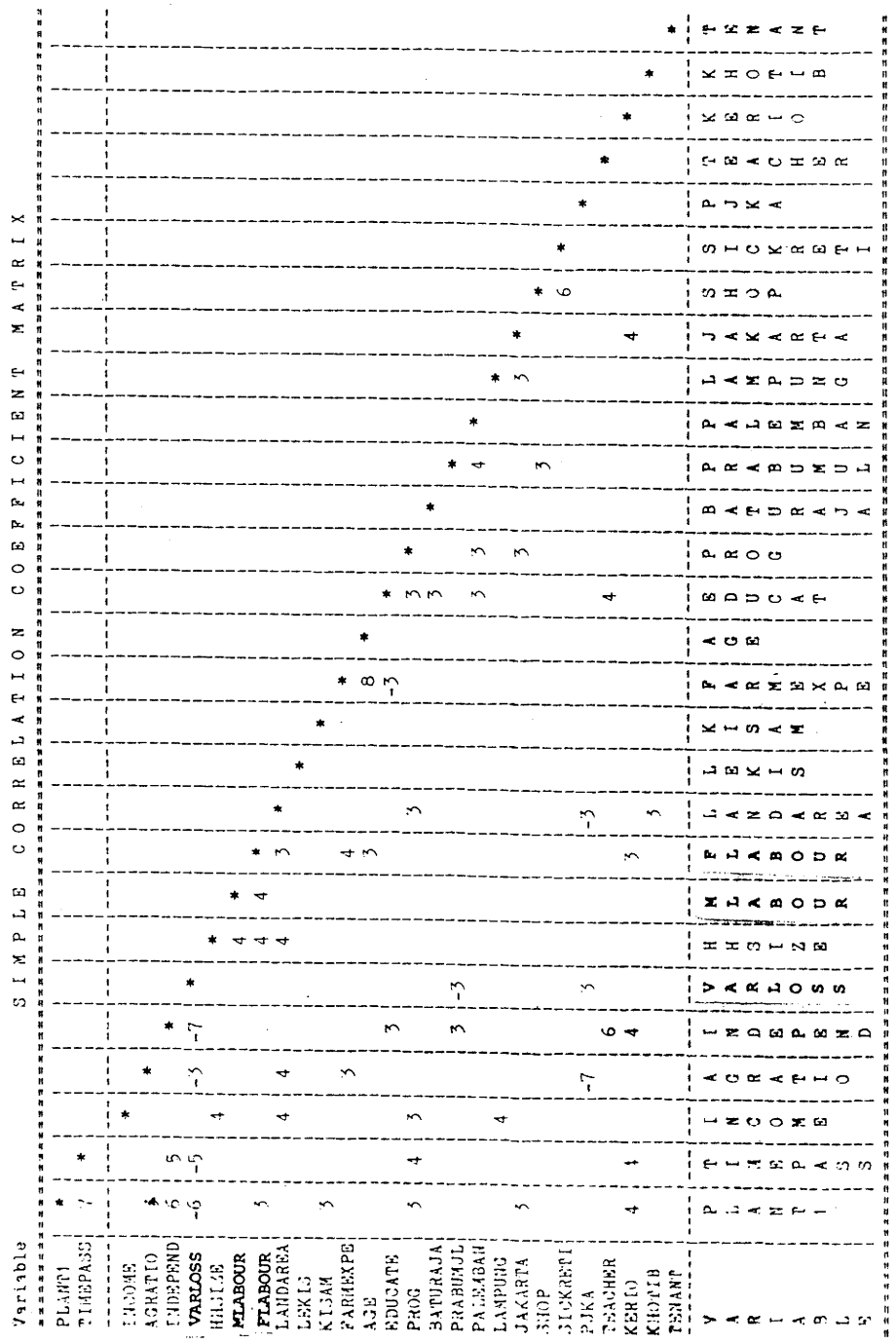
---

[14]Refer Equation (5.84).

Table 6-2: List of Variables

Classification	Variable	Definition
Dependent Variables		
	PLANT1	Number of Existing Citrus Siam Trees
	TIMEPASS	Length of Period since adoption (yrs.)
Independent Variables		
Income Level	INCOME	Annual Income (x Rp 10^6)
	INC2	Square of INCOME
	INC3	Cube of INCOME
Rank of Income	RANK	Rank of income level (ascending order)
	RANK2	Square of RANK
	RANK3	Cube of RANK
Subjective Relative Income		
	RELINC	$= S_i = X_i/\tilde{X}_i$
	RELINC2	Square of RELINC
	RELINC3	Cube of RELINC
Independence Coefficient		
	INDEPEND	$= l_{ii}$
	INDEP2	= Square of INDEPEND
	INDEP3	= Cube of INDEPEND
Subjective Variance of Loss Ratio		
	VARLOSS	$= \sigma_i^2 = \sigma_{ii}$
Interdependence Expectation Index		
	Q	to be estimated for every Basic Association
Production Factors		
	AGRATIO	Proportion of Agricultural Income
	HHSIZE	No. of Household Members
	MLABOUR	No. of Male Members(15-60yrs.)
	FLABOUR	No. of Female Members(15-60yrs.)
	LANDAREA	Farm size (ha.)
	LEKIS	Dummy for Farm Location in Lekis area
	KISAM	Dummy for Farm Location in Kisam area
Human Capital Factors (household heads)		
	FARMEXPE	Years of farming experience
	AGE	Age
	EDUCATE	Educational attainment proxy
	EDUC2	Square of EDUCATE
	PROG	No. of times listening to agricultural programme
Visits to City	BATURAJA	Frequency to Baturaja (in one year)
	PRABUMUL	Frequency to Prabumulih (in one year)
	PALEMBAN	Frequency to Palembang (in one year)
	LAMPUNG	Frequency to Lampung province (in one year)
	JAKARTA	Frequency to Jakarta and Java (in one year)
Socio-Economic Characteristics (dummy variables)		
	SHOP	for shop-owner
	SICKRETI	for sick or retired household head
	PJKA	for National Railway workers
	TEACHER	for school teachers
	KERIO	for village head (present & past)
	KHOTIB	for religious teachers (present & past)
	TENANT	for lessees

Figure 6-4: Simple Correlations among Variables



is highly negatively correlated with INDEPEND. From the definition of the subjective variance, Equation (6.2), a positive relation may be expected between these two variables. This contradiction denotes that there are very strong negative relationships between PLANT1/TIMEPASS and VARLOSS, and very strong positive relationships between PLANT1/TIMEPASS and INDEPEND.

FARMEXPE (years of farming experience) is, as expected, strongly positively correlated with AGE (household head's age). SHOP (being a shop owner) is highly correlated with SICKRETI (being retired or semi-retired). Villagers in the latter class had been merchants, and accumulated their capital before they opened grocery shops in the village.

PJKA (being a National Railway worker) is negatively correlated with AGRATIO (the agricultural income ratio). National Railway workers have their plots of land, and grow subsistence crops such as cassava and banana. They do not usually sell these products, and their agricultural income ratios are therefore very low or non-existent.

TEACHER (being a teacher) is highly correlated with INDEPEND. The teachers constitute an elite group in the village, and have a very strong influence on other villagers through their widely spread networks of interactions. They are trusted, and asked for both information and judgment on various matters. This high correlation is accordingly to be expected.

6.6.1.2 Tobit Analysis without Interdependence Variables

Table 6-3 shows results of Tobit analysis where variables associated with the interdependence approach are excluded. Columns (1) and (3) show results of the regression analyses in which all the explanatory variables are included (full-sized regression). Columns (2) and (4) show results of optimally reduced size regression analyses (optimal-sized regression). Using a backward elimination method, statistically insignificant explanatory variables were excluded one-by-one until the Likelihood Ratio test reached 5 percent significance level. Significant variables which remained in the optimal-sized regressions are discussed in the following text.

About 50 percent of the variation (in terms of R-square) of PLANT1 (the scale of adoption) is explained in the full-size regression. In the optimal-sized regression, about 47

Table 6-3: Tobit Analysis without Interdependence Variables

Dependent Variable	(1) PLANT1 FULL SIZE	(2) PLANT1 OPTIMAL SIZE	(3) TIMEPASS FULL SIZE	(4) TIMEPASS OPTIMAL SIZE
	COEFFICIENT	COEFFICIENT	COEFFICIENT	COEFFICIENT
INCOME	-7.6953 (-0.30)	---	0.56834 (1.10)	0.54518 (1.10)
AGRATIO	1.4989 (2.27)	1.1102 (2.72)	0.029430 (2.10)	0.030431 (2.31)
HHSIZE	4.0788 (0.39)	---	-0.018933 (-0.09)	---
MLABOUR	-17.568 (-0.77)	---	-0.75132 (-1.56)	-0.75246 (-1.72)
FLABOUR	29.392 (1.06)	---	0.61105 (1.05)	0.75255 (1.56)
LANDAREA	-2.3818 (-0.65)	---	-0.074344 (-0.96)	-0.066188 (-0.93)
LEKIS	-64.830 (-0.81)	---	0.37181 (0.23)	---
KISAM	419.25 (2.80)	380.17 (2.70)	4.6139 (1.47)	4.4274 (1.43)
FARMEXPE	-0.64094 (-0.29)	---	0.015725 (0.34)	---
AGE	2.6615 (1.42)	2.2935 (2.02)	0.049453 (1.24)	0.062030 (2.50)
EDUCATE	16.027 (1.41)	19.581 (1.92)	0.33362 (1.40)	0.30418 (1.42)
EDUC2	-1.0513 (-1.49)	-1.1693 (-1.76)	-0.018890 (-1.27)	-0.018204 (-1.28)
PROG	20.092 (3.01)	17.580 (2.93)	0.40034 (2.89)	0.41166 (3.02)
BATURAJA	0.35833 (1.89)	0.29569 (1.67)	0.012045 (2.93)	0.012057 (2.97)
PRABUMUL	11.174 (0.85)	10.781 (1.05)	0.37415 (1.32)	0.34735 (1.38)
PALEMBAN	-0.63585 (-0.15)	---	-0.11456 (-1.21)	-0.10413 (-1.15)
LAMPUNG	-7.7425 (-1.72)	-6.5923 (-1.51)	-0.11383 (-1.29)	-0.12135 (-1.28)
JAKARTA	61.902 (1.94)	47.527 (1.66)	0.63299 (0.95)	0.60445 (0.95)
SHOP	-13.166 (-0.16)	---	-0.20490 (-0.12)	---
SICKRETI	111.80 (1.32)	111.60 (1.74)	1.5240 (0.85)	1.2340 (0.87)
PJKA	29.531 (0.44)	---	2.3285 (1.66)	2.3441 (2.34)
TEACHER	125.18 (1.37)	122.85 (1.45)	4.6544 (2.37)	4.5398 (2.41)
KERIO	114.60 (1.14)	158.18 (1.69)	2.7420 (1.27)	2.5563 (1.21)
KHOTIB	-21.320 (-0.20)	---	1.5929 (0.69)	---
TENANT	-137.44 (-2.50)	-137.00 (-2.63)	-1.5308 (-1.42)	-1.6022 (-1.52)
CONSTANT	-310.25 (-3.09)	-270.32 (-3.91)	-6.5790 (-3.12)	-7.0243 (-3.63)
L.L.H.	-366.06293	-367.86665	-163.06491	-163.41388
A.I.C.	7.1284	6.9612	3.4375	3.3530
R-SQUARE	0.4979	0.4748	0.4898	0.4844
Adj.R-sq	0.3489	0.3974	0.3380	0.3685
N	110	110	110	110
P	25	14	25	20
LR-TEST(a)	65.12616**	61.51872**	59.49576**	58.79782**
LR-TEST(b)	---	3.60744*	---	0.69794*

Notes:
L.L.H. Value of log-likelihood function.
A.I.C. Akaike Information Criterion.
P Number of Explanatory Variables.
N Number of observations.
Figures in parentheses are asymptotic t-ratios.
Variables statistically significant at less than 5 % level ($|t\text{-ratio}| \geq 1.98$) in the optimal-sized regressions are discussed in the text.
(a): Likelihood Ratio test against all zero coefficients.
(b): Likelihood Ratio test against corresponding full size regression.
* no significant difference at 5 percent level.
** significant at 0.5 percent level.

percent of the variation is explained, and five explanatory variables are found to be significant. AGRATIO (the ratio of agricultural income), FLABOUR (female labour), KISAM (the location of Kisam), AGE (household head's age), PROG (frequency of listening to radio agricultural programmes), and JAKARTA (frequency of visits to Jakarta) are positive determinants. TENANT (being a tenant) is found to be a negative determinant.

About 49 percent of the variation of TIMEPASS (time since adoption) is explained in the full-sized regression. In the optimal-sized regression, about 48 percent of the variation is explained, and five variable are found to be significant. AGRATIO (proportion of agricultural income), AGE (household head's age), PROG (frequency of listening to radio agricultural programmes), BATURAJA (visits to Baturaja), and TEACHER (being a teacher) are positive determinants.

PROG is found to be positive determinants for both dependent variables. This shows, as usually found in literature, that a villager who frequently listens to agricultural programmes on radio tends to adopt earlier and on a larger scale. AGRATIO and AGE are also found to be positive determinants for both dependent variables. The results suggest that a villager who relies more on agriculture and/or who is older adopts citrus siam more and earlier.

Variables significant specifically for PLANT1 (scale of adoption) are KISAM and TENANT. This may indicate that a better agro-economic environment of a villager's household and farm stimulates him to adopt more. If his farm is located in the Kisam area (Figure 2-2), he adopts more due to wide areas of land being available after the cutting and burning of old rubber jungle. If a villager is a tenant, he cannot control what he grows, and his financial position is also likely to be poor; hence, he grows less or he may not have adopted citrus siam yet.

Variables significant specifically for TIMEPASS (time since adoption) are BATURAJA and TEACHER. This may imply that the information a villager receives, and his capability to digest it, are important to him in deciding the time of adoption. With more frequent visits to Baturaja, or being a teacher, a villager tends to adopt earlier.

6.6.2 Step B

Table 6-4 shows the results of regression analysis with Equation (6.5) for the estimation of relative risk-aversion index and interdependence expectation indices, and for the exclusion of income level. For PLANT1 (the scale of adoption), there are very significant positive coefficients of D_{3k} (k=1,2,...,17), and negative coefficients of D_1 and D_2.[15] For TIMEPASS (the time since adoption), similar but less significant results are observed. For testing the hypotheses here, the Monte-Carlo method is employed due to the complicacy of hypotheses and significantly correlated estimated coefficients. The actual procedure is described in detail for the detection of the Cancian Dip in Appendix F.2.

6.6.2.1 Relative Risk-Aversion Index of the Independence Utility Function

The coefficients for D_1 and D_2 were both significantly negative, as expected, and Monte-Carlo significance tests for $\rho_i^R \geq 1$ suggest that the hypothesis, $\rho_i^R \geq 1$, cannot be rejected for both scale of adoption (significance level = 5.45%) and time of adoption (significance level = 7.37%). It is therefore assumed in further analysis that the Arrow-Pratt relative risk-aversion index of a villager's independent utility function is constant, and equals one.

6.6.2.2 Interdependence Expectation Index

Table 6-5 shows the estimated interdependence expectation indices of villagers who belong to basic associations. The indices for scale of adoption are significantly negative, excepting villagers of Basic Association 14, while those for time of adoption are a little less significant.

The indices estimated for each basic association from the two regressions are almost proportionate (correlation 0.8625), except for few basic associations. This suggests that the interdependence expectation index is based on constant factors at least in the village and differentiated by types of adoption behaviour.

The relation between the interdependence expectation index, Q_i, and the

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[15] D_1, D_2 and D_k's represent respectively $-\omega_{ii}\sigma^i_{ii}/2X_i$, $\sigma^i_{ii}/2X_i$ and $-D^i_k(1-l_{ii})\sigma^i_{ii}/\tilde{X}_i$ in Equation (6.5).

Table 6-4: Estimation of Interdependence Expectation Indices

VARIABLE	PLANT1 COEFFICIENT	T-RATIO	TIMEPASS COEFFICIENT	T-RATIO
D1	-0.16157D+05	(-2.51)	-0.66647D+02	(-2.83)
D2	-0.91246D+05	(-2.93)	-0.29981D+03	(-3.11)
D301	0.70363D+04	(3.50)	0.28852D+02	(0.66)
D302	0.10105D+05	(4.29)	0.15282D+03	(2.66)
D303	0.11000D+05	(3.99)	0.12201D+03	(2.00)
D304	0.83836D+04	(4.09)	0.10082D+03	(2.03)
D306	0.92769D+04	(4.10)	0.11359D+03	(2.11)
D307	0.95278D+04	(4.32)	0.96832D+02	(1.86)
D308	0.84094D+04	(3.97)	0.82099D+02	(1.70)
D310	0.66047D+04	(3.31)	0.85450D+02	(1.79)
D311	0.71030D+04	(3.29)	0.60234D+02	(1.17)
D312	0.99798D+04	(4.56)	0.12250D+03	(2.34)
D313	0.10338D+05	(4.77)	0.16331D+03	(2.81)
D314	0.47984D+04	(1.70)	-0.46385D+02	(-0.59)
D315	0.67408D+04	(3.35)	0.84685D+02	(1.79)
D316	0.92641D+04	(4.26)	0.95796D+02	(1.91)
D317	0.78393D+04	(3.54)	0.71280D+02	(1.36)
AGRATIO	0.46585D+00	(0.89)	0.24438D-01	(1.66)
INCOME	0.83002D+01	(0.32)	0.77716D+00	(1.19)
HHSIZE	0.67610D+00	(0.10)	-0.11773D+00	(-0.59)
MLABOUR	-0.28674D+02	(-1.79)	-0.81570D+00	(-1.82)
FLABOUR	0.19522D+02	(1.02)	0.56101D+00	(1.07)
LANDAREA	0.88267D+00	(0.30)	-0.71916D-01	(-0.92)
LEKIS	0.93960D+02	(1.09)	0.41533D+01	(1.87)
KISAM	0.31902D+03	(2.89)	0.33286D+01	(1.08)
FARMEXPE	0.55742D+00	(0.36)	0.22703D-01	(0.54)
AGE	0.15737D+01	(1.17)	0.47916D-01	(1.35)
EDUCATE	0.14735D+02	(1.64)	0.44763D+00	(1.83)
EDUC2	-0.10689D+01	(-1.84)	-0.28245D-01	(-1.76)
PROG	0.13275D+02	(2.94)	0.28652D+00	(2.26)
BATURAJA	0.14899D+00	(1.12)	0.11719D-01	(2.91)
PRABUMUL	-0.48698D+01	(-0.53)	0.23607D+00	(0.92)
PALEMBAN	-0.21442D+01	(-0.70)	-0.97384D-01	(-1.15)
LAMPUNG	-0.54300D+01	(-2.01)	-0.10105D+01	(-1.58)
JAKARTA	0.49903D+02	(2.32)	0.43920D+00	(0.74)
SHOP	-0.69757D+02	(-1.17)	-0.12611D+01	(-0.75)
SICKRETI	0.10028D+03	(1.71)	0.23211D+01	(1.41)
PJKA	-0.20389D+01	(-0.03)	-0.26529D+00	(-0.15)
TEACHER	-0.21942D+03	(-2.05)	-0.53214D+00	(-0.18)
KERIO	-0.48922D+02	(-0.66)	0.19508D+01	(0.90)
KHOTIB	-0.13110D+02	(-0.15)	0.28483D+01	(1.13)
TENANT	-0.30763D+02	(-0.81)	-0.70622D-01	(-0.07)
CONSTANT	0.30544D+03	(1.80)	-0.25560D+00	(-0.07)
L.L.H.	-333.98763		-147.61102	
A.I.C.	6.8543		3.4657	
R-SQUARE	0.8250		0.6625	
LR-TEST	129.27676		90.40354	

Notes:
Tobit analysis using Equation (6.5).
See also Notes of Table 6-3.

F.2.

Table 6-5: Estimated Interdependence Expectation Indices

BASIC ASSOCIATION	INTERDEPENDENCE EXPECTATION INDEX PLANT1 Q_{1i}	TIMEPASS Q_{2i}	INTERDEPENDENCE WEIGHT (AVERAGE) ω_{ii}	NO. VILLAGERS
1	-0.43551***	-0.43290	0.025420	20
2	-0.62542***	-2.2930 ***	0.041196	8
3	-0.68081***	-1.8307 **	0.034988	3
4, 5	-0.51889***	-1.5128 **	0.097725	9 (8 + 1)
6	-0.57418***	-1.7044 **	0.032855	5
7	-0.58972***	-1.4529 **	0.078573	7
8	-0.51907***	-1.2318 **	0.048171	6
9	---	---	---	0
10	-0.40879***	-1.2821 **	0.078659	6
11	-0.43963***	-0.90378	0.045023	5
12	-0.61770***	-1.8380 ***	0.090497	3
13	-0.63984***	-2.4504 ***	0.187424	4
14	-0.29700*	+0.69599	0.307714	5
15	-0.41721***	-1.2707 **	0.023111	7
16	-0.57338***	-1.4374 **	0.046746	15
17	-0.48521***	-1.0695 *	0.073719	7
AVERAGE	-0.50914	-1.2198	TOTAL	110
S.D.	0.091441	0.69077		

Q_{1i} = 0.36677 (2.71) ω_{ii} − 0.53402 (-42.78) (R=0.2528)
Q_{2i} = 3.0707 (3.03) ω_{ii} − 1.4281 (-15.27) (R=0.2802)
Q_{1i} = 0.11418 (17.71) Q_{2i} − 0.36986 (-40.98) (R=0.8625)

Note:
Significance tests were conducted with Monte-Carlo methods.
Asterisks denote significance levels.
*** less than 1 percent
** less than 5 percent
* less than 10 percent
Figures in parentheses are t-ratios.

interdependence weight, ω_{ii}, is found to be significantly positive for two dependent variables (regressions at bottom of Table 6-5). This result, therefore, suggests that the way a villager expects others' income changes may well be based on the type of behaviour discussed in Section 5.6.6.

6.6.2.3 Exclusion of Income Level

The coefficients for income levels were found to be insignificant for both scale of adoption and time of adoption. Income levels are thus not entered independently as a socio-economic characteristic in the function which relates a villager's risk-premium and his adoption behaviour.

6.6.2.4 Scale of Adoption

Table 6-6 shows the results of regression analysis using Equations (6.9) and (6.10) for PLANT1 (scale of adoption).

In the full-sized regression based on Equation (6.10), about 82 percent of the variation in PLANT1 is explained, which is 30 percent more than in the regression without the interdependence variables. In the optimal-sized regression, about 78 percent is explained, and 14 variables are found to be significant.

Variables associated with the interdependence approach are all found to have the theoretically expected signs. Among income level variables (INCOME, INC2, INC3), only INCOME is found to be significant, others being excluded in the process of the backward elimination due to their low levels of statistical significance. Among the variables of independence coefficient (INDEPEND, INDEP2, INDEP3), only INDEP3 is excluded in the elimination process. VARLOSS (subjective variance of loss ratio) is also found to be a significantly negative determinant, as expected in Equation (5.84). The interdependence expectation index is a positive determinant, as expected in Equation (5.85).

Nine minor explanatory variables are significant. MLABOUR (male labour) is a significantly negative determinant of the scale of adoption. This suggests that households with greater male labour tend to continue producing rubber or other crops, while households with smaller male labour forces adopt citrus siam to a greater extent because of its smaller labour requirements of this crop. FLABOUR (female labour) is found to be a positive determinant though less significant. This reinforces the earlier argument about labour requirements. Households with greater female labour forces grow more citrus, because post-planting activities for citrus siam are relatively light and quite manageable by female members.

KISAM (farm in Kisam area) is a significantly positive determinant. In Kisam area,

Table 6-6: Tobit Analysis of Scale of Adoption

	Equation (6.9)	Equation (6.10)	
	Full Size	Full Size	Optimal Size
	REGRESSION T-RATIO	REGRESSION T-RATIO	REGRESSION T-RATIO
VARIABLE	COEFFICIENT	COEFFICIENT	COEFFICIENT
INCOME	0.31343D+2 (1.69)	0.89808D+2 (0.88)	0.47989D+2 (3.37)
INC2		-0.17655D+2 (-0.33)	
INC3		0.14101D+1 (0.19)	
INDEPEND	0.14925D+3 (0.36)	0.85681D+3 (0.49)	0.27310D+4 (3.62)
INDEP2		0.46092D+4 (0.43)	-0.75815D+4 (-4.20)
INDEP3		-0.20340D+5 (-1.09)	
VARLOSS	-0.10697D+5 (-3.38)	-0.10021D+5 (-3.32)	-0.11119D+5 (-4.51)
Q	0.52605D+3 (3.18)	0.69088D+3 (4.12)	0.69356D+3 (4.62)
AGRATIO	0.25703D+0 (0.50)	0.27276D+0 (0.56)	
HHSIZE	-0.13081D+1 (-0.17)	-0.25162D+0 (-0.04)	
MLABOUR	-0.27524D+2 (-1.64)	-0.32712D+2 (-2.00)	-0.38877D+2 (-2.88)
FLABOUR	0.22110D+2 (1.12)	0.18695D+2 (1.01)	0.19997D+2 (1.44)
LANDAREA	0.13601D+1 (0.48)	0.12483D+1 (0.45)	
LEKIS	0.41018D+2 (0.68)	0.77485D+2 (1.34)	0.97894D+2 (1.92)
KISAM	0.32903D+3 (3.11)	0.33387D+3 (3.40)	0.39219D+3 (4.09)
FARMEXPE	0.79085D+0 (0.52)	-0.30641D+0 (-0.22)	
AGE	0.12482D+1 (0.94)	0.17351D+1 (1.40)	0.15089D+1 (2.01)
EDUCATE	0.19649D+2 (2.32)	0.18977D+2 (2.38)	0.23475D+2 (3.17)
EDUC2	-0.15374D+1 (-2.75)	-0.15913D+1 (-2.94)	-0.18310D+1 (-3.41)
PROG	0.13153D+2 (2.82)	0.14606D+2 (3.32)	0.14711D+2 (3.54)
BATURAJA	0.20368D+0 (1.55)	0.14677D+0 (1.20)	
PRABUMUL	-0.60890D+1 (-0.64)	0.56937D+1 (0.61)	
PALEMBAN	-0.13368D+0 (-0.04)	-0.37207D+1 (-1.18)	-0.29896D+1 (-1.24)
LAMPUNG	-0.48610D+1 (-1.65)	-0.42232D+1 (-1.61)	-0.38770D+1 (-1.66)
JAKARTA	0.40592D+2 (1.73)	0.38230D+2 (1.70)	0.37801D+2 (2.09)
SHOP	-0.77388D+2 (-1.24)	-0.14813D+3 (-2.39)	-0.12691D+3 (-2.37)
SICKRETI	0.10448D+3 (1.73)	0.15184D+3 (2.69)	0.14342D+3 (2.69)
PJKA	-0.10149D+2 (-0.22)	0.58008D+1 (0.13)	
TEACHER	-0.32195D+2 (-0.34)	-0.17321D+3 (-1.80)	-0.15162D+3 (-1.88)
KERIO	-0.82934D+1 (-0.11)	0.22562D+2 (0.27)	
KHOTIB	-0.18764D+2 (-0.25)	0.62333D+1 (0.09)	
TENANT	-0.58549D+2 (-1.49)	-0.33837D+2 (-0.91)	
CONSTANT	0.75026D+3 (3.24)	0.71116D+3 (3.08)	0.75459D+3 (4.12)
L.L.H.	-342.27990	-334.37062	-336.77830
A.I.C.	6.7505	6.6795	6.4869
R-SQUARE	0.7458	0.8163	0.8019
ADJ.R-SQ	0.6579	0.7400	0.7601
N	110	110	110
P	28	32	19
LR-TEST(a)	112.69222**	128.51078**	123.69542**
(b)	---	---	4.81536*

Notes:
Tobit analysis using Equations (6.9) and (6.10).
See also Notes of Table 6-3.
(a): Likelihood Ratio test against all zero coefficients.
(b): Likelihood Ratio test against corresponding full-size regression.
* no significant difference at 5 percent level.
** significant at 0.5 percent level.

large plots are available after opening old rubber plots. This factor seems to significantly affect the size of adoption. AGE (household head's age) is also a significantly positive determinant. Since FARMEXPE (length of farming experience) and AGE are strongly correlated, this result suggests that a villager who is older and has longer farming experience adopts more citrus siam.

Educational attainment (EDUCATE and EDUC2) is found to affect the scale of adoption non-monotonically. There is a certain maximum effect point of educational attainment, corresponding with the sixth year of primary education. After primary education, educational attainment had a decreased but positive effect on scale of adoption, and after junior high school education (12 educational attainment point, See Table 2-3),[16] it affected it negatively. Most villagers have only primary education or less, and those with higher educational attainment may possess other socio-economic characteristics which reduce the educational influence.

PROG (listening to radio agricultural programmes) is found to be a highly significant determinant of adoption. JAKARTA (visits to Jakarta) is significant.

SHOP (shop-owner) is a negative determinant. Running a grocery shop is a busy occupation, and shop owners usually cannot spare much time for farming even though they have farm plots.

SICKRETI (semi-retired from trade) is a positive determinant. Just before villagers retired or semi-retired, they planted large areas of citrus siam, using capital they had accumulated through their business. They adopted citrus siam owing to its smaller labour requirement. It was often said in the village that income from citrus siam production is a pension, and that citrus siam can be inherited by sons.

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[16]The ratio of the coefficient of EDUCATE to that of EDUC2 is 12.78, 11.93 and 12.82 in the three regressions in Table 6-6.

6.6.2.5 Time of Adoption

Table 6-7 shows the results of regression analysis of Equations (6.9) and (6.10) for the time of adoption. In the full-sized regression based on Equation (6.10), about 70 percent of the variation in TIMEPASS is explained; this is 20 percent more than in the model without the interdependence variables. In the optimal-sized regression, about 69 percent is explainned, and 11 variables are found to be significant, with relationships being quite similar to those already discussed for scale of adoption.

Polynomials of income level and independence coefficient (INCOME, INC2, INC3, INDEPEND, INDEP2, INDEP3) and interdependence expectation index (Q) all have the expected signs, except for INC3 which was excluded in the elimination process. The subjective variance of loss ratio in citrus siam production (VARLOSS) is found insignificant, as might also be anticipated. The present values of this variable would not seem likely to have any relation with the past decision on time of adoption.

Among other minor determinants, LEKIS and AGE are found to be significant, and to be different from the results without the interdependence variables. If a villager has a farm house in Lekis, he tends to adopt earlier due to the strong influence from Javanese migrants in the neighbouring area. They have, as mentioned elsewhere, large areas of citrus siam using saplings/budgrafts smuggled directly from Java. AGE may have represented a villager's farming experience. As examined in Section 6.6.1.1, a villager's age and farming experience are strongly correlated and it was to be expected that one of these variables would be excluded in the elimination process.

BATURAJA (visits to Baturaja) is found to be significant. A villager who more frequently visits Baturaja, the nearest town, adopts citrus siam earlier. Knowledge of citrus siam production may have been acquired by frequent visits to Baturaja where citrus siam traders gather and market their citrus siams.

Educational attainment (EDUCATE, EDUC2) also has a similar effect, and the maximum positive effect is obtained at a value of 7 for the proxy. This is equivalent to graduation from primary schooling. When the educational attainment proxy value exceeds 13 points, which is equivalent to the second year of senior high school education, the effect becomes negative.

Table 6-7: Tobit Analysis of Time of Adoption

VARIABLE	Equation (6.9) Full Size REGRESSION COEFFICIENT	T-RATIO	Equation (6.10) Full Size REGRESSION COEFFICIENT	T-RATIO	Optimal Size REGRESSION COEFFICIENT	T-RATIO
INCOME	0.12101D+1	(2.66)	0.41304D+1	(1.56)	0.24955D+1	(2.38)
INC2			-0.12590D+1	(-0.90)	-0.31034D+0	(-1.50)
INC3			0.13309D+0	(0.70)		
INDEPEND	0.22057D+1	(0.26)	0.10335D+3	(2.18)	0.10140D+3	(2.52)
INDEP2			-0.53215D+3	(-1.80)	-0.50349D+3	(-2.10)
INDEP3			0.76068D+3	(1.47)	0.68305D+3	(1.69)
VARLOSS	-0.63778D+2	(-1.16)	-0.54873D+2	(-1.06)	-0.61542D+2	(-1.33)
Q	0.23351D+1	(3.75)	0.25931D+1	(4.00)	0.28088D+1	(4.62)
AGRATIO	0.21740D-1	(1.69)	0.20702D-1	(1.68)	0.12541D-1	(1.42)
HHSIZE	-0.17775D+0	(-0.93)	-0.15565D+0	(-0.84)	-0.19506D+0	(-1.16)
MLABOUR	-0.68045D+0	(-1.59)	-0.10107D+1	(-2.35)	-0.83072D+0	(-2.20)
FLABOUR	0.68109D+0	(1.37)	0.70033D+0	(1.49)	0.64366D+0	(1.51)
LANDAREA	-0.76320D-1	(-1.11)	-0.33911D-1	(-0.48)		
LEKIS	0.30696D+1	(2.01)	0.32656D+1	(2.15)	0.36172D+1	(2.52)
KISAM	0.39531D+1	(1.50)	0.43118D+1	(1.70)	0.36941D+1	(1.55)
FARMEXPE	0.30783D-1	(0.81)	0.11672D-1	(0.32)		
AGE	0.42204D-1	(1.28)	0.45035D-1	(1.43)	0.53868D-1	(2.69)
EDUCATE	0.47678D+0	(2.23)	0.52749D+0	(2.53)	0.52433D+0	(2.81)
EDUC2	-0.30664D-1	(-2.20)	-0.38947D-1	(-2.75)	-0.38247D-1	(-3.06)
PROG	0.29911D+0	(2.57)	0.30426D+0	(2.70)	0.28706D+0	(2.74)
BATURAJA	0.11337D-1	(3.22)	0.10187D-1	(3.05)	0.94713D-2	(3.05)
PRABUMUL	0.27932D+0	(1.14)	0.33327D+0	(1.31)	0.38845D+0	(1.58)
PALEMBAN	-0.79232D-1	(-1.02)	-0.11539D+0	(-1.42)	-0.12973D+0	(-1.67)
LAMPUNG	-0.10382D+0	(-1.81)	-0.79423D-1	(-1.37)	-0.67833D-1	(-1.24)
JAKARTA	0.41301D+0	(0.73)	0.53267D+0	(0.94)		
SHOP	-0.15706D+1	(-0.98)	-0.17957D+1	(-1.10)	-0.21210D+1	(-1.37)
SICKRETI	0.22073D+1	(1.43)	0.27691D+1	(1.83)	0.27134D+1	(1.84)
PJKA	0.63051D+0	(0.51)	0.10684D+1	(0.90)		
TEACHER	0.80736D+0	(0.37)	0.56815D+0	(0.25)		
KERIO	0.86873D+0	(0.44)	-0.86076D+0	(-0.40)		
KHOTIB	0.27277D+1	(1.39)	0.19237D+1	(1.01)	0.19725D+1	(1.12)
TENANT	-0.38706D+0	(-0.42)	-0.17316D+0	(-0.19)		
CONSTANT	0.76501D+0	(0.19)	-0.39380D+1	(-0.94)	-0.19894D+1	(-0.56)
L.L.H.	-150.93232		-145.28583		-146.31331	
A.I.C.	3.2715		3.2597		3.1148	
R-SQUARE	0.6413		0.7040		0.6884	
ADJ.R-SQ	0.5173		0.5755		0.6004	
N	110		110		110	
P	28		33		24	
LR-TEST(a)	93.76094**		95.05392**		92.99896**	
(b)	---		---		2.05496*	

Notes:
Tobit analysis using Equations (6.9) and (6.10).
See also Notes of Table 6-3.
(a): Likelihood Ratio test against all zero coefficients.
(b): Likelihood Ratio test against corresponding full-size regression.
* no significant difference at 5 percent level.
** significant at 0.5 percent level.

6.6.3 Step C

As already detailed, Cancian (1967, 1979) used income quartiles and found "upper-middle class conservatism", which was a curvilinear effect of socio-economic status (represented by income level) on villagers' innovativeness. The interdependence approach also demonstrates such a curvilinear effect on scale of adoption.[17]

In this section, the curvilinear relationships between (1) income and (2) scale of adoption, time of adoption, and the number of adopters are first examined using income quartiles. These relationships excepting the number of adopters are next examined using the results of Tobit analysis with polynomials of a single socio-economic status variable and also with all other variables included.

Table 6-8: Income Quartiles Analysis

Quartile	Average Income (Rp.)	PLANT1 (No.)	TIMEPASS (Yr.)	Adopters (a) 25% (Apr.80)	50% (Jun.83)	No. of Villagers
1	441519	30.7	0.73	7.41%	29.63%	27
2	722014	50.1	1.31	17.86%	50.00%	28
3	1089953	99.7	1.86	29.63%	59.26%	27
4	2155268	105.0	2.85	46.43%	60.71%	28
All	1108306	71.5	1.69	25.45%	50.00%	110

Notes: (a) At 25% and 50% adoption levels in the village.

Table 6-8 shows that the average number of citrus siam trees planted, average time of adoption and proportions of adopters (at both 25 and 50 percent adoption levels) all increase with rising income quartile.

There is no obvious Cancian Dip observed in this case.

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[17] See Figure 5-1 in Chapter 5 , page 214.

According to Cancian's second hypothesis, there may be a greater possibility of a Cancian Dip at early stages of the adoption process. Actually, in Belatung, there was seemingly a Cancian Dip right at the beginning stage (about four percent adoption level in 1977 with four adopters). However, since present income levels were used for constructing the income quartiles, the situation six years previously may not be well represented. In addition, the very small number of total adopters at that stage may lead to a misleading conclusion.

The second hypothesis also indicates that the upper-middle class villagers are quick to catch up the upper class villagers at later stages. This situation is apparent in Table 6-8. While there was a 14 percent increase in terms of the proportion of adopters in the upper class, there was a 30 percent increase in the upper-middle class. This observation supports the second hypothesis.

The results of the Tobit regression analyses of the curvilinear effect of socio-economic status, measured in terms of income level (INCOME), income ranking (RANK), subjective relative income (RELINC), independence coefficient (INDEPEND) and independence weight (WEIGHT) on the scale of adoption (PLANT) and the time of adoption (TIMEPASS) are shown in Tables 6-9 and 6-10 respectively.

Socio-economic status, as represented by villagers' independence coefficients, best explains the scale of adoption, with a R-square 0.3711. The coefficients of the polynomials indicate that there is a gap between 0.1835 and 0.2851, with a bottom at 0.2512 on the scale of the independence coefficient. However, in this gap there is only one villager, whose independence coefficient is 0.1976. Therefore, it is not felt that the existence of the gap has statistical significance. The significance of the existence of a Cancian Dip was tested by a Monte-Carlo method, which is explained in detail in Appendix F.2. The probability of a Cancian Dip with these estimated coefficients is merely 66.63 percent, which is equivalent to a significance level of 33.37 percent (one-side test). The existence of a Cancian Dip with this low percentage cannot be accepted.

The results of regression analysis with all other variables on scale of adoption in Table 6-6 show also the insignificance of the existence of the Cancian Dip. The coefficients of polynomials of INCOME and INDEPEND are all insignificant in the full-sized regression.

Table 6-9: Simple Curvilinearity Tests - 1

Scale of Adoption and Socio-Economic Status

VARIABLE	COEFFICIENT	COEFFICIENT	COEFFICIENT
INCOME	0.36791D+2 (1.59)	0.22632D+3 (3.45)	0.22890D+3 (1.28)
INC2		-0.41735D+2 (-3.09)	-0.43189D+2 (-0.45)
INC3			0.19762D+0 (0.02)
CONSTANT	-0.49089D+2 (-1.44)	-0.17542D+3 (-3.30)	-0.17655D+3 (-1.97)
L.L.H.	-0.39739D+3	-0.39251D+3	-0.39251D+3
R-SQUARE	0.0123	0.1174	0.1172
AIC	7.26163	7.19102	7.20920
ADJ.R-SQ.	0.0031	0.1009	0.0922
RELINC	0.35515D+2 (1.32)	0.24558D+3 (3.20)	0.33664D+3 (1.57)
RELINC2		-0.51078D+2 (-2.90)	-0.10735D+3 (-0.86)
RELINC3			0.85058D+1 (0.45)
CONSTANT	-0.45771D+2 (-1.26)	-0.18003D+3 (-3.07)	-0.21708D+3 (-2.16)
L.L.H.	-0.39776D+3	-0.39342D+3	-0.39332D+3
R-SQUARE	0.0076	0.0928	0.0907
AIC	7.26841	7.20770	7.22400
ADJ.R-SQ.	-0.0016	0.0758	0.0650
RANK	0.19102D+1(3.04)	0.32393D+1 (1.15)	-0.15944D+00 (-1.98)
RANK2		-0.10418D-1 (-0.49)	0.53033D-01 (0.37)
RANK3			-0.33474D-03 (-0.45)
CONSTANT	-0.12721D+3 (-2.81)	-0.15931D+3 (-1.98)	-0.11367D+03 (-0.88)
L.L.H.	-0.39396D+3	-0.39384D+3	-0.39374D+3
R-SQUARE	0.0764	0.0788	0.0811
AIC	7.19919	7.21341	7.23158
ADJ.R-SQ	0.0678	0.0616	0.0551
INDEPEND	0.13135D+4 (5.29)	0.27445D+4 (2.88)	0.68254D+04 (3.21)
IND2		-0.40500D+4 (-1.57)	-0.32181D+05 (-2.44)
IND3			0.49350D+05 (2.18)
CONSTANT	-0.78605D+2 (-3.42)	-0.13546D+3 (-3.13)	-0.25775D+03 (-3.59)
L.L.H.	-0.38446D+3	-0.38323D+3	-0.38085D+3
R-SQUARE	0.3079	0.3127	0.3711
AIC	7.02652	7.02238	6.99733
ADJ.R-SQ.	0.3015	0.2999	0.3533
WEIGHT	0.10402D+4 (5.27)	0.16624D+4 (3.42)	0.30577D+4 (2.80)
WEIGHT2		-0.15207D+4 (-1.41)	-0.99077D+4 (-1.67)
WEIGHT3			0.11346D+5 (1.44)
CONSTANT	-0.68378D+2 (-3.09)	-0.93792D+2 (-3.26)	-0.13150D+3 (-3.34)
L.L.H.	-0.38458D+3	-0.38358D+3	-0.38254D+3
R-SQUARE	0.2863	0.2997	0.3275
AIC	7.02879	7.02880	7.02799
ADJ.R-SQ	0.2797	0.2866	0.3085

Table 6-10: Simple Curvilinearity Tests - 2

Time of Adoption and Socio-Economic Status

VARIABLE	COEFFICIENT	COEFFICIENT	COEFFICIENT
INCOME	0.95883D+0 (2.05)	0.46430D+1 (3.50)	0.59836D+1 (1.64)
INC2		-0.80658D+0 (-2.98)	-0.15617D+1 (-0.81)
INC3			0.10270D+0 (0.39)
CONSTANT	-0.90447D+0 (-1.31)	-0.33711D+1 (-3.14)	-0.39508D+1 (2.17)
L.L.H.	-0.19075D+3	-0.18624D+3	-0.18616D+3
R-SQUARE	0.0342	0.1419	0.1402
A.I.C.	3.50450	3.44071	3.45748
ADJ.R-SQ.	0.0253	0.1259	0.1159
RELINC	0.95451D+0 (1.76)	0.50202D+1 (3.22)	0.86725D+1 (1.98)
RELINC2		-0.98256D+0 (-2.78)	-0.32431D+1 (-1.27)
RELINC3			0.34194D+0 (0.90)
CONSTANT	-0.85271D+0 (-1.17)	-0.34644D+1 (-2.91)	-0.49414D+1 (-2.41)
L.L.H.	-0.19128D+3	-0.18734D+3	-0.18693D+3
R-SQUARE	0.0243	0.1086	0.1123
A.I.C.	3.51420	3.46065	3.47146
ADJ.R-SQ.	0.0153	0.0919	0.0872
RANK	0.43142D-1 (3.40)	0.63392D-1 (1.13)	0.71598D-1 (0.44)
RANK2		-0.15855D-3 (-0.37)	-0.31185D-3 (-0.11)
RANK3			0.80894D-6 (0.05)
CONSTANT	-0.25176D+1 (2.78)	-0.30097D+1 (-1.87)	-0.31195D+1 (-1.20)
L.L.H.	-0.18696D+3	-0.18689D+3	-0.18689D+3
R-SQUARE	0.1174	0.1173	0.1175
A.I.C.	3.43562	3.45255	3.47071
ADJ.R-SQ.	0.1092	0.1008	0.0925
INDEPEND	0.25162D+2 (4.81)	0.42787D+2 (2.09)	0.17026D+3 (3.87)
IND2		-0.49770D+2 (-0.89)	-0.93553D+3 (-3.40)
IND3			0.15593D+4 (3.29)
CONSTANT	-0.12525D+1 (-2.53)	-0.19622D+1 (-2.09)	-0.56847D+1 (-3.89)
L.L.H.	-0.18112D+3	-0.18073D+3	-0.17530D+3
R-SQUARE	0.2659	0.2546	0.3993
A.I.C.	3.32950	3.34049	3.25996
ADJ.R-SQ.	0.2591	0.2407	0.3823
WEIGHT	0.21304D+2 (5.26)	0.27220D+2 (2.75)	0.78560D+2 (3.61)
WEIGHT2		-0.14403D+2 (-0.65)	-0.32646D+3 (-2.77)
WEIGHT3			0.42371D+3 (2.70)
CONSTANT	-0.10833D+1 (-2.38)	-0.13323D+1 (-2.24)	-0.26362D+1 (-3.44)
L.L.H.	-0.17882D+3	-0.17861D+3	-0.17496D+3
R-SQUARE	0.3131	0.3082	0.4099
A.I.C.	3.28758	3.30193	3.25389
ADJ.R-SQ.	0.3067	0.2953	0.3932

With respect to the curvilinear effect of socio-economic status on time of adoption (Table 6-10), the interdependence weight (WEIGHT) is the best explanator. The three coefficients estimated suggest that there is a gap between 0.1924 and 0.3858, with a bottom at 0.3213 on the scale of the interdependence weight. There are seven villagers in this gap. All of them are situated at the left side down-slope of the gap. The significance level is 27.99 percent (one-tailed test). Again, therefore, the existence of a gap cannot be statistically accepted.

The second best results are shown by the interdependence coefficient (INDEPEND), and the results suggest that there is a gap between 0.1400 and 0.3200, with a bottom at 0.2600. There are six villagers who fall into this gap, three on the left side down-slope and three on the right side up-slope. Statistically this gap has a significance level of 7.94 percent (one-tailed test). Although this is better than the significance of the gap detected with the interdependence weight, it is statistically still unacceptable.

In the full-sized regression in Table 6-7, coefficients of INDEPEND show relatively high significance levels. However, the statistical significance test of the Cancian Dip shows 9.34 percent level of significance. This is also unacceptable.

6.7 Interpretations

The statistical results presented in the last section are strongly indicative that the interdependence approach is superior to a non-interdependence approach in explaining villagers' adoption behaviour.

As shown in Tables 6-3, 6-6 and 6-7, only 50 percent of the variation in the scale of adoption is explained without variables associated with the interdependence approach, but with these variables 82 percent is explained. Similarly, the incorporation of the variables associated with the interdependence approach significantly increases the explanatory power. The adjusted R-square increases by 0.3911 and the A.I.C. decreases by 0.4489. Only about 49 percent of the variation in the time of adoption is explained without the interdependence variables, but with these variables about 70 percent is explained. Similarly the incorporation of these variables considerably increases the explanatory power. The adjusted R-square increases by 0.2375 and the A.I.C. decreases by 0.1778.

The variables of a villager's risk-premium are all very significant in explaining the scale of adoption, and all but the subjective variance of loss ratio are very significant in explaining the time of adoption. Since the subjective variance of loss ratio is a variable which represents a villager's present condition in terms of the quality of information about the citrus siam production, it cannot represent the quality of information he had at his time of adoption. And it may be that the particular measure chosen did not reflect the actual subjective variance very well. This latter result may accordingly be expected.

The interdependence expectation index is found to be negative for all villagers, excepting Basic Association 14. This means that villagers generally hold the view that an increase in his income level causes decreases in others' income levels. According to the analysis in Section 5.6.6, this is not difficult to understand. This situation can happen when villagers are facing price elastic demand for their agricultural products or their subjective shares in the total village income are very small. While the relationship between the interdependence expectation index and the price elasticities of demand for agricultural products could not be tested, the relationship between the index and villagers' subjective shares were found to be positive. This supports the interpretation based on the supply-demand diagrams (Figure 5-7 on page 231).

As a by-product of the villagers' negative interdependence expectation indices, the relations between (1) their adoption behaviour, i.e., scale and time of adoption, and (2) income levels and independence coefficient, are theoretically predicted to be monotonic, other things remaining equal. The gaps detected by polynomials in regressions with other variables are all found to be statistically insignificant. This is also the case for the gaps detected in regressions without other variables. This proposition is, therefore, supported empirically.

Thus the analysis provides support to the interdependence approach, as it shows greater ability to explain adoption behaviour, and as statistical tests show that its theoretical propositions can be accepted.

The contextual effect in this study is represented by several variables, independence coefficient (INDEPEND), subjective variance of loss ratio (VARLOSS), and interdependence expectation index (Q). These three explanatory variables are components

of a villager's risk-premium, and were all found to be significant and to have the expected signs. It therefore seems that the contextual effect is successfully represented by the interdependence variables above.

Among individual socio-economic characteristics, several variables showed interesting results. Family labour availability, educational attainment and listening to radio agricultural programmes were found to be very significant.

Family labour availability was incorporated into the regression analysis in three forms: (1) number of male labourers (15-60 years old) (2) number of female labourers (15-60 years old) and (3) number of household members. Male labour was found to be a negative determinant of citrus siam adoption.[18] Female labour and household size were found not significant. This sexual differentiation of labour force availability can be interpreted as representing the actual sexual differentiation of labour in relation to villagers' rubber smallholdings and citrus siam production. As discussed in Section 6.2.3, if a villager finds that citrus siam production is labour-saving, in comparison with his rubber smallholding or the production of other crops, he may leave his citrus siam production in his wife's hands and try to pursue other economic opportunities inside or outside the village. Plots suitable for citrus siam production are often found near the village's residential area or along the Ogan river, which are easily accessible to women, and maintenance activities required for citrus siam are much less in terms of hours. Villagers seem to perceive that the major activities for citrus siam production are planting and harvesting, which are concentrated in July and December. Trimming and weeding are not considered as important. On the other hand, activities required for rubber production are almost daily matters. Once villagers decide to collect latex during a week, they have to work from early in the morning till noon on at least three or four days, in order to sell a slab(s) of a reasonable size once a week (on Tuesday). The typical villager of Belatung has a good number of rubber trees which can still produce latex. Therefore, if he has a large male labour force available in the household, he is more likely

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[18]MLABOUR is found to be significant only in the regression with interdependence variables. The interdependence approach seems to have contributed in finding determinants otherwise undetected.

to continue tapping these. If he has smaller male labour force, however, he is likely to consider other opportunities, like citrus siam production, for which not much male labour seems to be required.

Educational attainment was found to have its maximum effect on adoption behaviour at a level corresponding to the sixth grade of the primary education (proxy = 6) or the graduation from the primary education (proxy = 7), depending on what dependent variables were analysed.[19] Most villagers have educational attainment levels of less than 7, which is equivalent to graduating from primary school, and the effect of educational attainment on citrus siam adoption behaviour increases up to this level. It appeared that there was a negative effect at a high educational attainment level. Villagers with higher educational attainment correspond, however, to various non-farming occupational dummy variables. Considering this, it may be hasty to conclude that higher educational attainment has a negative effect on citrus siam adoption behaviour.

Another human capital factor, listening to radio agricultural programmes, was also found to be a very significant positive determinant of citrus siam adoption behaviour. Agricultural broadcasts include a reasonable amount of information on citrus siam production techniques, and other economic information. The significant relationship found in this study implies that the type of information provided through radio programmes has some influence on villagers' decision-making, and that listening to the agricultural radio programmes tend to have an effect on citrus siam adoption behaviour.

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[19]Refer to Table 2-3 for the definition of the educational attainment proxy. EDUCATE and EDUC2 are significant only in the regressions with interdependence variables. The interdependence approach seems to have contributed in finding determinants otherwise undetected.

CHAPTER 7

Conclusions

7.1 Summary

Neo-classical economic analysis generally uses a model of human behaviour which treats individuals as atomistic, astructural, self-interested, and independent beings. However, during the recent past, a considerable literature has grown developing models which will better appreciate human behaviour. In this context, there is increasing recognition that individuals' decisions are often greatly influenced by their social relationships, including their relative positions in society and interactions with other members in society. This has led to the development of models where individuals' utility functions, in addition to the conventional variables such as own income, also contain attributes of other persons as arguments. However, the attempts to incorporate the relative social position of the individual into a utility function framework is yet in its infancy; attempts made so far are rather simplistic.

On the other hand, the sociological and anthropological literature has paid greater attention to these aspects for a long time. Techniques and approaches developed for analysis of a person's social position can provide a useful source of ideas and concepts for economists to develop more realistic economic models of human behaviour. In particular, the techniques of network analysis used in sociology and anthropology, which have many similarities with input-output analysis in economics, appear to show much promise as a useful approach for economists.

In this thesis, an attempt is made to draw on this body of sociological/anthropological literature to develop a model of utility maximisation which explicitly incorporates both social rank and social position. This approach is called in this thesis the interdependence approach.

To enable empirical testing, the particular model developed was designed to explain the adoption process of innovation in the context of a reasonably close-knit social setting. Data were collected from a village in South Sumatra where farmers who traditionally grew rubber had rapidly adopted a new crop "citrus siam". The general model was modified to address this particular situation, and empirically testable implications were developed and statistically tested. In the course of this, some light was shed on determinants of adoption that may have wider relevance.

In formulating an interdependence utility model, economic models of the contextual effect were reviewed. The contextual effect is an aggregated effect of economic externalities through relationships between an agent and a set of other agents. Relative income utility models, in which an agent's relative income level is incorporated as an argument of his utility function, were found to be special cases of interdependent preference models. The basically sociological concept of the "reference group", which has been incorporated into several interdependent preference models, was identified as a crucial concept for an agent in perceiving his own relative income level. Thus the agent does not refer to all agents in his surroundings, but only to a small set of other agents in gaining his perception of his own relative income level. It was decided to construct an interdependence utility function including an agent's subjective relative income level and his absolute income level as arguments, and to analyse his risk attitude derived from this function. The function was specifically developed in a manner designed to address questions of new technology adoption.

As formulated, a person's subjective relative income level is the ratio of his income level to the weighted average income level of all persons in a system. Weights represent the degree of influence of the members of his reference group, and the "interdependence coefficients" were used for this purpose. In other words, a person's interdependence is regarded as his weight to the other's income in his subjective consideration of an average income of the system (village). From this interdependence utility function, a person's risk-premium was derived. This provided a new viewpoint from which the person's risk attitude could be examined. The key factor is the interdependence expectation effect, i.e, the person's perception of opportunities to increase his income level, and of others'

opportunities to do the same. If the person believes that his income increase is negatively correlated with others' income increases, this raises his risk-averseness. On the other hand, if he thinks that his income change is positively correlated with others' income changes, he becomes less risk-averse and possibly risk-taking.

Thus, the interdependence expectation effect controls relationships between (1) a person's income level and independence coefficient and (2) his risk-premium. If a person's interdependence expectation index is negative, these relationships are monotonically decreasing, but if the index is positive (or rather more precisely greater than a certain positive value), they are not monotonic. The risk-premium was then related to the adoption behaviour, such as time and scale of adoption.

In this model, the relationship between adoption behaviour and income level is not a monotonic one, but, is consistent with what Cancian called "upper-middle class conservatism". It was shown that if the crop has an inelastic demand with respect to its price, the possibility of the positive index increases. This is likely to be the case for subsistence crop which have a limited regional market. This can also provide an explanation of the observation that the Cancian Dip is found more frequently in areas where subsistence crops are grown, than in cash crop areas.

On the other hand, if the person's interdependence expectation index is negative, the relation above is a monotonically increasing one, and corresponds to the situation widely analysed in studies of adoption behaviour by both economists and sociologist. In this case, this interdependence approach successfully presented an integrated framework for both cases.

Two major approaches in network analysis were reviewed, and it was found that Burt's structural (equivalence) approach can overcome the weakness of the relational approach, and that it can quantify the intensity of relations or influence among agents in the system.

Network analysis was used to identify relational and structural associations of persons according to their kinship, economic exchanges, and direct agricultural information networks. By cross-tabulating persons according to their membership of relational and structural associations, basic associations were identified. A basic

association is a set of persons who share almost identical agricultural information, and play similar roles in disseminating agricultural information. It is a reference group for a person. The characteristics of relational associations were briefly discussed, and "interdependence coefficients" among persons were derived quantitatively for the empirical analyses. These interdependence coefficients, then, became the weights in the utility function to represent the degrees of influence of the members of these reference groups.

Information has been considered extremely important in the adoption process. Two types of information can be distinguished. A person can immediately make use of knowledge based on his own experience in adopting and using the agricultural innovation, and he can also utilise the information based on the experiences of others. This indirect information may be the crucial input in the pre-adoption stages. However, this indirect information will be evaluated by the person according to his relationship with the given source of the information. The network of relationships among all potential adopters of the agricultural innovation should thus be recognised an important element.

The data for empirical testing of the model came from a village in South Sumatra where farmers who had traditionally grown rubber were rapidly adopting a new crop "citrus siam".

The locations of citrus siam adopters and non-adopters in the village network system were examined, and it was found that the lag between the times of adoption of two adopters is very well determined by their interdependence coefficients and various interactions, as well as by differences in their economic factors and socio-economic characteristics.

Belatung villagers were found to have negative interdependence expectation indices, as expected from their long history of cash crop production. It was also found that their interdependence expectation indices were almost identical in any type of adoption behaviour, i.e., scale and time of adoption. The relations between their adoption behaviour, i.e., scale and time of adoption, and their income levels were, therefore, expected to be monotonic, and were found to be so in the village.

Cancian's "upper-middle class conservatism" hypothesis was also tested with

polynomials of variables which separately represent persons' socio-economic status. As expected, Cancian's hypothesis was not supported here since in the framework of the interdependence approach, "upper-middle class conservatism" cannot occur when the persons' interdependence expectation indices are negative.

7.2 Citrus Siam Adoption in Belatung

In this study, citrus siam adoption behaviour in the South Sumatran village of Belatung was explained from the point of view of the interdependence approach, and the use of the interdependence variables helped to identify some important determinants of adoption behaviour. It should be noted that, in this study, adoption behaviour is understood as "copying" behaviour of non-adopters, not as "diffusing" behaviour of adopters. This is because the relative income utility function was assured to represent a person's relative deprivation, with positive interdependence coefficients.

The adoption of citrus siam in Belatung appeared to be determined by three major factors, apart from interdependence variables. The first factor, which may be specific to this village and its surrounding areas, was a shortage of male labour. In such a situation, it was quite natural for households to search for a crop whose labour requirements are less, and manageable for small families lacking male labour. Citrus siam looks to be one answer to this problem. As already described, citrus siam is a relatively less labour-intensive crop.

The second factor was educational attainment. Primary education was of much importance and the influence of education declined as its level rose.

A third factor was access to agricultural programmes on radio, and this highlights the potential role of public media in dissemination of information.

The theoretical and empirical analysis also brought into question commonly found views on the criteria for selection of farmers in a community as agents of technological information diffusion. In this study, it was found that the village head was the first adopter of citrus siam in the village, but was not followed by other villagers for a long time. The matrix of interdependence coefficients showed that others were not influenced by him at all, because he was "too unique" in terms of a role in disseminating agricultural

information. In other words, he was not an "easily copiable" person to others. Thus, the nature of the socio-economic structure can have an important bearing on the characteristics of persons as agents of information diffusion.

7.3 Limitations of the Study and Future Research

The empirical analysis demonstrated that the interdependence approach developed in this study is superior to conventional approaches. It can provide a theoretical explanation of the "Cancian Dip" or "upper middle class conservatism". Generally, adoption behaviour can be explained much better than in conventional approaches, and important determinants of the adoption behaviour including social factors can be more clearly identified.

However, this approach has certain limitations. Firstly, researchers have to select a type of interdependence among persons. Monetary interdependence which can be derived from an input-output matrix of monetary transactions can be utilised, but it then excludes more general types of interdependence among persons. This introduces an element of arbitrariness to the empirical analysis.

Secondly, there is also a problem in the choice of a particular measure of interdependence, which quantitatively represents interdependence among persons. In sociological and anthropological literature, numerous types of such measures have been proposed, but there is no consensus so far among network scholars as to which is best. In this study, the two major approaches of network analysis, the relational approach and the structural (equivalence) approach, were carefully examined. The structural equivalence proximity was then chosen as an interdependence coefficient owing to its statistical robustness.

Thirdly, it is necessary that all persons in a system should be approached in the collection of data on interactions in the system. A census survey of a system is required at this stage of the development of network analysis. However, it must be pointed out that this problem is an operational one, and will not be major as appropriate network sampling techniques are being developed.

A further limitation arose from the fact that direct elicitation of subjective risk was

not feasible and an indirect technique had to be used to obtain estimates. Due to time and data constraints, it was also not possible to analyse the influence of relative price changes on adoption patterns in a comprehensive manner. The validity of empirical findings, of course, cannot be generalised as they are derived from a single village study.

Three areas can be immediately identified where the application of this approach may prove to be of much value.

Firstly, this interdependence approach can provide a plausible explanation for the backward bending labour supply curve without having to postulate a relatively complicated "independent" utility function; in fact, a simple Cobb-Douglas specification is adequate.

Secondly, in models of relative income utility, usually only relative deprivation (negative externality of others' incomes) can be explained. However, the approach can be applied to studies of charitable activities, through widening the concept of the subjective relative income level by allowing negative values of interdependence coefficients. For example, adoption behaviour can also be interpreted as a benevolent attitude towards others, in which adopters willingly give information to non-adopters.

Finally, the methodology of the study presented here can be applied to the study of diffusion of new technology among firms in a industry. In most studies of technology adoption, the actual interdependence among firms in an industry is ignored. As shown in this study, interdependence can be measured through the degree of independence of a firm. A firm's independence can be measured, for example, in terms of its self-finance ratio and reliance on up- and down-stream industries.

Despite the limitations of this study, it is hoped that the advantages of this approach have been sufficiently demonstrated, and that the work done here will stimulate further theoretical and empirical studies to broaden and refine the approach.

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Appendix A

Fieldwork

A.1 Fieldwork Stages

Fieldwork was conducted in Indonesia between August 1982 and October 1983. The fieldwork in Belatung, South Sumatra was started on 7 September 1982, and ended on 20 September 1983. The whole period can be divided into five stages.

Stage 1 (August - December 1982)

The author reached Indonesia on 15 August 1982. After contacts with relevant institutes and government offices, the author reached the fieldwork area on 7 September 1982. A questionnaire survey was first conducted of citrus siam adopters whom the village head of Belatung had identified. The same questions were then asked of non-adopters. Since no reliable list of households was available, lists of all villagers' households and of citrus siam adopters were also compiled. The first report to the Indonesian Institute of Sciences (LIPI) was written in December (Higuchi 1982).

Stage 2 (January - April 1983)

A questionnaire survey of citrus siam adopters identified in Stage 1 was conducted. The second report to LIPI was written in March (Higuchi 1983a).

Stage 3 (May - June 1983)

The Javanese immigrants' area in Lekis of Lebuk Batang Lama (a neighbouring village) was selected for comparative study, and a survey was conducted with the same questionnaires. However, because of the author's bad health and the need to report to government offices in Palembang and Jakarta, this work was interrupted and left uncompleted. This data is not used in this study. The third report to LIPI was written in June (Higuchi 1983b).

Stage 4 (July - September 1983)

Inaccurate data obtained in Stages 1 and 2 was checked, and gaps in the data were filled. The fourth report to LIPI was written in September (Higuchi 1983c).

Stage 5 (September - October 1983)

The fieldwork in Belatung was completed on 20 September 1983. Official data was then collected in Palembang, Jakarta, Bogor and Bandung. The author finally left for Australia on 20 October 1983.

During the whole period of the fieldwork, data were stored immediately after daily survey excursions, in a micro-computer, Osbourne-1, provided by the Research School of Pacific Studies, Australian National University. Parts of the data were then processed to identify missing, inaccurate and exaggerated data, and to identify groups and associations within the village in terms of villagers' socio-economic interactions. Programmes for data processing were written concurrently in Microsoft BASIC. These programmes were later revised in FORTRAN at the Australian National University, and used for further detailed analysis.

A.2 Structure of Data

Data collected and used in the study can be classified into three categories.

Basic Data

The first category contains the basic socio-economic and agronomic data from all households of the village. This data covers the following:

1. Household Members - name, sex, age, relation with household head, education, main occupation.
2. Land Use - area, plots, crops, distance from house, tenure.
3. Agricultural Products - crops, area, harvest, output prices, marketing locations.
4. Rubber Production - classification of rubber by age, products, coagulation methods, hired tapper usage and relations, attitudes towards rubber replanting and continuation.

5. Household economy - income, expenditure, monthly average expenditure on basic needs.

6. Kinship Structure - identification of all close (± 2 generations) relatives of villagers.

Citrus Siam Data

The second category of data contains data on citrus siam production, collected from citrus siam adopters.

1. Planting history - dates of plantings, number of trees, area, usage of mounds, distance between trees, former crops, tree losses and reasons for loss.

2. Harvest history - data, quantity, prices and marketing.

3. Attitudes towards citrus siam

4. Detailed data of the first planting - incentives, sapling and output prices at the time, labour usage, source of sapling, other costs.

5. Data of replanting

6. Harvesting and marketing - harvesting costs, marketing costs.

7. Maintenance costs.

Socio-Economic Interactions

The third category of data contains the answers of household heads to questions about the socio-economic interactions among villagers and their exposures to various media. The following types of socio-economic interactions were selected:

1. Agricultural information exchange

2. Household goods exchange

3. Money lend/borrowing

4. Labour exchange (Adat labour exchange)

5. Hired-in/out Labour

6. Land lease

7. Daily shopping (village grocery shops used)

8. Zakat, Wakap (religious/customary donations to the poor in the form of rice and money)

9. Arisan (illegal association for mutual monetary assistance)

A.3 Questionnaire

Questionnaire No. 4 (May-June 1983)

Name _____ bin _____ ID NO._____

Interview Date _____
Time _____
Place _____

1. How long have you been independent as a farmer? _____year

2. Place of Birth _____

3. Household Member (All persons in this household though one may have married.)

Name	Sex	Relation with H. Head	Age (year)	Education (final) type	grade	year finished	Job	Help farming?
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								

Farming Status

1. Total area of farm (ha.) _____ha.

2. Number of plots. _____plots

No.	Place	Major Crop	Other crops	Area (dp x dp)	(ha)	Dist. from House (min.)	Status OO/SC /LH/LL	Method of share	Land owner
1.				x					
2.				x					
3.				x					
4.				x					
5.				x					
6.				x					
7.				x					
8.				x					
9.				x					
10.				x					

Crops (in 1982)

	Area (dp*dp)	(ha)	No. of trees	Harv't (kg)	Sales /not	Price	Market
1.Rubber							
2.Citrus Siam							
3.Coffee							
4.Pepper							
5.Cloves							
6.Rice Lebak							
7.Rice Ladang							
8.Duku							
9.Durian							
10.Pineapple							
11.Banana							
12.Citrus Manis							
13.Citrus Bali							
14.Citrus Garut							
15.Citrus Kambing							
16.Cinnamon							
17.Coconut							
18.Rambutan							
19.							
20.							

Citrus Siam

1.Planting Citrus Siam

	Month	Year	No. of trees	area (ha)	(dp*dp)	mound (Y/N)	inter-val (MxM)	Former crops	Reason of loss
1-st									********
loss			-	-			*****	********	
2-nd									********
loss			-	-			*****	********	
3-rd									********
loss			-	-			*****	********	

2. Harvest of Citrus Siam

	Month	Year	Harvest (kg)	Price (Rp/kg)	Total (Rp)	Market
1-st						
2-nd						
3-rd						
4-th						

3. If you have not planted Citrus siam, are you interested in planting Citrus siam?

1.Yes, but not yet planned.
2.Yes, and already planned.
3.Not certain.
4.Not. -----

4. If you are interested in planting Citrus siam, what is the reason why you do not plant it now?

1. No money for opening land -----
2. No time for opening land -----
3. No labour for opening land -----
4. No land for citrus siam -----
5. No money for buying saplings/budgrafts -----
6. No money for hedging -----
7. Information about citrus siam is not enough -----
8. because planting citrus siam is still risky -----
(chemicals and fertilisers not yet available)
9. Want to wait for colleagues to harvest -----
10. Other_____
_____

5. To whose citrus siam plots are you paying attention?

1._____
2._____
3._____
4._____
5._____

1-st planting

1. Date of the 1-st planting Month_____Year_____

2. What is the reason to plant Citrus siam? _____
_____
_____

3. Motives of this decision? (What convinced you to plant citrus siam?)
_____
_____
_____

4. What did you grow before citrus siam?

Name of Crop 1._____
2._____
3._____

5. Price of citrus siam at that time?

Rp_____/(Unit_____)

6. Harvest and productivity of the previous crops, before planting citrus siam?

Harvest _____(Unit_____)
Productivity(*)_____(Unit_____/ha)

7. Labour costs for previous crops.

Labour Type	Labour				Other costs
	Month	Family	External		
		day / men	day / men	Rp	
1.					
2.					
3.					
4.					
5.					
6.					

8. How many saplings/budgrafts of citrus siam were planted? _____

9. Why did you plant this number of saplings/budgrafts?

Reasons 1._____
2._____
3._____

10. Price of saplings/budgrafts, then?

Rp_____/one

11. Where did you buy those saplings/budgrafts?

Name of Market_____

12. Costs of planting citrus siam.

Type of Work	Month	Amount of Labour: Family day	Family men	External day	External men	Other costs: Rp
1.Opening						
2.Mounding						
3.Hedging						
4.Planting						
5.						
6.						
7.						

13. Price of citrus siam fruits when planting?

Rp_____/Unit_____

Re-planting (First/Second/Third/Fourth/Fifth)

1. Date of the re-planting Month_____Year_____

2. Reasons to re-plant citrus siam? _____
_____
_____

3. If already stop growing citrus siam, why?
_____
_____
_____

4. What convinced you to re-plant citrus siam?
_____
_____
_____

5. Previous crops?
_____
_____
_____

6. Price of the previous crops, at the time of re-planting?

Rp_____/Unit(_____)

7. Harvest and productivity of the previous crop?

Harvest _____(Unit_____)
Productivity _____(Unit_____/ha)

8. Labour costs for the previous crop.

Type of work	Labour					Other costs
	Month	Family		External		
		day	men	day	men	Rp
1.						
2.						
3.						
4.						
5.						
6.						

9. How many saplings/budgrafts were planted? _____

10. Why did you plant this number of saplings/budgrafts?
_____
_____
_____

11. Price of sapling/budgraft at the re-planting?

Rp_____/one

12. Where did you buy saplings/budgrafts then?

Name of Market_____

13. Costs of replanting of citrus siam

Type of work	Labour				Other costs
	Month	Family		External	
		day	men	day	men	Rp
1.Opening						
2.Mounding						
3.Hedging						
4.Planting						
5.						
6.						
7.						
8.						

14. Price of citrus siam fruits at the time of re-planting?

Rp_____/Unit(_____)

Harvesting & Marketing (First/Second/Third/Fourth/Fifth)

1. Date of Harvest Month_____Year_____

2. Harvesting costs

Type of work	Labour				Other costs
	Month	Family	External		
		day / men	day / men	Rp	
1.Picking					
2.Packing					
(box)		**** / *****	**** / *****	*****	Total=
		**** / *****	**** / *****	*****	Price=
		**** / *****	**** / *****	*****	Source=
3.					
4.					
5.					
6.					
7.Contract		**** / *****	**** / *****	*****	Total=Rp

3. Date of Marketing Month_____Year_____

4. Costs of marketing

Market/ merchant	Month	Harvest (kg)	Price (Rp/kg)	Total (Rp)	Transportation costs (Rp)
1.Belatung					
2.Lebuk B. Lama					
3.Baturaja					
4.Tanjung Kar'g					
5.Palembang					
6.Jakarta					
7.					
8.					
Family consumption			**********	********	**********
Total			**********		

Annual Costs for Citrus siam

1. Year_____

2. Annual work costs for citrus siam

Type of work	Labour				Other costs
	times/ year	Family	External		
		day / men	day / men	Rp	
1.Fertilising					
2.Chemicals					
3.Giving lime					
4.Watering					
5.Weeding					
6.Selection					
7.					
8.					

Rubber

1. Condition of rubber

	No. plot	Area (dp x dp)	(ha)	No. of trees	Year of planting	Status (OO/SC/LH/LL)
1.Immatured	1.					
	2.					
2. Productive	1.					
	2.					
3. Old unproductive	1.					
	2.					

2. Harvest of rubber

Rainy season_____(kg/week) Dry season _____(kg/week)

3. What do you use for coagulation?

	Usage (kg/week)	Price (Rp/kg)	Source
1.Asam Cuka			
2.Alum			
3.Other			

4. Rubber Tapper

Name of Tapper	Origin of Tapper	Method of Sharing	Harvest(kg/week) Rainy Season	Dry Season
1.				
2.				
3.				
4.				

5. Do you tap others' rubber?

Name of Owner	Origin	Method of Sharing	Harvest(kg/week) Rainy Season	Dry Season
1.				
2.				
3.				

6. Do you want to re-plant rubber?

1.Yes, 2.Not decided, 3.No _____

7. Do you like to continue producing rubber?

1.Yes, 2.Not decided, 3.No _____

General Economic Data

1. Annual Income in 1982

Rp_____/year

2. Source of Annual Income in 1982

Agriculture	Rp_____/year
Fishery	Rp_____/year
Work outside village	Rp_____/year
Shop	Rp_____/year
Remittances	Rp_____/year
From whom	1_____ 2_____ 3_____
Others	
1_____	Rp_____/year
2_____	Rp_____/year
3_____	Rp_____/year

3. Annual income in 1982 is lower or greater than usual?

Lower/Usual/Greater

4. Monthly Expenditure (1982)

1. Regular expenditure

Foods/Clothes/Housing	Rp_____/month
Educational Costs	Rp_____/month
Other costs	Rp_____/month

2. Special Expenditure

1.Lebaran 1 & 2	Rp_____	
2.Medical	Rp_____	
3.Marriage	Rp_____	
4.Festivity	Rp_____	
5.Purchase of Durables	Rp_____	
6.Zakat	Rp_____ or	Rice _____kg
		other_____( )
7._____	Rp_____	
8._____	Rp_____	

3. Total Monthly Expenditure

Monthly Rp_____/month

4. Monthly Consumption

	Consumed	Home production	Bought	Unit
1. Rice				
2. Meat(beef)				
(buffalo)				
(goat)				
(chicken)				
3. Fresh Fish				
4. Dried Fish				
5. Prawn				
6. Vegetables				
7. Coffee				
8. Tea				
9. Salt				
10.Sugar				
11.Coconut oil				
12.Kerosene				
13.Cigarette				
14.Soap				
15.Flour				
16.Milk				
17.Eggs				
18.Onion(m/p)*				
19.Potatoes				
20.Fruits				
21.Cassava				
22.				
23.				

Note

*: "m" stands for merah=red, red onion, and "p" for putih=white, white onion.

Information Network Data

1. Do you have a radio?

Yes/No

2. Do you listen to "Siaran Pedesaan" on radio?

1. 7 times/week (every day)
2. 4-6 times/week (often)
3. 1-3 times/week
4. 1-2 times/month
5. No

_____

3. Outside experience or job?

Name of city	Year	Type of Work
1.	19___ until 19__	
2.	19___ until 19__	
3.	19___ until 19__	
4.	19___ until 19__	
5.	19___ until 19__	

4. How many times a year do you go to cities?

City	Times	Purpose
1.Baturaja		
2.Prabumulih		
3.Palembang		
4.Tanjung Karang		
5.Jakarta		
6.		
7.		

5. With whom do you often talk about agricultural problems?

Name 1._____ 5._____ 9._____

2._____ 6._____ 10._____

3._____ 7._____

4._____ 8._____

Kinship Relation

Grandfather father-side	_____	Grandmother father-side	_____
Grandfather mother-side	_____	Grandmother mother-side	_____
		Father-in-law	_____
Father	_____	Mother	_____
Uncle	1_____	Wife's uncle	1_____
	2_____		2_____
	3_____		3_____
Elder brother	1_____	Wife's elder brother	1_____
	2_____		2_____
	3_____		3_____
Younger brother	1_____	Wife's younger brother	1_____
	2_____		2_____
	3_____		3_____
Elder sister	1_____	Wife's elder sister	1_____
	2_____		2_____
	3_____		3_____
Younger sister	1_____	Wife's younger sister	1_____
	2_____		2_____
	3_____		3_____

Independent children

Son	1_____	Wife	_____	Son's father-in-law	1_____
	2_____	Wife	_____		2_____
	3_____	Wife	_____		3_____
Daughter	1_____	Husband	_____	Daughter's father-in-law	1_____
	2_____	Husband	_____		2_____
	3_____	Husband	_____		3_____

A.4 Questionnaire for Economic Exchange Networks

QUESTIONNAIRE-5 JULY-SEPTEMBER 1983 ECONOMIC EXCHANGE NETWORK DATA

NAME _____ bin _____ ID NO. _____

INTERVIEW DATE _____
TIME _____
PLACE _____

A. DAILY SHOPPING

1. PLEASE LIST NAMES OF SHOPS IN BELATUNG WHERE YOUR FAMILY BUY DAILY GOODS.

1. _____ 4. _____
2. _____ 5. _____
3. _____

2. IF YOU OWN A SHOP, WHO OFTEN COMES TO YOUR SHOP?

1. _____	6. _____	11._____	16._____
2. _____	7. _____	12._____	17._____
3. _____	8. _____	13._____	18._____
4. _____	9. _____	14._____	19._____
5. _____	10._____	15._____	20._____

B. DAILY GOODS EXCHANGE

1. IF SHOPS ARE CLOSED OR IF WE DO NOT HAVE MONEY, WE SOMETIMES ASK OUR NEIGHBOURS, FAMILY MEMBERS OR FRIENDS TO LEND SOME DAILY GOODS, SUCH AS RICE, SUGAR AND SALT. PLEASE LIST NAMES OF PERSONS TO WHOM YOU CAN ASK FOR THIS SORT OF DAILY GOODS BORROWING.

1. _____ 6. _____
2. _____ 7. _____
3. _____ 8. _____
4. _____ 9. _____
5. _____ 10._____

C. HIRED LABOUR SOURCES

1. IF YOU WANT TO USE HIRED LABOUR FOR YOUR AGRICULTURE, TO WHOM DO YOU ASK, OR TO WHOM DID YOU ASKED RECENTLY?

1. _____ 4. _____
2. _____ 5. _____
3. _____

2. HAVE YOU RECENTLY BEEN HIRED AS LABOURER? IF SO, WHO HIRED YOU?

1. _____ 4. _____
2. _____ 5. _____
3. _____

3. DO YOU USE TAPPERS FOR YOUR RUBBER? IF SO, WHO ARE THEY? AND WHAT SORT OF ARRANGEMENT DO YOU HAVE WITH THEM?

NAME	ARRANGEMENT	NAME	ARRANGEMENT
1. _____	_____	4. _____	_____
2. _____	_____	5. _____	_____
3. _____	_____		

4. DO YOU WORK FOR OTHERS AS TAPPER? IF SO, FOR WHOM DO YOU WORK? AND WHAT SORT OF ARRANGEMENT DO YOU HAVE?

NAME	ARRANGEMENT	NAME	ARRANGEMENT
1. _____	_____	4. _____	_____
2. _____	_____	5. _____	_____
3. _____	_____		

D. "GOTONG ROYONG"

1. TO WHOSE FARM HAVE YOU OR YOUR FAMILY MEMBERS GONE TO HELP AS "GOTONG ROYONG"?

1. _____	6. _____
2. _____	7. _____
3. _____	8. _____
4. _____	9. _____
5. _____	10._____

2. WHO HAVE RECENTLY COME TO HELP YOUR FARM AS "GOTONG ROYONG"?

1. _____	6. _____
2. _____	7. _____
3. _____	8. _____
4. _____	9. _____
5. _____	10._____

E. "ZAKAT" RELATIONSHIPS

1. THIS YEAR, DID YOU PAY SOMETHING AS "ZAKAT"? IF SO, WHAT SORT OF GOODS, AND TO WHOM DID YOU PAY "ZAKAT"?

NAME	GOODS (RICE,MONEY,ETC)	NAME	GOODS (RICE,MONEY,ETC)
1. _____	_____	6. _____	_____
2. _____	_____	7. _____	_____
3. _____	_____	8. _____	_____
4. _____	_____	9. _____	_____
5. _____	_____	10._____	_____

F. "ARISAN" GROUP MEMBERSHIP

1. ARE THERE "ARISAN" GROUPS IN BELATUNG? IF ANY, PLEASE GIVE NUMBERS OF GROUPS.

_____GROUPS

2. IF THESE GROUPS HAVE NAMES, PLEASE LIST THEIR NAMES.

1. _____ 4. _____
2. _____ 5. _____
3. _____

3. WHO ARE LEADERS OF THESE "ARISAN" GROUPS?

1. _____ 4. _____
2. _____ 5. _____
3. _____

4. ARE YOU OR YOUR WIFE A MEMBER OF AN "ARISAN" GROUP?
IF SO, PLEASE LIST THE NAME OF THE GROUP.

1. _____
2. _____
3. _____

5. HAVE YOU WON SOME MONEY RECENTLY? IF SO, FOR WHAT DID YOU USE THAT MONEY?

1. _____
2. _____
3. _____

G. MONEY LENDING/BORROWING

1. IF YOU NEED MONEY, TO WHOM DO YOU ASK FOR SOME MONEY?

1. _____ 4. _____
2. _____ 5. _____
3. _____

2. HAVE YOU LENT SOME MONEY TO OTHERS IN BELATUNG?
TO WHOM DID YOU LENT?

1. _____ 4. _____
2. _____ 5. _____
3. _____

H. LAND USE

1. IS ANY PLOT OF YOUR LAND USED BY OTHERS IN BELATUNG? IF SO, WHO IS USING A PLOT OF YOUR LAND? AND WHAT SORT OF ARRANGEMENT DO YOU HAVE WITH HIM?

	NAME	ARRANGEMENT		NAME	ARRANGEMENT
1.	_____	_____	4.	_____	_____
2.	_____	_____	5.	_____	_____
3.	_____	_____			

2. TO WHOM AND WHEN DID YOU SELL PLOTS OF YOUR LAND?
AND WHAT SORT OF ARRANGEMENT DID YOU HAVE WITH HIM?

	NAME	YEAR	ARRANGEMENT		NAME	YEAR	ARRANGEMENT
1.	_____	____	_____	4.	_____	____	_____
2.	_____	____	_____	5.	_____	____	_____
3.	_____	____	_____				

Appendix B

Appendix to Chapter 2

B.1 Equivalence Scales of Age-Sex Groups

Average consumption levels of age-sex groups are calculated with respect to monthly subsistence consumption, to monthly rice consumption and to annual total consumption in Table B-1. These average consumption levels were adjusted by household size because the household size may affect the consumption related to the household itself.

While almost all calculated average consumption levels for male age groups were statistically significant and exhibit a plausible pattern, most of those for female age-groups were insignificant. Figures for household size adjustments were all insignificant statistically. But they indicate that the economy of scale in terms of household size existed at least in the village and that larger households consumed less than smaller households in the village.

The average consumption level of an average adult male was calculated as the average of the coefficients for adult males between 15 and 59 years old. The average adult male's average consumption levels with respect to monthly subsistence consumption, monthly rice consumption and annual total consumption were Rp.21,105, 38.60 Kg and Rp.305,130 respectively. The average consumption level of an average adult male was somewhat greater than thought plausible, but when the correlations between male age-groups and certain female age-groups (5 to 10 years younger) which represent husband-wife relations are taken into consideration, the figures appear to be acceptable.

Table B-1: Equivalence Scales of Age-Sex Groups

Male Age (yr)	Monthly Subsistence Consumption (Rp.)	Monthly Rice Consumption (Kg.)	Annual Total Consumption (million Rp.)
	(per person)	(per person)	(per person)
0	4542 (0.39)	6.19 (0.40)	0.08812 (0.40)
1-4	16692 (2.16)	33.75 (3.30)	0.15681 (1.08)
5-9	21398 (2.56)	32.94 (2.98)	0.34052 (2.17)
10-14	23968 (2.94)	29.31 (2.72)	0.30894 (2.02)
15-19	24553 (3.07)	41.53 (3.93)	0.29227 (1.94)
20-24	16382 (1.64)	34.53 (2.62)	0.28557 (1.52)
25-29	19478 (1.60)	30.51 (1.90)	0.38275 (1.67)
30-39	26980 (2.26)	45.52 (2.88)	0.40212 (1.79)
40-49	27444 (2.30)	43.17 (2.74)	0.28958 (1.29)
50-59	21794 (1.82)	36.33 (2.29)	0.47078 (2.09)
60-	29914 (2.72)	43.79 (3.01)	0.35179 (1.70)
Female			
0	13486 (0.97)	16.65 (0.91)	0.19356 (0.74)
1-4	11840 (1.22)	23.73 (1.85)	0.09478 (0.52)
5-9	9340 (1.21)	21.95 (2.15)	0.29021 (2.00)
10-14	31648 (3.88)	39.06 (3.62)	0.42749 (2.79)
15-19	15619 (1.67)	26.75 (2.16)	0.24015 (1.36)
20-24	12347 (1.34)	15.69 (1.29)	0.11136 (0.64)
25-29	4230 (0.33)	-16.15 (0.96)	0.11643 (0.49)
30-39	1607 (0.14)	-2.23 (0.15)	0.21821 (1.02)
40-49	15452 (1.26)	15.07 (0.93)	0.52550 (2.28)
50-59	13639 (1.13)	10.59 (0.67)	0.23634 (1.04)
60-	14707 (1.10)	22.89 (1.30)	0.33551 (1.34)
Household Size	Household Size Adjustment (difference from average consumption per household)		
(person)	(per household)	(per household)	(per household)
1-2	13597 (0.84)	-3.44 (0.16)	0.06633 (0.22)
3-4	-11209 (0.47)	-35.80 (1.14)	-0.17381 (0.39)
5-6	-21076 (0.59)	-59.91 (1.27)	-0.27930 (0.42)
7-8	-35101 (0.74)	-89.84 (1.42)	-0.60420 (0.67)
9-10	-83525 (1.32)	-129.48 (1.55)	-1.28029 (1.08)
11-12	-81882 (1.09)	-129.97 (1.31)	-1.36909 (0.97)
R-square	0.90897	0.89120	0.88189
Adjusted R-square	0.87898	0.85536	0.84298
F-value	30.31236	24.86700	22.66656
N	113	113	113

Note: Figures in parentheses are absolute values of t-ratios. Intercept is suppressed.
Source: Fieldwork

Appendix C

Appendix to Chapter 3

C.1 Changes of Interdependence Coefficient

Villager i's interdependence with Villager j is affected negatively by the social distance between them.

$$\frac{\partial l_{ji}}{\partial s_{ij}} = -2\,(s_{im_i} - s_{ij})\,\frac{\sum_{k\neq j}(s_{im_i} - s_{ik})^2}{(\sum_{k=1}^{n}(s_{im_i} - s_{ik})^2)^2} < 0,\quad j \neq i, m_i.$$

Villager i's interdependence with Villager j is positively affected by the social distance between Villager i and a third villager, Villager q.

$$\frac{\partial l_{ji}}{\partial s_{iq}} = \frac{2\,s_{iq}\,(s_{im_i} - s_{iq})\,(s_{im_i} - s_{ij})^2}{(\sum_{k=1}^{n}(s_{im_i} - s_{ik})^2)^2} > 0,\quad q \neq i, j, m_i.$$

Villager i's interdependence with Villager j is both positively and negatively by the social distance between Villager i and the villager most remote from him, Villager m_i, depending on the social distance between Villager i and Villager j.

$$\frac{\partial l_{ji}}{\partial s_{im_i}} = 2\,(s_{im_i} - s_{ij})\,\frac{s_{ij}\sum_{k=1}^{n}(s_{im_i} - s_{ik}) - \sum_{k=1}^{n} s_{ik}(s_{im_i} - s_{ik})}{(\sum_{k=1}^{n}(s_{im_i} - s_{ik})^2)^2}$$

$$\begin{cases} > 0 & if\ s_{ij} > \bar{s}_i \\ = 0 & if\ s_{ij} = \bar{s}_i \\ < 0 & if\ s_{ij} < \bar{s}_i \end{cases}$$

where the radius which distinguishes the effect is defined as:

$$\bar{s}_i = \frac{\sum_{k=1}^{n} s_{ik}\,(s_{im_i} - s_{ik})}{\sum_{k=1}^{n} (s_{im_i} - s_{ik})}$$

C.2 Changes of Independence Coefficient

Villager i's independence coefficient is negatively affected by the social distance between Villager i and the villager most remote from him, Villager m_i.

$$\frac{\partial l_{ii}}{\partial s_{im_i}} = -\,2\,s_{im_i}\,\frac{\sum_{k=1}^{n} s_{ik}(s_{im_i} - s_{ik})}{(\sum_{k=1}^{n} (s_{im_i} - s_{ik})^2)^2} < 0$$

Villager i's independence coefficient is positively affected by the social distance between himself and any other villager, Villager q.

$$\frac{\partial l_{ii}}{\partial s_{iq}} = 2\,s_{im_i}{}^2\,\frac{s_{im_i} - s_{iq}}{(\sum_{k=1}^{n} (s_{im_i} - s_{ik})^2)^2} > 0 \quad q \neq i, m_i.$$

C.3 Location of Villagers' Houses

Figure C-1 shows the location of villagers' houses. It should be noted that there are several villagers who live on their farms. While some of them have their own houses in the village residential area, these are used by their children of school-age, and rarely by them, except on weekly market days.

These other areas are (1) Talang Kisam, (2) Lekis South and (3) Lekis East. These areas are shown in the corner of Figure C-1 (Refer Figures 2-1 and 2-2 for house locations in the wider area.).

The main residential area of the village can be divided into several quarters denoted by Roman numbers.

C.4 Relationships among Networks

The villagers interactions in the various networks are very likely to be correlated with one another. Thus, an interaction in a certain network may be partly explained by interactions in other networks, and by the geographical distances between villagers' houses.

Kinship relations are regarded as the most basic relations, being ascribed to all villagers by birth. Geographical distances between houses are largely determined by villagers' inheritances, which are themselves dependent on long-term kinship relations. Hence, kinship relations, and geographical distances remain solely as explanatory variables of other types of interactions.

In order to examine the relations between a particular interaction and other interactions, probit or logit analysis should be employed because of limited dependent variables (dichotomous variables). However, due to the very large number of observations, these methods could not be used. OLS was used instead. Table C-1 show results of OLS regressions among interactions.

It is obvious that there is no serious multicollinearity among variables because variables are alternately regarded as dependent variables in regression analyses and there is no high R-squares.

The direct agricultural information exchange is related positively to all other types

Figure C-1: Location of Villagers' Houses

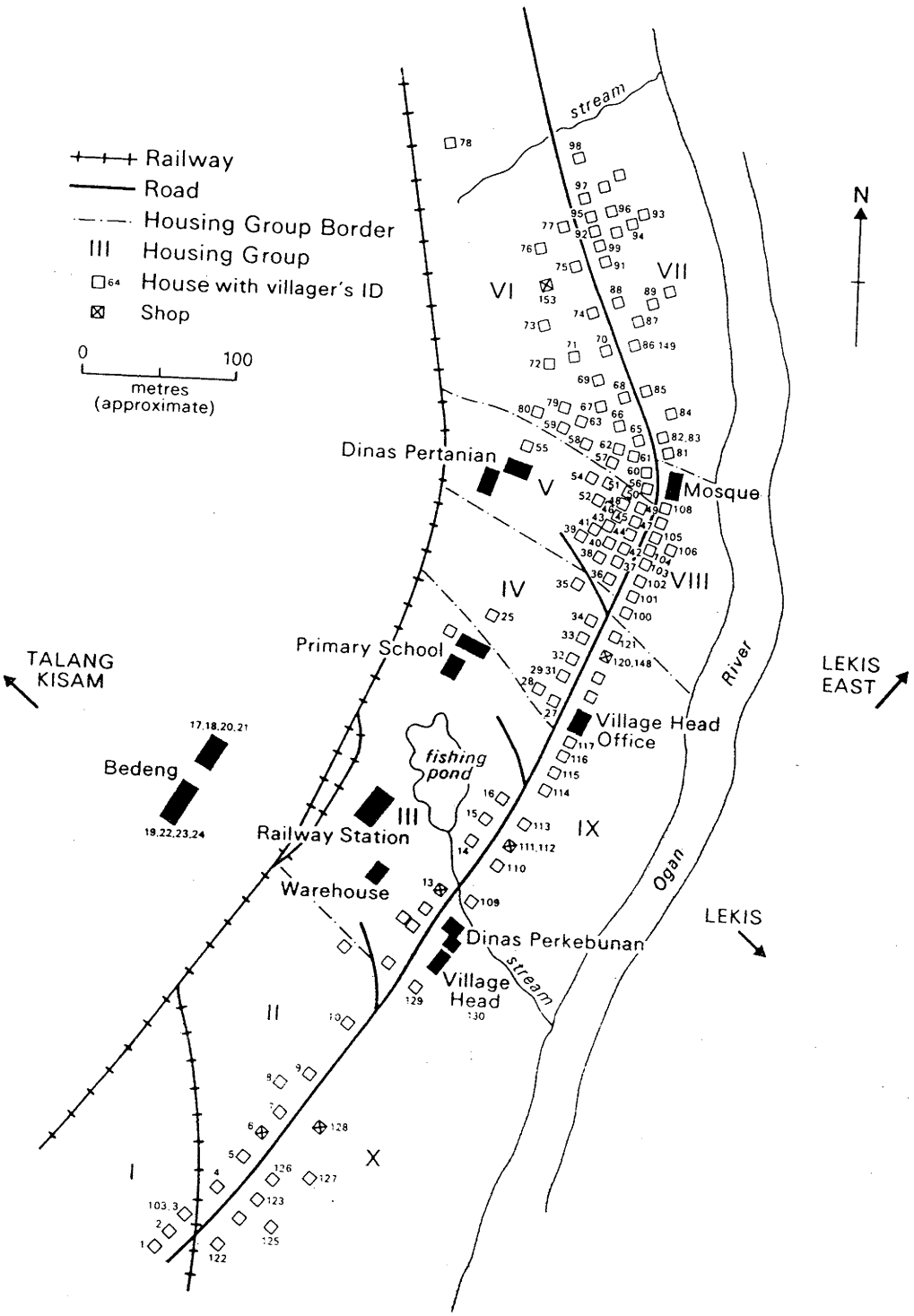


Table C-1: Relationships among Networks

		DEPENDENT VARIABLES							
		1	2	3	5	6	7	8	9
	1	***	0.08895 (12.29)	0.05983 (7.87)	---	0.03127 (4.10)	0.01574 (2.64)	0.01960 (6.28)	0.04035 (5.45)
EXPLANATORY VARIABLES	2	0.24068 (12.31)	***	0.26512 (22.41)	---	0.04364 (3.57)	---	0.01363 (2.81)	---
	3	0.14466 (7.78)	0.23907 (21.72)	***	0.16485 (2.85)	0.03886 (3.23)	0.02454 (2.66)	---	---
	4	0.07022 (7.77)	0.04695 (8.55)	0.04201 (7.21)	0.08194 (2.83)	---	0.02283 (4.93)	0.00737 (3.08)	---
	5	---	---	0.00672 (2.86)	***	0.01113 (4.72)	---	---	-0.00517 (-2.18)
	6	0.06934 (3.73)	0.03520 (3.12)	0.03744 (2.86)	0.26359 (4.40)	***	---	---	0.05928 (4.90)
	7	0.05022 (2.14)	---	0.03112 (2.06)	---	---	***	---	0.04269 (2.80)
	8	0.28820 (6.37)	0.07728 (2.80)	---	0.29874 (2.04)	---	---	***	---
	9	0.10306 (5.60)	---	---	-0.12945 (-2.18)	0.06023 (5.06)	0.02750 (2.91)	---	***
	D	0.75777 (12.42)	0.86613 (23.98)	---	3.27755 (17.45)	---	---	---	---
	CONST.	0.00943 (3.56)	-.01368 (-8.57)	0.00263 (1.40)	0.40826 (48.02)	0.00591 (3.15)	0.00566 (4.65)	0.00093 (1.49)	0.01470 (7.79)
	Adj.R.sq	0.11884	0.21754	0.11715	0.05283	0.01709	0.00821	0.01114	0.00958
	F	117.36	320.81	153.65	65.16	25.00	15.28	26.91	17.69
	DF1	8	6	6	6	5	4	3	4
	DF2	6894	6896	6896	6896	6897	6898	6899	6898

Notes: Figures in parentheses are t-values. Adjusted R-squares are very low, but all regressions are significant at less than 0.1% level because of the large observation size. Estimations are conducted with stepwise OLS in SPSS with the inclusion-exclusion criterion at 5 % level.
--- denotes a variable excluded due to the low significance.
*** denotes a dependent variable itself.

Variables

1. Direct Agricultural Information
2. Household Goods Exchange
3. Money Lending/Borrowing
4. Kinship
5. Meeting-at-shops
6. Hired Labour
7. Land Sales/Purchases
8. Land Lease
9. Citrus Siam Observation
D. Inversed Geographical Distance between Houses

of interactions except meeting-at-shops relation. When two villagers exchange household goods, the possibility of direct exchange of agricultural information is higher. When they lend or borrow small amounts of money, the possibility is also higher. If they are relatives, the possibility is higher. When they are in land sales-purchase or lease contract, or hired labour contract, the possibility is increased. When one of them observe, the other's citrus siam production, it increases the possibility. Finally, if they are living closely in terms of geographical distances, they have a higher possibility of information exchange.

The household goods exchange interaction is related positively to five types of interactions and geographical distances. When villagers directly exchange agricultural information, the possibility for them to exchange household goods is higher. When they lend or borrow small amounts of money, they are likely to exchange household goods like lending or borrowing of money. If they are relatives, they feel relatively more free to borrow or lend household goods. When they have land lease or hired labour contracts with each other, or if they live closer to each other, again the possibility is higher.

The lending/borrowing of money is related positively to six types of interactions. When villagers directly exchange agricultural information, they are more likely to lend or borrow a small amount of money each other. When they exchange household goods or if they are relatives, the possibility is higher. When they meet more often at the same shops in the village, the possibility is higher due to their increased opportunities to meet each other. When they are in hired labour contract or when they have sold or bought between them, the possibility is higher.

The meeting-at-shops relation, which is measured in terms of the number of shops two villagers commonly use, is related positively to five types of interactions and negatively to the citrus siam observation activity. When they lend or borrow money with each other, the relation is likely to increase. The causal relationship may be that increased opportunities to meet at shops may create the opportunity to lend or borrow money to buy something at the shops. If they are relatives or live closer, the possibility is higher. When they are in hired labour or land lease contract, the possibility is again higher. The negative sign of the citrus siam observation activity implies that these two

activities do not coexist. A villager who observes the other villager's citrus siam production may avoid meeting the latter villager at shops. This argument may be too strong, but at least this sort of tendency exists between the two activities.

The hired labour relation is related positively to five types of interactions. The direct exchanges of agricultural information, household goods exchange, lending and borrowing of small amounts of money, and opportunities to meet at shops create more opportunities to obtain information about the demand of hired labour. The citrus siam observation activity is also positively related to the hired labour relation. The direction of causality may be opposite. If a villager is hired to work on another villager's citrus siam plot, he certainly observes the citrus siam production.

The land sales and purchases relation is related positively to four types of interactions. When a villager directly exchanges agricultural information with another, the possibility of land sales and purchases increases. When they lend or borrow small amounts of money each other, the possibility also increases. If they are relatives, the possibility again increases, because villagers tend to keep their own plots of land redeemable. If a member of the same kinship group is the new owner, the plots of land can be redeemed when the former owner financially recovers. The citrus siam observation activity is positively related to the possibility of the land sales and purchases.

Land lease relation is positively related to three types of interactions. When they directly exchange agricultural information, or when they exchange household goods, the possibility of land lease relation is higher. If they are relatives, the possibility is also higher. If two villagers are members of the same kinship group, and either one of them wants to lease-out his plot, he tends to prefer a financially inferior member of his kinship group to look after his plot. On the other hand, if a villager wants a plot of land, he first looks for a member of his kinship group who has more plots than family labour can manage.

The citrus siam observation is positively related to three types of interactions and negatively to one type of interactions. When they directly exchange agricultural information, the possibility to observe the other's citrus siam production is higher, and when they are in hired labour contract or they have sold or bought land, the possibility is

again higher. On the other hand, when they have a higher opportunity to meet at shops, the possibility is lower.

These results clearly indicate that the first five types of non-hierarchical interactions are related to each other quite significantly, and they are also very much related to hierarchical interactions. On the other hand, relations between hierarchical and non-hierarchical relations are not so significant, and especially hierarchical relations are quite independent of each other. These findings may be based on the fact that the number of villagers involved in the hierarchical relations are much smaller than those involved in the non-hierarchical relations.

C.5 FORTRAN programme for Modified NEGOPY

```
C=============================================================
C
C     READ NETnnn.MAT and IDENTIFY Cliques
C
C     by either NEGOPY or RANKING (modified NEGOPY)
C
C=============================================================
        PARAMETER (NMAX=153)
        INTEGER A(NMAX,NMAX),IJ(20),IRANK(NMAX),
     $          IROLD(NMAX),ID(NMAX),ISOLAT(NMAX),
     $          IRBEST(NMAX),IACROS(NMAX),IDOWN(NMAX),
     $          GROUP1(20),GROUP2(20),BELONG(3,NMAX),GROUP(1225)
        REAL ICHANG,CLIQUE
        DIMENSION RANK(NMAX),TEMP(NMAX),RNKOLD(NMAX),
     $            C(NMAX,NMAX),SUMACR(NMAX),SUMDWN(NMAX)
        CHARACTER*10 IFILE1,CONVER
        CHARACTER*20 FMT6,NAME(NMAX),NAME1(NMAX),FMT7,NAMAE
        CHARACTER*30 NAMNET,FMTTTY,FMTFIL
        CHARACTER*1 B(118,118),YES
C=============================================================================
C  VARIABLES
C     A          ORIGINAL SOCIOMETRIC MATRIX
C     C          CONVERSION INDEX MATRIX
C     B          GRAPHIC MATRIX FOR PRINT-OUT
C     IRANK      RANKING
C     IROLD      RANKING OF PREVIOUS ITERATION
C     ID         IDENTIFICATION NUMBER OF ACTOR IN PRESENT ANALYSIS
C     ISOLAT     =1: ACTOR=ISOLATE, =0:ACTOR<>ISOLATE
C     IRBEST     RANKING IN BEST PERFORMANCE TRIAL
C     IACROS     NUMBER OF ACTOR-I'S CHOICES
C     IDOWN      NUMBER OF ACTORS WHO CHOSE ACTOR-I
C     GROUP1     CLIQUE-I'S STARTING POINT
C     GROUP2     CLIQUE-I'S ENDING POINT
C     NAME       NAMES OF ACTORS
C=============================================================================
        N=NMAX
1       FORMAT( '1' )
2       FORMAT( '0' )
C=============================================================================
C
C     TTY OR BATCH
C
C=============================================================================
        TYPE 10
10      FORMAT ( ' 1   TTY '/' 2   BATCH '/' =', $ )
        ACCEPT *,TTYBAT
C=============================================================================
C
C     TYPE OF NETWORK
C
C=============================================================================
        TYPE 1010
1010    FORMAT ( ' TYPE OF NETWORK '/
     $  ' 1     AGRICULTURAL INFORMATION'/
     $  ' 2     SHOPPING & CUSTOMERS'/
     $  ' 3     EXCHANGE'/
     $  ' 4     LEND & BORROW MONEY'/
     $  ' 6     HIRED-IN & -OUTLABOUR FROM'/
     $  ' 8     LAND SALES & PURCHASE'/
     $  ' 10    NUMPANG/PARUHAN/RUBBER TAPPER-IN FROM TAPPER-OUT TO'/
     $  ' 14    ZAKAT WAKAP TO'/
     $  ' 16    KINSHIP GROUP'/
     $  ' 17    CITRUS SIAM OBSERVATION'//
     $  ' NETWORK NO.=', $ )
        ACCEPT *,NONET
        IF (NONET.EQ.1) NAMNET='AGRICULTURAL INFORMATION'
        IF (NONET.EQ.2) NAMNET='SHOPPING'
        IF (NONET.EQ.3) NAMNET='HOUSEHOLD GOODS EXCHANGE'
        IF ((NONET.EQ.4).OR.(NONET.EQ.5)) THEN
```

```
              NAMNET='LEND/BORROW MONEY'
              NONET=4
        END IF
        IF ((NONET.EQ.6).OR.(NONET.EQ.7)) THEN
              NAMNET='HIRED-IN/OUT LABOUR'
              NONET=6
        END IF
        IF ((NONET.EQ.8).OR.(NONET.EQ.9)) THEN
              NAMNET='LAND PURCHASE/SALES'
              NONET=8
        END IF
        IF (NONET.EQ.10) NAMNET='NUMPANG/PARUHAN'
        IF (NONET.EQ.11) NAMNET='SHOP CUSTOMERS'
        IF ((NONET.EQ.12).OR.(NONET.EQ.13)) THEN
              NAMNET='RUBBER TAPPER-IN/OUT'
              NONET=12
        END IF
        IF ((NONET.EQ.14).OR.(NONET.EQ.15)) NAMNET='ZAKAT TO'
        IF (NONET.EQ.16) NAMNET='KINSHIP'
        IF (NONET.EQ.17) NAMNET='CITRUS SIAM OBSERVATION'
        WRITE (6,1020) NAMNET
        TYPE 1020,NAMNET
1020    FORMAT ( //' CLIQUE IDENTIFICATION OF ',A30// )
C=======================================================================
C
C      ALL ACTORS OR A PARTIAL SET OF ACTORS
C
C=======================================================================
        NALL=1
C=======================================================================
C
C     SYMMETRICISE ORIGINAL MATRIX OR NOT
C
C=======================================================================
        TYPE 1040
1040    FORMAT ( ' 1 SYMMETRIC '/' 2 NON-SYMMETRIC'/' =',$)
        ACCEPT *,NSYM
        IF (NSYM.EQ.1) THEN
              WRITE (6,1050)
1050          FORMAT ( ' MATRIX SYMMETRICISED ' )
        ELSE
              WRITE (6,1060)
1060          FORMAT ( ' MATRIX NON-SYMMETRICISED(ORIGINAL) ' )
        END IF
        IF(NSYM.EQ.1) NACD=1
        IF(NSYM.EQ.2) NACD=3
C=======================================================================
C
C=======================================================================
        TYPE 1065
1065    FORMAT(' EXCLUDE SYCOPHANTS AND BRIDGES, TOO ? (1=YES/0=NO)',$)
        ACCEPT *,NEXCL
C=======================================================================
C
C     CONVERSION INDEX
C
C=======================================================================
1070    TYPE 1120
        ACCEPT 1130,NINDEX
1120    FORMAT ( / ' CONVERSION INDEX '/ /
     $  ' (1)0-1 MATRIX '/' (2)OBJECTIVE NEGOPY MATRIX '/
     $  ' (3)I.C.P. '/
     $  ' WHICH INDEX TO BE USED=',$ )
1130    FORMAT ( I2 )
        IF (NINDEX.EQ.1) WRITE (6,1140)
        IF (NINDEX.EQ.2) WRITE (6,1150)
        IF (NINDEX.EQ.3) WRITE (6,1160)
1140    FORMAT ( ' CONVERSION INDEX: 0-1 DISTANCE ' )
1150    FORMAT ( ' CONVERSION INDEX: OBJECTIVE NEGOPY ' )
1160    FORMAT ( ' CONVERSION INDEX: I.C.P. ' )
C=======================================================================
```

```
C
C     CONVERSION METHOD
C
C=====================================================================
        METHOD=2
        GOTO 1171
        TYPE 1170
        ACCEPT 1180,METHOD
1171    IF (METHOD.EQ.1) THEN
                WRITE (6,1190)
        ELSE
                WRITE (6,1200)
        END IF
1170    FORMAT ( / ' CONVERSION METHOD '/ /
     $  ' (1) NEGOPY '/' (2) RANKING '/' WHICH METHOD TO BE USED= ', $ )
1180    FORMAT ( I1 )
1190    FORMAT ( ' CONVERSION METHOD: NEGOPY ' )
1200    FORMAT ( ' CONVERSION METHOD: RANKING ' )
C=====================================================================
C
C     CLIQUE IDENTIFICATION RATE
C
C=====================================================================
        CLIQUE=0.5
        GOTO 1211
        TYPE 1210
        ACCEPT *,CLIQUE
1211    WRITE (6,1220) CLIQUE
1210    FORMAT ( ' CLIQUE IDENTIFICATION RATE= ', $ )
1220    FORMAT ( ' CLIQUE IDENTIFICATION RATE= ', F10.6 )
C=====================================================================
C
C     MATRIX INITIALISATION
C
C=====================================================================
        DO 1230 I=1,N
                DO 1240 J=1,N
                        A(I,J)=0
                        C(I,J)=0.
1240            CONTINUE
1230    CONTINUE
C=====================================================================
C
C       READ ID numbers of farmer-actors included
C
C=====================================================================
        IFILE1='IDINCL.DTA'
        OPEN (UNIT=11,FILE=IFILE1)
        DO 2000 I=1,N
               READ (11,2010,END=2020) ID(I)
2010            FORMAT (1X,I3 )
2000    CONTINUE
2020    NID=I-1
        IF (TTYBAT.EQ.1) TYPE 2030,NID
2030    FORMAT ( ' NO OF FARMER-ACTORS= ',I3 )
        CLOSE(UNIT=11)
        IFILE1='NAME.DTA'
        OPEN (UNIT=11,FILE=IFILE1)
        DO 2031 I=1,N
                READ(11,2032,END=2033) NAME1(I)
2032            FORMAT( 13X,A20 )
2031    CONTINUE
2033    DO 2034 I=1,NID
                NAME(I)=NAME1(ID(I))
2034    CONTINUE
        DO 2050 I=1,N
                DO 2060 J=1,NID
                        IF (ID(J).EQ.I) GOTO 2050
2060            CONTINUE
                BELONG(1,I)=-4
                BELONG(2,I)=-4
```

```
2050    CONTINUE
C=====================================================================
C
C     READ NETnnn.MTA
C
C=====================================================================
        IF(NONET.LT.10) THEN
                WRITE(IFILE1,3001) NONET
3001            FORMAT( 'NET00',I1,'.MAT' )
        ELSE
                WRITE(IFILE1,3002) NONET
3002            FORMAT( 'NET0',I2,'.MAT' )
        END IF
        OPEN (UNIT=10,FILE=IFILE1)
        READ(10,3010) ((A(I,J),J=1,N),I=1,N)
3010    FORMAT(1X,153I1)
        CLOSE(UNIT=10)
        DO 3030 I=1,NID
                IK=ID(I)
                DO 3040 J=1,N
                        JK=ID(J)
                        C(I,J)=A(IK,JK)
3040            CONTINUE
3030    CONTINUE
        DO 3100 I=1,NID
        DO 3100 J=1,NID
                A(I,J)=C(I,J)
                C(I,J)=0.
3100    CONTINUE
        DO 3035 I=1,NID
                        A(I,I)=1
3035    CONTINUE
C=====================================================================
C       SYMMETRICISE ORIGINAL MATRIX
C=====================================================================
        N=NID
        IF (NSYM.EQ.1) THEN
                DO 5000 I=1,N
                DO 5000 J=I+1,N
                        IF ((A(I,J).EQ.1).OR.(A(J,I).EQ.1)) THEN
                                A(I,J)=1
                                A(J,I)=1
                        END IF
5000            CONTINUE
        END IF
        WRITE(FMT6,3036) NID
3036    FORMAT( '1X,I3,1X,',I3,'A1)' )
        DO 3050 I=1,NID
        DO 3050 J=1,NID
                IF(A(I,J).EQ.1) THEN
                        B(I,J)='#'
                ELSE
                        B(I,J)='_'
                END IF
3050    CONTINUE
        WRITE(7,FMT6) ((ID(I),(B(I,J),J=1,NID)),I=1,NID)
        CLOSE(UNIT=7)
C=====================================================================
C
C     Start calculation of Conversion index
C
C       1. 0-1 DISTANCE Matrix
C       2. NEGOPY
C       3. I.C.P.
C=====================================================================
        IF (NINDEX.EQ.1) THEN
                DO 6000 I=1,N
                        DO 6000 J=1,N
                                C(I,J)=A(I,J)
6000            CONTINUE
                GOTO 7000
```

```
        END IF
        IF (NINDEX.GE.2) THEN
                TYPE 2
                DO 6010 I=1,N
                        DO 6020 J=1,N
                                IF (A(I,J).EQ.0) THEN
                                   C(I,J)=0
                                   GOTO 6020
                                ELSE
                                   C(I,J)=1
                                   DO 6030 K=1,N
                                   IF((K.EQ.I).OR.(K.EQ.J))GOTO 6030
                                   C(I,J)=C(I,J)+A(I,K)*A(K,J)
6030                               CONTINUE
                                END IF
6020                    CONTINUE
6010            CONTINUE
        END IF
        IF (NINDEX.EQ.3) THEN
                DO 6040 I=1,N
                        SUMS=0
                        DO 6050 J=1,N
                                SUMS=SUMS+A(J,I)
6050                    CONTINUE
                        DO 6060 J=1,N
                                C(I,J)=C(I,J)/SUMS
6060                    CONTINUE
6040            CONTINUE
        END IF
C=======================================================================
C
C     Start Iterations
C
C       by:     1. NEGOPY method
C               2. RANKING method
C
C=======================================================================
7000    DO 7010 I=1,9
                IJ(I)=0
7010    CONTINUE
C=======================================================================
C
C     ISOLATES IDENTIFIED
C
C=======================================================================
        IF (TTYBAT.EQ.2) GOTO 8001
        TYPE 8000
8001    WRITE (6,8000)
8000    FORMAT ( / ' ISOLATES' / )
        NISOL=0
        NSY=0
        NBR=0
        DO 8010 I=1,N
                IACROS(I)=0
                IDOWN(I)=0
                ISOLAT(I)=0
                SUMACR(I)=0
                SUMDWN(I)=0
                DO 8020 J=1,N
                        IACROS(I)=IACROS(I)+A(I,J)
                        IDOWN(I)=IDOWN(I)+A(J,I)
                        SUMACR(I)=SUMACR(I)+C(I,J)
                        SUMDWN(I)=SUMDWN(I)+C(J,I)
8020            CONTINUE
                IAD=IACROS(I)+IDOWN(I)
                IF (IAD.EQ.2) THEN
                        ISOLAT(I)=1
                        BELONG(1,ID(I))=-1
                        BELONG(2,ID(I))=-1
                        NISOL=NISOL+1
                        IF (TTYBAT.EQ.2) GOTO 8031
```

```
                        TYPE 8030,NISOL,ID(I),NAME(I)
8031                    WRITE (6,8030) NISOL,ID(I),NAME(I)
8030                    FORMAT( 1X,I5,5X,'ACTOR-',I3,2X,A20 )
                END IF
                IF(NEXCL.EQ.0) GOTO 8010
                IF ((IAD.EQ.6).AND.(NSYM.EQ.1)) THEN
                        ISOLAT(I)=3
                        BELONG(1,ID(I))=-3
                        BELONG(2,ID(I))=-3
                        NBR=NBR+1
                END IF
                IF ((IAD.EQ.4).AND.(NSYM.EQ.1)) THEN
                        ISOLAT(I)=2
                        BELONG(1,ID(I))=-2
                        BELONG(2,ID(I))=-2
                        NSY=NSY+1
                END IF
8010    CONTINUE
        IF(NSYM.NE.1) GOTO 8999
        IF(NEXCL.EQ.0) GOTO 8999
        IJJ=0
        TYPE 8080
        WRITE(6,8080)
8080    FORMAT ( /,' SYCOPHANTS ',/)
        DO 8082 I=1,N
                IF(ISOLAT(I).EQ.2) THEN
                        IJJ=IJJ+1
                        DO 80821 J=1,N
                                IF((A(I,J).NE.0).AND.(I.NE.J))THEN
                                        JSY=J
                                        GOTO 80822
                                END IF
80821                   CONTINUE
80822                   IF(TTYBAT.EQ.2) GOTO 8083
                        TYPE 8084,IJJ,ID(I),NAME(I),ID(JSY),NAME(JSY)
8083                    WRITE(6,8084)IJJ,ID(I),NAME(I),ID(JSY),NAME(JSY)
8084             FORMAT(1X,I5,5X,'ACTOR-',I3,2X,A20,'  (',I3,1X,A20,')')
                END IF
8082    CONTINUE
        IIJ=0
        TYPE 8050
        WRITE(6,8050)
8050    FORMAT( /,' BRIDGES',/ )
        DO 8040 I=1,N
                IF(ISOLAT(I).EQ.3) THEN
                        IIJ=IIJ+1
                        JBR1=0
                        JBR2=0
                        DO 80401 J=1,N
                                IF(J.EQ.I) GOTO 80401
                                IF(A(I,J).NE.0) THEN
                                        IF(JBR1.EQ.0) THEN
                                                JBR1=J
                                        ELSE
                                                JBR2=J
                                                GOTO 80402
                                        END IF
                                END IF
80401                   CONTINUE
80402                   IF (TTYBAT.EQ.2) GOTO 8032
                        TYPE 8033,IIJ,ID(I),NAME(I),ID(JBR1),NAME(JBR1),
     $                          ID(JBR2),NAME(JBR2)
8032                    WRITE (6,8033) IIJ,ID(I),NAME(I),
     $                          ID(JBR1),NAME(JBR1),ID(JBR2),NAME(JBR2)
8033                    FORMAT( 1X,I5,5X,'ACTOR-',I3,2X,A20,'  (',I3,1X,
     $                          A20,' & ',I3,2X,A20,')' )
                END IF
8040    CONTINUE
C=======================================================================
C
C     START CONVERSION ITERATIONS
```

```
C
C=====================================================================
8999    BEST=10000.
        IF (TTYBAT.EQ.2) GOTO 9001
        TYPE 1
        TYPE 9000
9001    WRITE (6,1)
        WRITE (6,9000)
9000    FORMAT(' TRIAL   CONVERGED  ICHANG  IDIF  CONCENTRATION  INDEX')
        IF(TTYBAT.EQ.1) THEN
                NTRY=20
        ELSE
                NTRY=100
        END IF
        DO 9010 ITRY=1,NTRY
                ICONVE=0
                DO 9020 I=1,N
                        RANK(I)=INT(RANS(0)*N)+1
                        IF(ISOLAT(I).EQ.1) RANK(I)=N+1
                        IF(ISOLAT(I).EQ.2) RANK(I)=N+2
                        IF(ISOLAT(I).EQ.3) RANK(I)=N+3
                        IRANK(I)=RANK(I)
9020            CONTINUE
                DO 9030 K=1,N
                        DO 9040 I=1,N
                                IROLD(I)=IRANK(I)
                                RNKOLD(I)=RANK(I)
9040                    CONTINUE
                        DO 9050 I=1,N
                            RANK(I)=0
                            IF(ISOLAT(I).NE.0)THEN
                                    RANK(I)=RNKOLD(I)
                                    GOTO 9051
                            END IF
                            JSYBR=0
                            DO 9060 J=1,N
                                IF(NSYM.EQ.1) THEN
                                  IF(ISOLAT(J).NE.0) THEN
                                        RRR=0.
                                        JSYBR=JSYBR+A(I,J)
                                  ELSE
                                        RRR=RNKOLD(J)
                                  END IF
                                  RANK(I)=RANK(I)+RRR*C(I,J)
                                ELSE
                                  RRANK=RNKOLD(J)*(C(I,J)+C(J,I))
                                  RANK(I)=RANK(I)+RRANK
                                END IF
9060                        CONTINUE
                            IF(NSYM.EQ.1)THEN
                                RA=RANK(I)
                                  RANK(I)=RANK(I)/(SUMACR(I)-JSYBR)
                                  IF(ISOLAT(I).EQ.2) RANK(I)=N+2
                                  IF(ISOLAT(I).EQ.3) RANK(I)=N+3
                                RB=RANK(I)
                            ELSE
                                  RANK(I)=RANK(I)/(SUMACR(I)+SUMDWN(I))
                            END IF
9051                        TEMP(I)=RANK(I)
9050                    CONTINUE
C=====================================================================
C
C     RANKING TEMP(I),I=1,N
C
C=====================================================================
                        DO 9070 III=1,N
                                RMIN=N*2
                                DO 9080 JJJ=1,N
                                        IF (RMIN.GT.TEMP(JJJ)) THEN
                                                RMIN=TEMP(JJJ)
                                                IJMIN=JJJ
```

```
                                        END IF
9080                                CONTINUE
                                    TEMP(IJMIN)=N*3
                                    IRANK(IJMIN)=III
9070                        CONTINUE
C=============================================================================
C
C     CALCULATE STOP-ITERATION CRITERION
C
C=============================================================================
                            CHANGE=0
                            ICHANG=0
                            IDIF1=0
                            IDIF2=0
                            DO 9090 I=1,N
                                    CHANGE=CHANGE+(RNKOLD(I)-RANK(I))**2
                                    ICHANG=ICHANG+(IROLD(I)-IRANK(I))**2
                                    IF (IROLD(I).NE.IRANK(I)) IDIF2=IDIF2+1
9090                        CONTINUE
                            DO 9100 I=9,2,-1
                                    IJ(I)=IJ(I-1)
9100                        CONTINUE
                            IJ(1)=ICHANG
C=============================================================================
C
C     JUDGING STOP-ITERATION
C
C=============================================================================
                            IF (((IJ(1).EQ.IJ(2)).AND.(IJ(2).EQ.IJ(3))
     $                     .AND.(IJ(3).EQ.IJ(4)).AND.(IJ(4).EQ.IJ(5))
     $                     .AND.(IJ(5).EQ.IJ(6)).AND.(IJ(6).EQ.IJ(7))
     $                     .AND.(IJ(7).EQ.IJ(8)))
     $                     .OR.((IJ(1).EQ.IJ(3)).AND.(IJ(2).EQ.IJ(4))
     $                     .AND.(IJ(3).EQ.IJ(5)).AND.(IJ(4).EQ.IJ(6))
     $                     .AND.(IJ(5).EQ.IJ(7)).AND.(IJ(6).EQ.IJ(8)))
     $                     .OR.((IJ(1).EQ.IJ(4)).AND.(IJ(2).EQ.IJ(5))
     $                     .AND.(IJ(3).EQ.IJ(6)).AND.(IJ(4).EQ.IJ(7))
     $                     .AND.(IJ(5).EQ.IJ(8)).AND.(IJ(6).EQ.IJ(9))))
     $                             GOTO 9200
                            IF (ICHANG.EQ.0) THEN
                                    ICONVE=1
                                    GOTO 9200
                            END IF
                            IF (METHOD.NE.1) THEN
                                    DO 9110 I=1,N
                                            RANK(I)=IRANK(I)
9110                                CONTINUE
                            END IF
9030                CONTINUE
                    GOTO 9010
C=============================================================
C
C     CALCULATE CONCENTRATION RATE
C
C=============================================================
9200                SUMQ=0
                    NNN=N-NISOL-NBR
                    DO 9210 I=1,NNN
                            IR=IRANK(I)
                    DO 9210 J=1,NNN
                            JR=IRANK(J)
                            IF (A(I,J).NE.0) THEN
                                    SUMQ=SUMQ+1
                                    B(IR,JR)='#'
                            ELSE
                                    B(IR,JR)='_'
                            END IF
9210                CONTINUE
                    SUMWID=0
                    DO 9220 I=1,NNN
                            DO 9230 J=1,NNN
```

```
                                IF (B(I,J).EQ.'#') THEN
                                        JSTART=J
                                        GOTO 9240
                                END IF
9230                        CONTINUE
9240                        DO 9250 J=NNN,1,-1
                                IF (B(I,J).EQ.'#') THEN
                                        JEND=J
                                        GOTO 9260
                                END IF
9250                        CONTINUE
9260                        WIDE=JEND-JSTART+1
                            SUMWID=SUMWID+WIDE
9220                CONTINUE
                    CONCEN=SUMQ/SUMWID
C=====================================================================
C
C     PRESERVING BEST-PERFORMANCE TRIAL'S IRANK IN IRBEST(I)
C
C=====================================================================
                    IF (IDIF2-CONCEN.LT.BEST) THEN
                            BEST=IDIF2-CONCEN
                            IBEST=ITRY
                            IDBEST=IDIF2
                            CONBST=CONCEN
                            DO 9300 JK=1,N
                                    IRBEST(JK)=IRANK(JK)
9300                        CONTINUE
                    END IF
                    IF (ICONVE.EQ.1) THEN
                            CONVER='YES'
                    ELSE
                            CONVER='NO'
                    END IF
                    IF (TTYBAT.EQ.2) GOTO 9311
                    TYPE 9310,ITRY,CONVER,K,ICHANG,IDIF2,CONCEN,IDIF2-CONCEN
9311            WRITE(6,9310)ITRY,CONVER,K,ICHANG,IDIF2,CONCEN,IDIF2-CONCEN
9310            FORMAT(1X,I5,3X,A3,2X,I4,2X,F6.2,2X,I4,2X,F13.5,2X,F9.5)
9010    CONTINUE
C=====================================================================
C
C     PRINT-OUT THE BEST RESULT
C
C=====================================================================
        WRITE (6,2)
        IF (TTYBAT.EQ.2) GOTO 10001
        TYPE 10000,IBEST,IDBEST,CONBST,BEST
10001   WRITE (6,10000) IBEST,IDBEST,CONBST,BEST
10000   FORMAT ( ' BEST RESULT TRIAL=',I3,' IDBEST=',I5,
     $          ' CONBST=',F10.7,' BEST=',F10.7 )
C=====================================================================
C
C     REARRANGEMENT OF MATRIX
C
C=====================================================================
        TYPE 2
        WRITE (6,1)
        DO 10010 I=1,N
                IR=IRBEST(I)
                TEMP(IR)=I
                DO 10020 J=1,N
                        JR=IRBEST(J)
                        IF (A(I,J).GE.1) THEN
                                B(IR,JR)='#'
                        ELSE
                                B(IR,JR)='_'
                        END IF
10020           CONTINUE
10010   CONTINUE
C=====================================================================
C
```

```
C     PRINT-OUT ON TTY
C
C=====================================================================
        IF (TTYBAT.EQ.2) GOTO 10050
        DO 10030 KK=1,3
            K1=1+(KK-1)*120
            K2=MIN(N,KK*120)
            WRITE(FMTTTY,10040) K2-K1+1
10040       FORMAT ( ' ( 1X,I3,X,I3,X,',I3,'A1 ) ' )
            TYPE (FMT=FMTTTY),((I,ID(TEMP(I)),(B(I,J),J=K1,K2)),I=1,N)
            IF(K2.EQ.N) GOTO 10050
            TYPE 2
10030   CONTINUE
C=====================================================================
C
C     PRINT-OUT IN FILE (FOR06.DAT)
C
C=====================================================================
10050   DO 10060 KK=1,3
            K1=1+(KK-1)*120
            K2=MIN(N,KK*120)
            WRITE(FMTFIL,10070) K2-K1+1
10070       FORMAT ( ' ( 1X,I3,X,I3,X,',I3,'A1 ) ' )
            WRITE(6,FMT=FMTFIL)((I,ID(TEMP(I)),(B(I,J),J=K1,K2)),I=1,N)
            IF (K2.EQ.N) GOTO 11000
            WRITE (6,1)
10060   CONTINUE
C=====================================================================
C
C     START CLIQUE IDENTIFICATION
C
C=====================================================================
C   FROM NOW ON ISOLATES,SYCOPHANTS & BRIDGES ARE EXCLUDED FROM ANALYSIS
C=====================================================================
11000   N=N-NISOL-NBR-NSY
        DO 11010 I=1,N
                IROLD(I)=0
                IRANK(I)=0
                SUMACR(I)=0
                DO 11020 J=I,N
                        IF ((B(I,J).EQ.'#').OR.(B(J,I).EQ.'#')) THEN
                                C(I,J)=1
                                C(J,I)=1
                        ELSE
                                C(I,J)=0
                                C(J,I)=0
                        END IF
11020           CONTINUE
11010   CONTINUE
        DO 11025 I=1,N
                SUMACR(I)=0
                DO 11025 J=1,N
                        SUMACR(I)=SUMACR(I)+C(I,J)
11025   CONTINUE
        DO 11030 KK=1,2
                NCLIQ=0
                WRITE (6,1)
                IF (KK.EQ.1) THEN
                        IF (TTYBAT.EQ.2) GOTO 11041
                        TYPE 11040
11041                   WRITE (6,11040)
11040                   FORMAT ( /' FORWARD CLIQUE IDENTIFICATION ' )
                        NSTEP=1
                        N1=1
                        N2=N
                ELSE
                        IF (TTYBAT.EQ.2) GOTO 11051
                        TYPE 11050
11051                   WRITE (6,11050)
11050                   FORMAT ( /' BACKWARD CLIQUE IDENTIFICATION ' )
                        NSTEP=-1
```

```
                N1=N
                N2=1
            END IF
            DO 11060 ISTART=N1,N2,NSTEP
                MCQ=0
                IF (SUMACR(ISTART).EQ.1) GOTO 11060
                DO 11080 K=0,N2-ISTART,NSTEP
                    DO 11090 I=ISTART,ISTART+K,NSTEP
                        SUMI=0
                        DO 11100 J=ISTART,ISTART+K,NSTEP
                            SUMI=SUMI+C(I,J)
11100                   CONTINUE
                        SSAA=1+(SUMACR(I)-1)*CLIQUE
                        IF(SUMI.GE.SSAA) GOTO 11090
                        IF (MCQ.EQ.0) GOTO 11080
                        IF (TTYBAT.EQ.2) GOTO 11111
                        TYPE 11110,ISTART,
     $                   ID(INT(TEMP(ISTART))),
     $                   ISTART+K-NSTEP,
     $                   ID(INT(TEMP(ISTART+K-NSTEP)))
11111                   WRITE (6,11110) ISTART,
     $                   ID(INT(TEMP(ISTART))),
     $                   ISTART+K-NSTEP,
     $                   ID(INT(TEMP(ISTART+K-NSTEP)))
11110                   FORMAT ( ' CLIQUE   ',4(I8,'(',I3,')'))
                        NCLIQ=NCLIQ+1
                        GROUP1(NCLIQ)=ISTART
                        GROUP2(NCLIQ)=ISTART+K-NSTEP
                        ISTART=ISTART+K-NSTEP
                        GOTO 11060
11090                   CONTINUE
                        IF (MCQ.EQ.0) THEN
                            MCQ=1
                            KMCQ=K+ISTART
                        END IF
11080                CONTINUE
                     IF (MCQ.EQ.1) THEN
                      IF (TTYBAT.EQ.2) GOTO 11121
                      TYPE 11120,ISTART,ID(INT(TEMP(ISTART))),KMCQ,
     $                  ID(INT(TEMP(KMCQ))),N2,ID(INT(TEMP(N2)))
11121                 WRITE (6,11120) ISTART,ID(INT(TEMP(ISTART))),
     $                  KMCQ,ID(INT(TEMP(KMCQ))),N2,ID(INT(TEMP(N2)))
11120                 FORMAT ( ' CLIQUE   ',6(I8,'(',I3,')') )
                      NCLIQ=NCLIQ+1
                      GROUP1(NCLIQ)=ISTART
                      GROUP2(NCLIQ)=N2
                      ISTART=N2
                     END IF
11060           CONTINUE
C=====================================================================
C
C     PRINT-OUT NAMES IN CLIQUE-GROUPS IDENTIFIED
C
C=====================================================================
                DO 11130 I=1,NCLIQ
                    IF (TTYBAT.EQ.2) GOTO 11141
                    TYPE 11140,I
11141               WRITE (6,11140) I
11140               FORMAT( /' CLIQUE-',I2 )
                    IGST=GROUP1(I)
                    IGEN=GROUP2(I)
                    DO 11160 IG=IGST,IGEN,NSTEP
                    IF (TTYBAT.EQ.2) GOTO 11151
                   TYPE 11150,ABS(IG-IGST+NSTEP),ID(INT(TEMP(IG))),
     $                    NAME(INT(TEMP(IG)))
11151               WRITE (6,11150) ABS(IG-IGST+NSTEP),
     $                ID(INT(TEMP(IG))),NAME(INT(TEMP(IG)))
11150               FORMAT ( 9X,I3,2X,'ACTOR-',I3,2X,A20 )
                    IID=ID(INT(TEMP(IG)))
                    BELONG(KK,IID)=I
11160               CONTINUE
```

```
11130           CONTINUE
11030   CONTINUE
        DO 13000 I=1,NMAX
                DO 13010 K1=-4,30
                    DO 13020 K2=-4,30
                     IF((BELONG(1,I).EQ.K1).AND.(BELONG(2,I).EQ.K2))THEN
                        BELONG(3,I)=(K1+4)*30+K2+4
                     END IF
13020               CONTINUE
13010           CONTINUE
13000   CONTINUE
        IG=0
        WRITE(6,1)
        DO 14000 K=1,1225
                IF(K.EQ.31) GOTO 14000
                IF(K.EQ.62) GOTO 14000
                IF(K.EQ.93) GOTO 14000
                ITEMP=0
                DO 14010 I=1,NMAX
                        IF(BELONG(3,I).EQ.K) ITEMP=ITEMP+1
14010           CONTINUE
                IF(ITEMP.NE.0) THEN
                        IG=IG+1
                        TYPE 14020,IG,ITEMP
                        WRITE(6,14020) IG,ITEMP
14020                   FORMAT( ' GROUP-',I5,I10 )
                ELSE
                        GOTO 14000
                END IF
                DO 14030 I=1,NMAX
                        IF(BELONG(3,I).EQ.K)THEN
                                DO 15000 II=1,NID
                                        IF(I.EQ.ID(II)) THEN
                                                NAMAE=NAME(II)
                                                GOTO 15010
                                        END IF
15000                           CONTINUE
15010                           TYPE 14040,I,NAMAE
                                WRITE(6,14040) I,NAMAE
14040                           FORMAT (20X,I5,5X,A20)
                        END IF
14030           CONTINUE
14000   CONTINUE
        STOP
        END
```

C.6 List of Major Socio-Economic Characteristics of Villagers

As the results of the discussion between the village head of Belatung and the author, 153 village households were initially identified according to the landownership. However, some were living outside the village and did not utilise the land inside the village at all. In the process of the fieldwork, 118 village households were identifies as members of the village. For identifying these village households, the numbers from 1 to 153 were used, and are used throughout this study.

Villager	Characteristics
1	farmer from Lebuk Batang Lama
2	hired labourer for National Railway
3	National Railway worker
4	National Railway worker
5	National Railway worker
6	runs a very small grocery shop
7	National Railway worker
8	National Railway worker
9	section head of National Railway
10	primary school teacher
13	grocery shop owner
14	station official
15	only farmer who produces enough rice for his family and sells it
16	basically stays in Kota Bumi producing coffee
17	sharecropper of Director of Belatung station who lives in Lampung
18	native National Railway worker
19	National Railway worker
20	National Railway worker
21	native National Railway worker
22	National Railway worker
23	National Railway worker
24	National Railway worker
25	National Railway worker
29	ex-village head with innovative ideas, half retired and looked after by his son, teacher
30	village official but lives in Lekis East
31	Belatung primary school teacher
32	an elder looked after by his unmarried daughter
33	brother of Villager 34
34	dukun, traditional medical healer
35	two brothers and their mother
36	a member of Sebimbing Sekundang (rubber smallholder scheme)
37	Villager 36' son, newly built his house next to his father's
39	has a relative in Dinas Kehutanan (Forest Agency) in Palembang who sends agricultural information to him
40	entrepreneur, recently built a concrete/brick house
41	very successful Kota Bumi coffee farmer
42	entrepreneur, son-in-law of Villager 29
44	very lazy, works for his father-in-law, Villager 60

46	mechanic, bus driver
47	Kota Bumi coffee farmer
49	grocery shop owner
50	a household of a widow and her son
51	Kota Bumi coffee farmer
54	village official
55	
56	hard-working loner
57	usually stays at the farm on the opposite side of the Ogan
58	an elder
59	
60	wealthiest by reputation, used to have a grocery shop in the village, and bought many plots of land
61	widow
64	
65	son of Villager 64
66	an elder
67	
68	native National Railway worker, but almost always at farm and does not work for National Railway, he built a house in the village but has not finished
70	successful Coffee farmer in Lampung
71	religious teacher
72	
73	an elder, very poor
74	widow
76	principal of the village primary school
77	carpenter
78	part time but innovative farmer, army's civil official in Baturaja, appointed as village head of neighbouring village, Karta Mulya in April 1983
79	young entrepreneur often works for Villagers 49 & 128's shops
80	very poor, has sold almost all plots of land
81	son of Villager 29
82	
83	successful Kota Bumi coffee farmer
84	ex-village head
85	brother of Villager 91
86	pemborong, carpenter
87	
88	an old farmer from Karta Mulya, with no relatives
89	ex-village official for Villager 84, a nominal chairman of Sebimbing Sekundang (rubber smallholder scheme)
91	brother of Villager 85
92	active entrepreneur/farmer
93	
94	native National Railway senior worker, brother of Villager 14
95	brother of Villager 84
96	recently married to a daughter of Villager 80 and moved into Belatung
97	father stays in Belatung and son is a Kota Bumi coffee farmer
98	newly returned from Kota Bumi
100	half-retired, looked after by Villager 120
101	Villager 84's son-in-law
102	widow of very active entrepreneur/farmer
103	ex-religious teacher (died in July 1983)
104	active farmer in Lekis

106	Villager 94's son-in-law
108	notable trader/grower of citrus siam
109	
110	stays in Lekis area
111	grocery shop owner, formerly an itinerant merchant
112	teacher, son of Villager 71, religious teacher
113	his son-in-law is an extension worker of Dinas Perkebunan
114	recently started moved to his rubber smallholding and rarely appeared in the village
115	resident junior extension worker of Dinas Perkebunan
116	
117	Villager 148's son
120	village official, grocery shop owner
121	very active and political entrepreneur/farmer
122	recently moved into a house in the middle of the village
124	National Railway worker
125	sick but National Railway worker
126	owns a bus, driver himself
127	occasional carpenter
128	grocery shop owner, entrepreneur, plans to produce banana commercially
129	retired soldier
130	village head, pioneer of citrus siam
132	lives in Talang Kisam
134	lives in Talang Kisam, lumbering
135	lives in Talang Kisam, lumbering
139	lives in Lekis, very lazy, tries to run a grocery shop for villagers in Lekis area
140	lives in Lekis
148	brother of Villager 100, coffee farmer in Kota Bumi, too
149	active entrepreneur/farmer
150	National Railway worker
151	lives in Lekis East
153	widow of section head of National Railway, works as vendor for National Railway workers

Appendix D

Appendix to Chapter 4

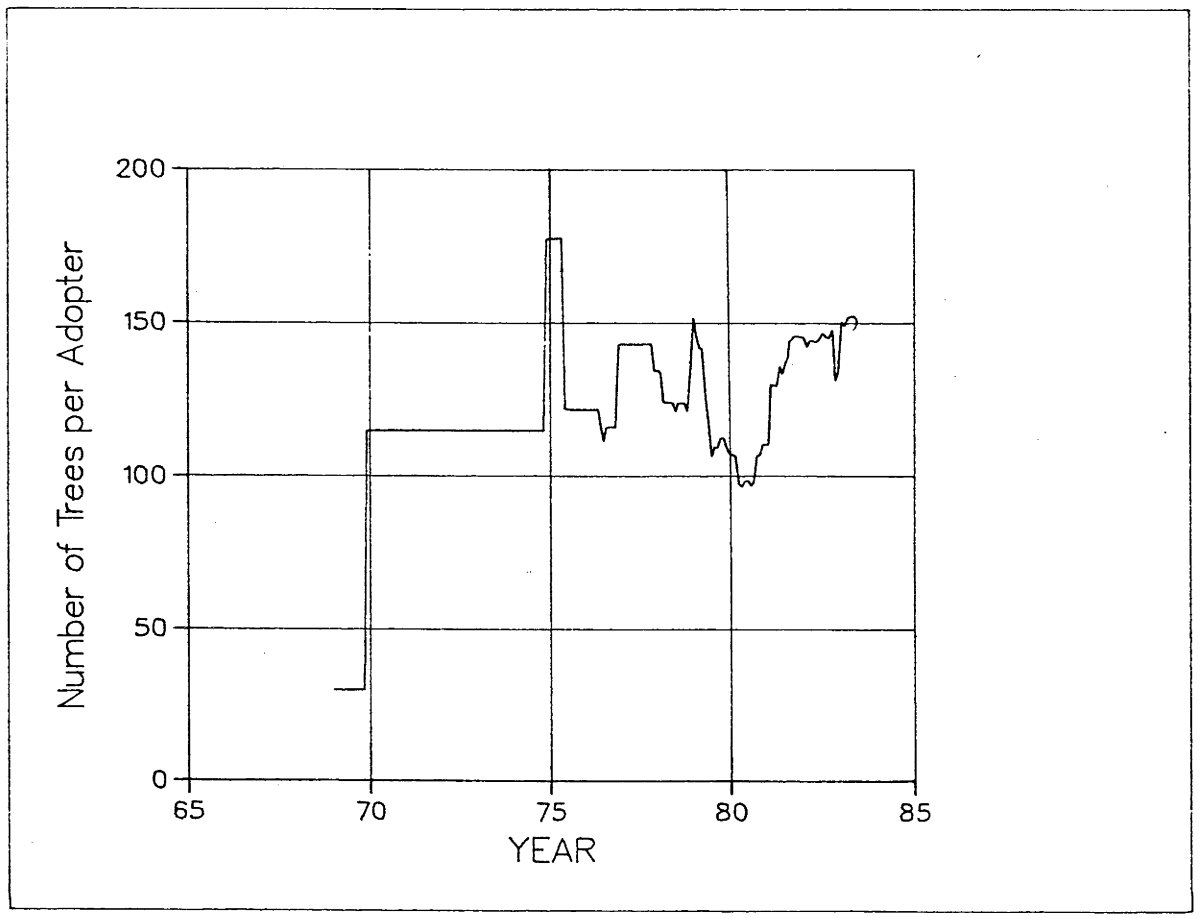
D.1 Average Number of Trees per Adopter

See Figure D-1

D.2 Derivation of Consumer Price Index

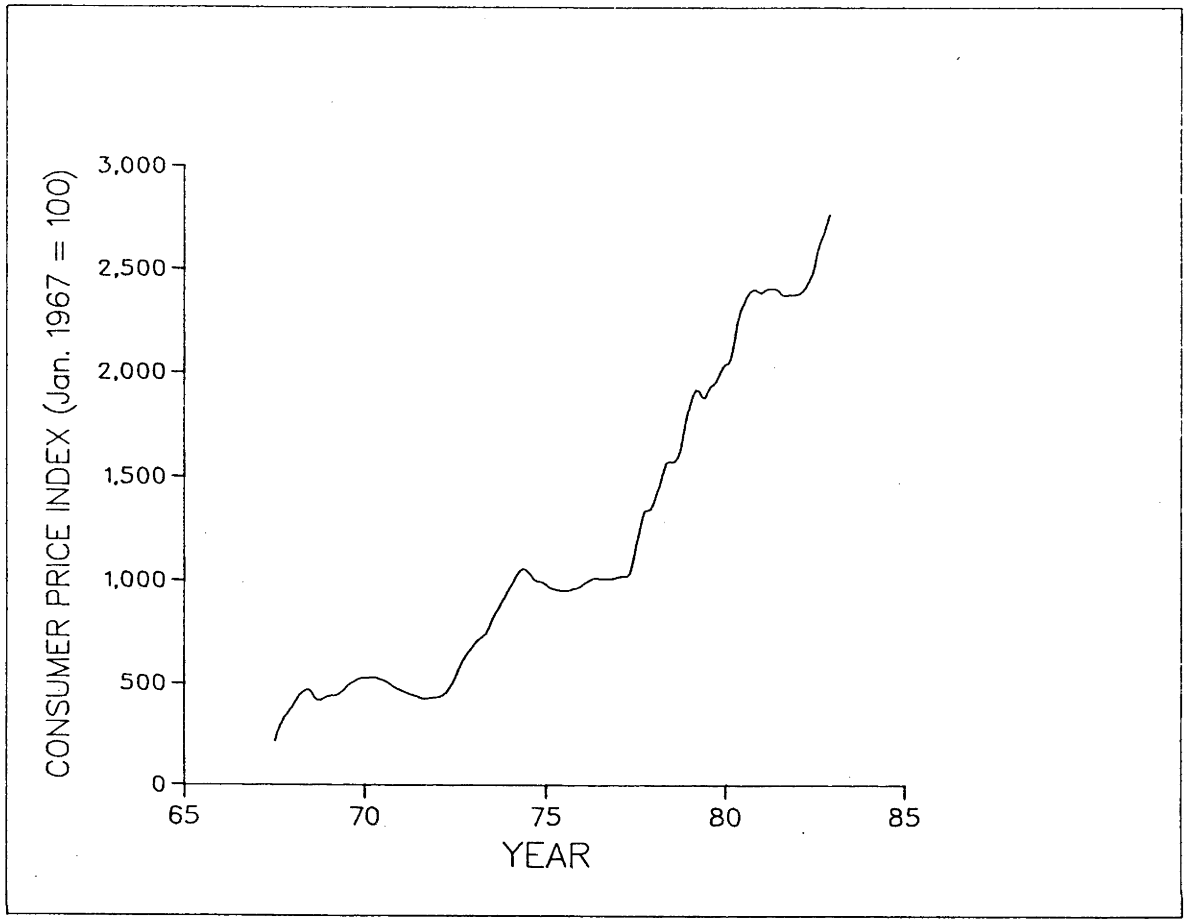
With Matroni's (n.d.) price data of numerous commodities traded at Baturaja markets between 1967 and 1980, and official data between 1981 and mid-1983, the consumer price index was calculated monthly by the Laspeyres method. Weights used in the calculation are shown in Table 2-2. Table D-2 shows seasonally adjusted consumer price index in Baturaja.

Figure D-1: Average Number of Trees per Adopter



Source:
Fieldwork.
Figures 4-3 and 4-4.

Figure D-2: Consumer Price Index in Baturaja



Source:
Matroni (n.d.)
Expenditure compositions based on household expenditure data collected during the fieldwork (Table 2-2).

Appendix E

Mathematical Appendix to Chapter 5

E.1 Mathematical Notations

c_i	Villager i's certainty equivalent (scalar).
$COV^i(\ )$	Villager i's covariance operator.
$E^i(\ )$	Villager i's expectation operator.
F_i	Substitute for $\int u'(X_i)/X_i\ dX_i$.
f	Function which relates scale of adoption, I_i, or time of adoption, to risk-premium and socio-economic characteristics.
f_k	The first order derivative of the function f with respect of its k-th argument.
grad(G)	Gradient of function G.
I_i	Villager i's scale of adoption.
I_i^*	Villager i's scale of adoption which correspond with P_i^*.
l_{ji}	Interdependence coefficient, which indicates Villager i's interdependence with Villager j ($j \neq i$).
l_{ii}	Villager i's interdependence coefficient with respect to himself. Especially called Villager i's independence coefficient.
m	Number of individualistic socio-economic characteristics.
n	Number of villagers in the system.
$P_i = PREMIUM_i$	Villager i's risk-premium.
P_i^*	Villager i's minimum risk-premium.
Q_{ik}	Villager i's interdependence expectation index with respect to Villager k, i.e., the ratio of covariance between Villager i's expected income distribution and Villager k's expected income distribution expected by Villager i to the variance of Villager i's expected income distribution.

Q_i	Villager i's interdependence expectation index, weighted average of Q_{ik} ($k \neq i$), IE index.
ρ_i^R	Villager i's Arrow-Pratt individualistic relative risk-aversion index.
S_i	Subjective relative income level of Villager i.
σ_{ii}^i	Variance of Villager i's expected income distribution.
σ_{ij}^i	Co-variance between Villager i's expected income distribution and Villager j's income distribution, expected by Villager i.
Σ^i	A variance-covariance matrix of Villager i's expectations of all villagers' income levels.
trace(M)	Trace of matrix M, sum of diagonal elements of matrix M.
$u_i = u(X_i)$	Villager i's independent utility function.
$u'_i = u'(X_i)$	Villager i's independent marginal utility function.
$u''_i = u''(X_i)$	The second-order derivative of Villager i's independent utility function.
U^i	Utility level of Villager i.
V^i	Villager i's utility function, which depends on his income level, X_i, as the first argument, and his subjective relative income level, S_i, as the second argument.
V_1^i	Villager i's marginal utility function with respect to the first argument.
V_{11}^i	The second-order derivative of Villager i's utility function with respect to the first argument.
V_2^i	Villager i's marginal utility function with respect to the second argument.
V_{22}^i	The second-order derivative of Villager i's utility function with respect to the second argument.
V_{12}^i	The second-order derivative of Villager i's utility function with respect to the first and second arguments.
$VAR^i(\ )$	Villager i's variance operator.
W^i	Villager i's interdependence utility function which depends all villagers' income levels, X_j ($j = 1,2,...,n$).
W_i^i	Villager i's interdependence marginal utility function with respect to his own income.

W^i_{ii} The second-order derivative of Villager i's interdependence utility with respect to his own income.

W^i_j Villager i's interdependence marginal utility function with respect to Villager j.

W^i_{jj} The second-order derivative of Villager i's interdependence utility with respect to Villager j's income level.

W^i_{ij} The second-order derivative of Villager i's interdependence utility with respect to Villager i's income level and Villager j's income level.

ω_{ij} Villager i's interdependence weight with respect to Villager j.

ω_{ii} Villager i's independence weight with respect to Villager i himself.

X_i Income level of Villager i. After page 212, this simply represents his present income level.

X^0_i Present income level of Villager i especially before page 212.

$\tilde{X}_i$ Villager i's subjective average social (village) income level.

X^t Transpose of vector X.

$\bar{X}^i_i$ Villager i's expected income level.

$\bar{X}^i_k$ Villager k's expected income level, expected by Villager i.

$\mathbf{Y}$ Certainty equivalent vector.

$\mathbf{Z}^i$ A matrix of second-order partial derivatives of Villager i's interdependence utility function, W^i, with respect to all villagers' income levels.

Z_{ik} Villager i's k-th individualistic socio-economic characteristic (k=1,2,...,m).

E.2 Two Other Scenarios of Interdependence Risk-Premium

Suppose he receives a windfall gain with certainty while he expects others also receive the same amount of windfalls irrespective to the expected income levels of others. He thinks that windfalls are equally distributed among others including himself. Hence

$$\mathbf{Y} = (P, P, \ldots, P)^t. \tag{E.1}$$

Suppose he has a windfall gain with certainty while he expects others also receive windfalls, the amounts of which are proportionate to their expected income levels, like the situation where the weather often affects all villagers' production in proportionate to the size of land. This scenario sounds a little arbitrary, but Malinvaud's (1971) "directional risk-premium" assumption in a multi-commodity utility function framework is equivalent to this scenario. Malinvaud (1971) and Kihlstrom and Mirman (1974) used the "directional risk-premium" assumption and derived two different risk-aversion indices. Kihlstrom and Mirman's index is not applicable to a utility function which is not strictly concave. Malinvaud's index can be applied to any type of utility function. Person i's certainty equivalent vector in this scenario is

$$\mathbf{Y} = (\,1 - R\,)\,(\bar{X}^i_1, \bar{X}^i_2, \ldots, \bar{X}^i_n)^t, \tag{E.2}$$

where R is called "risk-premium rate".

In the same vein as Malinvaud's naming of this scenario, the first scenario can be named the "uni-directional risk-premium" and the second one the "equi-directional risk-premium". In the following analysis, the "uni-directional risk-premium" and "directional risk-premium" are investigated.

Appendix F

Appendix to Chapter 6

F.1 Network Autocorrelation

Erbring and Young (1979) considered several types of contextual effects and developed two models: (1) the endogenous feedback model, in which the dependent variable is assumed to be interdependent, and (2) the network disturbance model in which error terms are assumed to be interdependent with each other.

The network disturbance model has the following formulation, with a non-limited dependent variable, Y, and explanatory variables (vector), X,

$$Y = X\beta + \epsilon \qquad (F.1)$$

$$\epsilon = \rho W\epsilon + \nu \qquad \nu \approx N(0,\sigma_\nu^2 I)$$

where ϵ is a n-dimensional column vector of error terms, a scalar ρ is an autocorrelation parameter analogous to a correlation coefficient, and W is the interdependence coefficient matrix. The elements of W are row-normalised. ν is a n-dimensional column vector of error terms which has a normal distribution with its average zero and its variance σ_ν^2I, where I is a n x n identity matrix. This model was used by White, Burton and Dow (1981) for their study of the sexual division of labour in African agriculture.

With this reformulation, true coefficients can be derived from the following equation with an appropriate regression method.

$$(I - \rho W)Y = (I - \rho W)X\beta + \nu, \quad \nu \approx N(0,\sigma_\nu^2 I) \qquad (F.2)$$

Transforming (I – ρW)Y to Y^* and (I – ρW)X to X^*, the OLS method can be used to estimate β with an appropriate value of ρ given. In order to estimate β and ρ simultaneously, at least a maximum likelihood method must be used. Dow et al. (1984)

found two problems associated with this network autocorrelation model: (1) construction of a plausible interdependence coefficient matrix W and (2) estimation of the autocorrelation parameter ρ. The first problem has already been solved by using the interdependence coefficient matrix elicited in Chapter 3. Secondly, if there is no autocorrelation, i.e., $\rho = 0$, this regression is identical to the first equation in Equation (F.1) of the original regression model, and the OLS method can be used. However, if there is autocorrelation, the network disturbances model has special statistical properties that the OLS method lacks. First, although the OLS estimates of regression coefficients are unbiased, they are more highly dispersed around the true population parameters than the ML (maximum likelihood) estimates. Second, the OLS estimates of the sampling variances of the regression coefficients will generally underestimate the true variance. Hence, with respect to estimates, underestimating the variances of the regression coefficients will lead to exaggerated attributions of significance to particular independent variables.

The appropriate estimation procedure has not been established for this problem, although several network statisticians have developed a maximum likelihood method (ML)[1], an iterative generalised least square (IGLS)[2] and an iterative residual regression method (IRR)[3] for non-limited dependent variable models.

---

[1]Ord (1975), Doreian (1980) and Cliff and Ord (1981)

[2]Ord (1975) and Bodson and Peeters (1975)

[3]Bodson and Peeters (1975)

F.2 Monte-Carlo method to test the Cancian Dip

In order to statistically test the following hypothesis for the existence of the Cancian Dip:[4]

$$D^2 = a_2^2 - 3\,a_1\,a_3 > 0 \quad and \quad a_3 > 0$$

where

a_1: coefficient for the first order polynomial

a_2: coefficient for the second order polynomial

a_3: coefficient for the third order polynomial

a simple statistical testing method available in statistics textbooks cannot be used. A method based on the Monte Carlo method and some matrix manipulations has been newly formulated by the author.

The procedure is as follows:

1. Create three standardised unit sets of random numbers.
2. Transform them to non-correlated sets of random numbers.
3. Transform them again to sets of random numbers which are correlated in the manner indicated by the correlation matrix derived from the estimation procedure of the above coefficients (CV option of Tobit analysis in the SHAZAM creates a variance-covariance matrix of the coefficients).
4. Calculate D^2 from these correlated random numbers and count incidences of $D^2 > 0$ and $a_3 > 0$, then calculate the significance level.

The procedure is now explained in detail.

---

[4] If a dependent variable Y_i and explanatory variable X_i are assumed to have the following cubic relationship,

$$Y_i = a_3 X_i^3 + a_2 X_i^2 + a_1 X_i + a_0$$

for this to have a Cancian Dip, the following derivative, Y_i', should have two real roots.

$$Y_i' = 3a_3 X_i^2 + 2a_2 X_i + a_1 = 0.$$

Therefore

$$D^2 = 4(a_2^2 - 3a_1 a_3) > 0.$$

Step 1

Three sets of random numbers which are uniformly distributed between 0 and 1 are calculated, and this is repeated ten times to make sums of these random numbers. By dividing the sums by ten, three sets of approximately normally distributed random numbers are secured. These are standardised to get normally distributed random numbers with their averages being zero and their standard deviations one. Then a correlation matrix of these random numbers is constructed. The correlation matrix is

$$\Sigma_x = \begin{bmatrix} 1 & \rho_{12} & \rho_{13} \\ \rho_{12} & 1 & \rho_{23} \\ \rho_{13} & \rho_{23} & 1 \end{bmatrix} = X\,X^t$$

where X is a 3 x n matrix of three sets of random numbers (n is the number of observations, set arbitrarily set, for example, at 1000). Due to the definition of these random numbers, the correlation matrix is a real symmetric matrix.

Step 2

Since the correlation matrix is a real symmetric one, there exists an orthogonal matrix, P, which can produce a diagonal matrix, A, from the correlation matrix.

$$A = P^t\,\Sigma_x\,P$$

where

$$P\,P^t = I$$

The orthogonal matrix, P, consists of eigen vectors (column vectors) of the correlation matrix, Σ_x. Let a standardised eigen vector which corresponds with the i-th eigen value of the correlation matrix, Y_i. Therefore, the orthogonal matrix, P, is

$$P = (\,Y_1, Y_2, Y_3\,)$$

With this orthogonal matrix, P, a 3 x n matrix of completely independent random numbers, X', can be created from the original matrix of random numbers, X, by

$$X' = P^t X$$

Step 3

For testing the hypothesis which involves three random numbers which are correlated to a certain degree, these independent random numbers created above must be modified into correlated random numbers.

Let R be a correlation matrix of three coefficients

$$R = \begin{bmatrix} 1 & \rho_{12} & \rho_{13} \\ \rho_{12} & 1 & \rho_{23} \\ \rho_{13} & \rho_{23} & 1 \end{bmatrix}$$

and B be a matrix, each column of which is an eigen vector of the correlation matrix R.

Suppose a 3 x 3 matrix Q which satisfies

$$Z = Q\ X'$$

where Z is a 3 x n matrix of standardised vectors of three random numbers each of which is correlated with others in the manner shown in the correlation matrix, R. Therefore, the correlation matrix can be written as follows:

$$R = Z\ Z^t = Q\ X'\ (Q\ X')^t = Q\ X'\ X'^t\ Q^t = Q\ Q^t$$

for X' has already been standardised ($X'\ X'^t = I$).

On the other hand, there are the following relationship between (1) B, the matrix of eigen vectors of R, which is an orthogonal matrix, and (2) Λ, a diagonal matrix of eigen values:

$$R\ B = B\ \Lambda, \quad and \quad B\ B^t = I,$$

therefore,

$$R = R\ B\ B^{-1} = B\ \Lambda\ B^{-1} = B\ \Lambda\ B^t$$

and

$$Q\,Q^t = B\,\Lambda\,B^t = B\,\Lambda^{1/2}\,\Lambda^{1/2}\,B^t$$

$$= B\,\Lambda^{1/2}\,(\,B\,\Lambda^{1/2}\,)^t$$

where $\Lambda^{1/2}$ is a diagonal matrix of square roots of the eigen values. Then,

$$Q = B\,\Lambda^{1/2}.$$

With this matrix Q, random numbers which correlate with each other in the certain manner indicated by the correlation matrix R can be created.

Step 4

From these new sets of designed random numbers, the values of $D^2 = a_2^2 - 3\,a_1\,a_3$ are calculated, co-occurrences of $D^2 > 0$ and $a_3 > 0$ are counted. As usual, 5 percent level is taken for the criterion.

The whole procedure is conducted by the FORTRAN programme called CHECK.FOR created by the author, and the programme is shown in the next section.

F.3 FORTRAN programme CHECK.FOR

```
C=====================================================================
C     EXISTENCE OF CANCIAN DIP
C     ------------------------
C
C     STATISTICAL SIGNIFICANCE OF NON LINEAR COMBINATION OF
C     THREE REGRESSION-COEFFICIENTS BY A MONTE-CARLO METHOD
C
C       X1: COEFFICIENT OF 1-ST ORDER
C       X2: COEFFICIENT OF 2-ND ORDER
C       X3: COEFFICIENT OF 3-RD ORDER
C
C       HYPOTHESIS: X2*X2-3*X1*X3 > 0 AND X3 > 0
C
C       CREATED BY YOICHIRO HIGUCHI
C       23 SEPTEMBER 1985
C       ECONOMICS RSPacS AUSTRALIAN NATIONAL UNIVERSITY
C=====================================================================
        PARAMETER NMAX=1000
        DOUBLE PRECISION X1(NMAX),X2(NMAX),X3(NMAX),TEST(NMAX),U(3,3),
     $          LAMDA1,LAMDA2,LAMDA3,COV12,COV13,COV23,
     $  SD1,SD2,SD3,C1,C2,C3,RAVE,RSD,RMAX,RMIN,CX1,CX2,CX3,
     $  SUMX1,SUMX2,SUMX3,COR12,COR13,COR23
        N=NMAX
C---------------------------------------------------------------------
C     INPUTS
C---------------------------------------------------------------------
        TYPE 200
200     FORMAT( ' REGRESSION-COEFFICIENT 1            = ', $ )
        ACCEPT *,COEFF1
        TYPE 2001
2001    FORMAT( ' T-RATIO OF REGRESSION-COEFFICIENT 1 = ', $ )
        ACCEPT *,T1
        TYPE 201
201     FORMAT( ' REGRESSION-COEFFICIENT 2            = ', $ )
        ACCEPT *,COEFF2
        TYPE 2002
2002    FORMAT( ' T-RATIO OF REGRESSION-COEFFICIENT 2 = ', $ )
        ACCEPT *,T2
        TYPE 2011
2011    FORMAT( ' REGRESSION-COEFFICIENT 3            = ', $ )
        ACCEPT *,COEFF3
        TYPE 2003
2003    FORMAT( ' T-RATIO OF REGRESSION-COEFFICIENT 3 = ', $ )
        ACCEPT *,T3
        TYPE 202
202     FORMAT( ' VALUE TO BE TESTED                  = ', $ )
        ACCEPT *,TESTRA

        TYPE 601
601     FORMAT( ' CORRELATION BETWEEN COEFFICIENTS 1 & 2 = ',$ )
        ACCEPT *,COR12
        TYPE 611
611     FORMAT( ' CORRELATION BETWEEN COEFFICIENTS 1 & 3 = ',$ )
        ACCEPT *,COR13
        TYPE 62
62      FORMAT( ' CORRELATION BETWEEN COEFFICIENTS 2 & 3 = ',$ )
        ACCEPT *,COR23
C---------------------------------------------------------------------
C     ITERATIONS 10 TIMES
C---------------------------------------------------------------------
        DO 1 KK=1,10
```

```
        ISEED=NMAX*(KK-1)
        TYPE 501,ISEED
501     FORMAT ( ' RANDOM SEED (INTEGER) = ',I7)
        DO 90 I=1,SEED
                R=RANS(1)
90      CONTINUE
C-----------------------------------------------------------------------
C     CREATE NORMAL UNIT RANDOM NUMBERS N(0,1)
C-----------------------------------------------------------------------
        DO 100 I=1,N
                X1(I)=0
                X2(I)=0
                X3(I)=0
                DO 120 J=1,10
                        X1(I)=X1(I)+RANS(0)
                        X2(I)=X2(I)+RANS(1)
                        X3(I)=X3(I)+RANS(2)
120             CONTINUE
                X1(I)=X1(I)/10
                X2(I)=X2(I)/10
                X3(I)=X3(I)/10
100     CONTINUE
C-----------------------------------------------------------------------
C     CHECK CORRELATIONS AMONG RANDOM NUMBERS
C-----------------------------------------------------------------------
        CALL STAND(X1,X2,X3,N,COV12,COV13,COV23)

C-----------------------------------------------------------------------
C     CONVERT THEM TO NON-CORRELATED RANDOM NUMBERS
C       AND TEST NON-CORRELATIONS
C-----------------------------------------------------------------------
        CALL EIGEN(COV12,COV13,COV23,U,LAMDA1,LAMDA2,LAMDA3)

        CALL TEST1(COV12,COV13,COV23,U)

        DO 110 I=1,N
                D1=X1(I)*U(1,1)+X2(I)*U(2,1)+X3(I)*U(3,1)
                D2=X1(I)*U(1,2)+X2(I)*U(2,2)+X3(I)*U(3,2)
                D3=X1(I)*U(1,3)+X2(I)*U(2,3)+X3(I)*U(3,3)
                X1(I)=D1
                X2(I)=D2
                X3(I)=D3
110     CONTINUE

        CALL STAND(X1,X2,X3,N,COV12,COV13,COV23)

        TYPE *,' FINISHED MAKING NON-CORRELATED RANDOM VARIABLES'
C-----------------------------------------------------------------------
C     CONVERT NON-CORRELATED RANDOM NUMBERS TO CORRELATED
C       RANDOM NUMBERS
C-----------------------------------------------------------------------
        TYPE *,'CONVERT NON-CORRELATED RANDOMS TO CORRELATED RANDOMS'

        CALL EIGEN(COR12,COR13,COR23,U,LAMDA1,LAMDA2,LAMDA3)

        CALL TEST2(COR12,COR13,COR23,U,LAMDA1,LAMDA2,LAMDA3)

        U(1,1)=U(1,1)*DSQRT(LAMDA1)
        U(1,2)=U(1,2)*DSQRT(LAMDA2)
        U(1,3)=U(1,3)*DSQRT(LAMDA3)
        U(2,1)=U(2,1)*DSQRT(LAMDA1)
        U(2,2)=U(2,2)*DSQRT(LAMDA2)
        U(2,3)=U(2,3)*DSQRT(LAMDA3)
```

```
        U(3,1)=U(3,1)*DSQRT(LAMDA1)
        U(3,2)=U(3,2)*DSQRT(LAMDA2)
        U(3,3)=U(3,3)*DSQRT(LAMDA3)
        DO 111 I=1,N
                D1=X1(I)*U(1,1)+X2(I)*U(1,2)+X3(I)*U(1,3)
                D2=X1(I)*U(2,1)+X2(I)*U(2,2)+X3(I)*U(2,3)
                D3=X1(I)*U(3,1)+X2(I)*U(3,2)+X3(I)*U(3,3)
                X1(I)=D1
                X2(I)=D2
                X3(I)=D3
111     CONTINUE

        CALL STAND(X1,X2,X3,N,COV12,COV13,COV23)

        TYPE *,' FINISHED MAKING CORRELATED RANDOMS'
C-----------------------------------------------------------------------
C     CALCULATE THE VALUES TO BE TESTED
C-----------------------------------------------------------------------
        TYPE *,' START CALCULATING THE VALUES TO BE TESTED'
        SD1=ABS(COEFF1/T1)
        SD2=ABS(COEFF2/T2)
        SD3=ABS(COEFF3/T3)
        C1=0
        C2=0
        C3=0
        RAVE=0
        RSD=0
        RMAX=0
        RMIN=0
        CX1=0
        CX2=0
        CX3=0
        SUMX1=0
        SUMX2=0
        SUMX3=0
        DO 215 I=1,N
                X1(I)=X1(I)*SD1+COEFF1
                X2(I)=X2(I)*SD2+COEFF2
                X3(I)=X3(I)*SD3+COEFF3
                SUMX1=SUMX1+X1(I)
                SUMX2=SUMX2+X2(I)
                SUMX3=SUMX3+X3(I)
215     CONTINUE
        AVEX1=SUMX1/N
        AVEX2=SUMX2/N
        AVEX3=SUMX3/N
        V1=0
        V2=0
        V3=0
        COV12=0
        COV13=0
        COV23=0
        DO 216 I=1,N
                V1=V1+(X1(I)-AVEX1)**2
                V2=V2+(X2(I)-AVEX2)**2
                V3=V3+(X3(I)-AVEX3)**2
                COV12=COV12+(X1(I)-AVEX1)*(X2(I)-AVEX2)
                COV13=COV13+(X1(I)-AVEX1)*(X3(I)-AVEX3)
                COV23=COV23+(X2(I)-AVEX2)*(X3(I)-AVEX3)
216     CONTINUE
        V1=V1/(N-1)
        V2=V2/(N-1)
        V3=V3/(N-1)
```

```
        COV12=COV12/(N-1)
        COV13=COV13/(N-1)
        COV23=COV23/(N-1)
        R12=COV12/SQRT(V1*V2)
        R13=COV13/SQRT(V1*V3)
        R23=COV23/SQRT(V2*V3)
        TYPE 217,V1,V2,V3,COV12,COV13,COV23,R12,R13,R23
217     FORMAT(1X,' VARIANCE OF BETA-1 = ',G15.6/
     $         1X,' VARIANCE OF BETA-2 = ',G15.6/
     $         1X,' VARIANCE OF BETA-3 = ',G15.6/
     $         1X,' COVARIANCE 1 & 2   = ',G15.6/
     $         1X,' COVARIANCE 1 & 3   = ',G15.6/
     $         1X,' COVARIANCE 2 & 3   = ',G15.6/
     $         1X,' CORRELATION COEFF. 1 & 2 = ',G15.6/
     $         1X,' CORRELATION COEFF. 1 & 3 = ',G15.6/
     $         1X,' CORRELATION COEFF. 2 & 3 = ',G15.6)
5555    DO 220 I=1,N
                IF(COEFF1.GE.0) THEN
                        IF(X1(I).LT.0) CX1=CX1+1
                ELSE
                        IF(X1(I).GT.0) CX1=CX1+1
                END IF
                IF(COEFF2.GE.0) THEN
                        IF(X2(I).LT.0) CX2=CX2+1
                ELSE
                        IF(X2(I).GT.0) CX2=CX2+1
                END IF
                IF(COEFF3.GE.0) THEN
                        IF(X3(I).LT.0) CX3=CX3+1
                ELSE
                        IF(X3(I).GT.0) CX3=CX3+1
                END IF
C-------------------------------------------------------
C--HYPOTHESIS TO BE TESTED-----------------------------
                TEST(I)=X2(I)*X2(I)-3.*X1(I)*X3(I)
                IF((TEST(I).GT.TESTRA).AND.(X3(I).GT.0)) C2=C2+1
C-------------------------------------------------------
C-------------------------------------------------------
                IF(RMAX.LT.TEST(I)) RMAX=TEST(I)
                IF(RMIN.GT.TEST(I)) RMIN=TEST(I)
                RAVE=RAVE+TEST(I)
                RSD=RSD+TEST(I)*TEST(I)
220     CONTINUE
        TYPE  230,T1,2*CX1/N*100,T2,2*CX2/N*100,T3,2*CX3/N*100
230     FORMAT(1X,'COEFFICIENT-1 T-RATIO = ',G15.6,' %  = ',G15.6/
     $         1X,'COEFFICIENT-2 T-RATIO = ',G15.6,' %  = ',G15.6/
     $         1X,'COEFFICIENT-3 T-RATIO = ',G15.6,' %  = ',G15.6)
5556    RAVE=RAVE/N
        RSD=SQRT((RSD-N*RAVE*RAVE)/(N-1))
        TYPE 400,RAVE,RSD,RMIN,RMAX
400     FORMAT( ' AVERAGE VALUE =',G15.6/
     $          ' SD            =',G15.6/
     $          ' MIN           =',G15.6/
     $          ' MAX           =',G15.6)
5557    C2=C2/N*100
        TYPE 300,KK,TESTRA,C2
        WRITE (6,300)KK,TESTRA,C2
300     FORMAT(1X,'ITERATION NO.',I3,'  COMBINED PROB: (D-SQUARE > ',
     $  F5.2,' AND X3 > 0 ) =',F10.4,'%')
C-----------------------------------------------------------------
C     ITERATION ENDS
C-----------------------------------------------------------------
1       CONTINUE
```

```
999     STOP
        END
C-----------------------------------------------------------------------
C     SUBROUTINE FOR STANDARDISATION OF RANDOM NUMBERS
C-----------------------------------------------------------------------
        SUBROUTINE STAND(XX1,XX2,XX3,N,CR12,CR13,CR23)
        DOUBLE PRECISION XX1(N),XX2(N),XX3(N),CR12,CR13,CR23,
     $          SUMX1,SUMX2,SUMX3,SDX1,SDX2,SDX3,AVEX1,AVEX2,AVEX3
        SUMX1=0
        SUMX2=0
        SUMX3=0
        SDX1=0
        SDX2=0
        SDX3=0
        DO 140 I=1,N
                SUMX1=SUMX1+XX1(I)
                SUMX2=SUMX2+XX2(I)
                SUMX3=SUMX3+XX3(I)
                SDX1=SDX1+XX1(I)*XX1(I)
                SDX2=SDX2+XX2(I)*XX2(I)
                SDX3=SDX3+XX3(I)*XX3(I)
140     CONTINUE
        AVEX1=SUMX1/N
        AVEX2=SUMX2/N
        AVEX3=SUMX3/N
        SDX1=SDX1-N*AVEX1*AVEX1
        SDX2=SDX2-N*AVEX2*AVEX2
        SDX3=SDX3-N*AVEX3*AVEX3
        SDX1=SQRT(SDX1/(N-1))
        SDX2=SQRT(SDX2/(N-1))
        SDX3=SQRT(SDX3/(N-1))
        DO 180 I=1,N
                XX1(I)=(XX1(I)-AVEX1)/SDX1
                XX2(I)=(XX2(I)-AVEX2)/SDX2
                XX3(I)=(XX3(I)-AVEX3)/SDX3
180     CONTINUE
        CR12=0
        CR13=0
        CR23=0
        DO 181 I=1,N
                CR12=CR12+XX1(I)*XX2(I)
                CR13=CR13+XX1(I)*XX3(I)
                CR23=CR23+XX2(I)*XX3(I)
181     CONTINUE
        CR12=CR12/(N-1)
        CR13=CR13/(N-1)
        CR23=CR23/(N-1)
        TYPE 182,CR12
182     FORMAT( ' CORRELATION BETWEEN RANDOM1 & 2 =',F10.8)
        TYPE 183,CR13
183     FORMAT( ' CORRELATION BETWEEN RANDOM1 & 3 =',F10.8)
        TYPE 184,CR23
184     FORMAT( ' CORRELATION BETWEEN RANDOM2 & 3 =',F10.8)
        TYPE *,' END OF SUBROUTINE STAND(STANDARDISATION)'
5558    RETURN
        END
C-----------------------------------------------------------------------
C     SUBROUTINE FOR CALCULATION OF EIGEN VALUES AND EIGEN VECTORS
C       ---REAL SYMMETRIC MATRIX
C-----------------------------------------------------------------------
        SUBROUTINE EIGEN(CR12,CR13,CR23,UU,L1,L2,L3)
        DOUBLE PRECISION A(3,3),UU(3,3),L1,L2,L3,
     $          CR12,CR13,CR23,EPS,AMAX,W,A1,A2,A3,
```

```
$           T,Z,ZZ,C,S,AW,AZ,ASC2
      A(1,1)=1
      A(2,2)=1
      A(3,3)=1
      A(1,2)=CR12
      A(1,3)=CR13
      A(2,1)=CR12
      A(2,3)=CR23
      A(3,1)=CR13
      A(3,2)=CR23
      EPS=0.000000001
      DO 10 I=1,3
              DO 11 J=1,3
                      UU(I,J)=0.0
11            CONTINUE
              UU(I,I)=1.0
10    CONTINUE
      N1=3-1
      KOUT=0
20    AMAX=0
      DO 25 I=1,N1
              I1=I+1
              DO 24 J=I1,3
                      W=ABS(A(I,J))
                      IF(AMAX-W) 23,24,24
23                    AMAX=W
                      K=I
                      L=J
24            CONTINUE
25    CONTINUE
      IF(EPS-AMAX) 40,50,50
40    KOUT=KOUT+1
      A1=A(K,K)
      A2=A(L,L)
      A3=A(K,L)
      W=(A1-A2)*0.5
      IF(ABS(W)-AMAX) 42,41,41
41    W=A3/W
      T=W/(SQRT(W*W+1.0)+1.0)
      GOTO 45
42    W=W/A3
      Z=SIGN(SQRT(W*W+1.0),W)+W
      T=1.0/Z
45    ZZ=T*T+1.0
      C=SQRT(1.0/ZZ)
      S=T*C
      DO 55 I=1,3
              AW=UU(I,K)
              AZ=UU(I,L)
              UU(I,K)=AW*C+AZ*S
              UU(I,L)=-AW*S+AZ*C
              IF(I-K) 53,55,53
53            IF(I-L) 54,55,54
54            AW=A(I,K)
              AZ=A(I,L)
              A(I,K)=AW*C+AZ*S
              A(I,L)=-AW*S+AZ*C
              A(K,I)=A(I,K)
              A(L,I)=A(I,L)
55    CONTINUE
      ASC2=2.0*A3*S*C
      A(K,K)=A1*C**2+A2*S**2+ASC2
      A(L,L)=A1*S**2+A2*C**2-ASC2
```

```
        A(K,L)=0
        A(L,K)=0
        GOTO 20
50      TYPE *,'EIGEN VALUES'
        TYPE 60,(I,A(I,I),I=1,3)
60      FORMAT(1H ,6HLAMDA(,I2,2H)=,F13.9)
        L1=A(1,1)
        L2=A(2,2)
        L3=A(3,3)
        TYPE *,'EIGEN VECTORS'
        TYPE 61,(J,(UU(I,J),I=1,3),J=1,3)
61      FORMAT(1H ,2HX(,I2,2H)=,3F13.9)
        TYPE *,'NUMBER OF ITERATIONS = ',KOUT
        TYPE *,'END OF SUBROUTINE EIGEN'
5559    RETURN
        END
C-----------------------------------------------------------------------
C     SUBROUTINE FOR TESTING MATRIX MANIPULATION - 1
C-----------------------------------------------------------------------
        SUBROUTINE TEST1(CR12,CR13,CR23,UU)
        DOUBLE PRECISION A(3,3),UU(3,3),B(3,3),C(3,3)
        A(1,1)=1
        A(2,2)=1
        A(3,3)=1
        A(1,2)=CR12
        A(1,3)=CR13
        A(2,1)=CR12
        A(2,3)=CR23
        A(3,1)=CR13
        A(3,2)=CR23
        DO 10 I=1,3
        DO 10 J=1,3
        B(I,J)=0
        DO 10 K=1,3
                B(I,J)=B(I,J)+A(I,K)*UU(K,J)
10      CONTINUE
        DO 20 I=1,3
        DO 20 J=1,3
        C(I,J)=0
        DO 20 K=1,3
                C(I,J)=C(I,J)+UU(K,I)*B(K,J)
20      CONTINUE
        TYPE 30,((C(I,J),J=1,3),I=1,3)
30      FORMAT(1X,3F10.6)
        TYPE *,'END OF SUBROUTINE TEST1'
5560    RETURN
        END
C-----------------------------------------------------------------------
C     SUBROUTINE FOR TESTING MATRIX MANIPULATION - 2
C-----------------------------------------------------------------------
        SUBROUTINE TEST2(CR12,CR13,CR23,UU,L1,L2,L3)
        DOUBLE PRECISION A(3,3),UU(3,3),B(3,3),C(3,3),L1,L2,L3
        A(1,1)=L1
        A(2,2)=L2
        A(3,3)=L3
        A(1,2)=0
        A(1,3)=0
        A(2,1)=0
        A(2,3)=0
        A(3,1)=0
        A(3,2)=0
        DO 10 I=1,3
        DO 10 J=1,3
```

```
      B(I,J)=0
      DO 10 K=1,3
            B(I,J)=B(I,J)+A(I,K)*UU(J,K)
10    CONTINUE
      DO 20 I=1,3
      DO 20 J=1,3
      C(I,J)=0
      DO 20 K=1,3
            C(I,J)=C(I,J)+UU(I,K)*B(K,J)
20    CONTINUE
      TYPE 30,((C(I,J),J=1,3),I=1,3)
30    FORMAT(1X,3F10.6)
      TYPE *,'END OF SUBROUTINE TEST2'
5561  RETURN
      END
```