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SPATIAL MOBILITY AMONG INDIGENOUS AUSTRALIANS: PATTERNS AND DETERMINANTS

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There is enormous literature on internal migration in both developed and less developed countries and in the former these studies often extend to such specific communities as recent immigrants and the foreign-born population. However, very little is known about the mobility patterns of Indigenous minorities in first world countries. This paper, based on recent census data, establishes the patterns and determinants of internal migration among the Indigenous population of Australia. Results show that compared to the total population, the Indigenous population is highly mobile and largely engaged in short rather than long-distance migration. Its migration pattern peaks at a relatively young age and dominated by family as opposed to labor migration. The zero-inflated negative binomial regression result shows that, at macro-level, the incidence and volume of inter-regional migration are influenced by regional differences in economic resources, in proportions of population identified as Indigenous, as well by geographic factors such as contiguity and physical distance between areal units. The paper also brings to light some novel approaches to the analysis of census migration data.

Key words: internal migration, determinants of migration, Indigenous migration, Australian migration, migration schedules, count data models.

Introduction

The study of internal migration has long attracted the attention of demographers and researchers in allied disciplines. This is understandable because the effects of migration extend beyond population dynamics and interacts with institutional, social and economic processes operating at the level of the wider society. At macro level, migration is associated with socio-cultural factors; it is influenced by government policies on investment, employment and social insurance schemes as well as by land ownership regulations and regional development programs; it is also directly affected by technology and the level of transport and communication network. In addition, migration has important implications for population dynamics, particularly when viewed from the standpoint of local communities and the diminishing role of natural increase as societies advance toward higher stages of demographic transition.

There is enormous literature on internal migration in both developed and less developed countries, and in the former these studies often extend to such specific communities as recent immigrants and the foreign-born population (Rumbaut 2004; Tamis and Gavaki 2002; Bell and Hugo 2000; Rogers and Raymer 1999; Coughlan and McNamara 1997; Newbald 1996; Belanger and Rogers 1992). However, very little is known about the mobility patterns of Indigenous minorities in first world countries, despite the enormous social, economic and historical circumstances that distinguish the minority population from both recent immigrants and the mainstream populations of these countries (Taylor and Bell 2004). This paper, based on recent

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census data, presents a comprehensive analysis of the patterns and determinants of internal migration among the Indigenous population of Australia.

Indigenous Australians are generally less educated than other Australians (Australian Bureau of Statistics (ABS) 2004a). As a result, they are relatively less represented in the country's mainstream institutions and disproportionately dependent on unemployment benefits and other government allowances (ABS, 2004a). Historically, following European settlement in 1788, the Indigenous population of Australia had been dispossessed from its land, forced to assimilate with the settler population and, until as recently as the 1960s, had to live with the direct influences of Christian missionaries and state agencies over its residential arrangements and way of life in general (Gray 2004). Although there had been attempts to examine the settlement and mobility patterns of Indigenous Australians, in the context of the historical experience and present day circumstances of this population, existing studies are either spatially restricted or deficient in terms of depth and analytical rigor (Taylor and Bell 1999, 2004; Warchivker et al. 2000; Povinelli E.A. 1993; Young 1990; Young and Doohan 1989; Gray 1989; Uzzell 1976). The present paper addresses these shortcomings; it accesses new source of data, applies more refined techniques of analysis and, for the first time, examines the determinants of Indigenous migration in Australia. Before proceeding further, however, it is essential to review the historical experience and current socio-economic circumstances of the population to provide a context to the study. This is the subject of the next section.

The Setting: Indigenous Australians

There are no accurate estimates of the Indigenous population of Australia before European settlement in 1788. Many estimates were based on post-settlement observations of a population already depleted by the adverse impacts of interaction with the settler population. The estimates varied from a minimum figure of 300,000 to as high as over 1 million, while recent archaeological findings suggest that a population of 750,000 could have been sustained (Muvaney 2002:6; Smith and Gray 1985:15; Radcliffe-Brown 1930: 671–696). Whatever the size of Indigenous Australians before 1788, it declined considerably under the impact of newly introduced diseases, economic dispossession, excessive mistreatment, and social and cultural dislocation (ABS 2005: 110; Gray 1983: 55). This trend continued well into the twentieth century (Smith 1980). Recent estimates, based on Australia's latest census conducted in 2001, put the Indigenous population of Australia around half a million, 458 520, or about 2.4 per cent of Australia's 19.4 million people (ABS 2005). Data for the period 1996–2001 show that Indigenous Australians have an infant mortality rate which was four times higher (22 per thousand against 6 per thousand) and a life expectancy at birth 17 years shorter (62 years against 79 years) than the rest of Australia's population (Kinfu and Taylor 2005: 248).

The socio-economic disadvantage of Indigenous Australians is reflected in the low educational attainment of this population. Recent survey data show that while over 80 per cent of non-Indigenous Australians had 10 or more years of education, and nearly 50 per cent had a diploma or higher qualification in 2002, among Indigenous Australians these were only 67 per cent and 28 per cent, respectively (ABS 2004a: 28). Partly due to their low level of human capital, at present Indigenous Australians have one of the highest unemployment rates in Australia. According to a study based on the 2001 population and housing census of Australia, nearly 40 per cent of adult Indigenous Australians who were able to work were unemployed as compared to less than 8 per cent for all adult Australians (Hunter, Kinfu and Taylor 2003, 10). The low socio-economic status of Indigenous Australians is also reflected in the greater dependence of this population on the welfare state for its income and housing needs. According to a recent national survey conducted by the ABS, some 52 per cent of adult Indigenous Australians in 2002 reported

government payments and other allowances as their main sources of income, while over 45 per cent of households were dependent on public or community housing. For the non-Indigenous population, the corresponding statistics were 27 per cent and 4.4 per cent, respectively (ABS 2004a: 28).

Indigenous Australians also have a different settlement pattern than the rest of Australia's population, with relatively high proportion residing in areas that are detached from centers of economic activity and mainstream institutions. According to results from the 2001 census, almost one-in-four of the Indigenous population lived in remote or very remote parts of Australia, 43 per cent lived in regional Australia, and only three out of ten resided in the country's five major metropolitan areas — Sydney, Melbourne, Brisbane, Perth and Adelaide. In contrast, among non-Indigenous Australians approximately two-in-three lived in metropolitan regions, while only less than 1 in 50 resided in remote or very remote parts of the country (ABS 2004b: 94–97).

Though still considerably less urbanized and socio-economically disadvantaged, Indigenous Australians are reported to be more mobile than the rest of the country's population (Peterson 2004; Taylor and Bell, 1999, 2004; Warchivker et al. 2000; Povinelli E.A. 1993; Young 1990; Young and Doohan 1989; Gray 1989; Uzzell 1976). However, these observations were based on either spatially restricted qualitative inquiries or on the basis of less rigorous analyses of census data that are already outdated. As a result, we know very little about the detailed characteristics of recent Indigenous migration or the factors affecting the patterns in the population.

The purpose of this paper is, therefore, to shed lights on these topics by presenting a systematic analysis of the characteristics and determinants of migration among Australia's Indigenous population. As far as this author is aware, this is the first comprehensive study on the age patterns and determinants of internal migration among Indigenous Australians, and should, therefore, contribute to a deeper understanding of Indigenous mobility behaviour in Australia. While obviously based on the Australian situation, this paper may also have some significance at the international level, providing the basis for comparisons with inter-jurisdictional movements of Indigenous peoples in New Zealand, Canada and the United States or in other countries (Bedford and Pool 2004; Eschbach 2004; Snipp 2004; Norris et al. 2004).

The balance of the article is set out as follows. The next section describes the data used in the study. This is then followed by the analyses of the intensity, age patterns and determinants of migration in the population. The last section presents concluding remarks.

Sources of data and caveats

A pre-requisite for a comprehensive study of internal migration is the existence of data on mobility history either from specialized migration surveys or population registers. The former are in short supply in Australia and the later are either spatially or compositionally unrepresentative (Bell 1996). Consequently, the analysis reported in this paper is primarily based on data from the 2001 Population and Housing Census of Australia, the most recent and detailed data available for analysis in the country. Although two types of population mobility, known as permanent and temporary migration, can be identified from the data, the focus in the present study will be on permanent migration.

The 2001 Australian census, as other censuses in the country since 1971, provides, for each person, information on current usual place of residence and places of residence one year and five years ago. On the basis of these data, respondents can be classified as permanent migrants if their region of usual residence at time of census was different from the one they held one year or five

years beforehand[1]. Although either of the two (five year and one year) data set could be used for the study of permanent migration, the information on one year mobility is preferred in the present analysis for the following three reasons. First, the one year mobility data generally has higher response rate than the five years ago mobility data — in the data at hand, the response rate for the one year ago data is as high as 97 per cent as compared to 93 per cent for the five years data. Second, in the context of the low educational status of Indigenous Australians and the practice of frequent change of residential location among this population (ABS, 2004a; Young 1990), the use of one year ago data will likely ensure that responses on mobility are less affected by recall errors and repeat migration (ABS, 2004a; Young 1990). Third, the one-year ago mobility data ensure that the characteristics of migrants recorded by the census closely approximate the characteristics of respondents that pertained at the time of residential mobility. This correspondence is crucial as the explanatory variables used in the analyses of determinants of mobility are taken from the census and, therefore, are only appropriate for a decision to migrate in the period immediately before the census.

Because migration is as much a spatial as it is a temporal phenomenon, the study of its dimensions and determinants must also trace its occurrence with respect to a system of geographic areas. The Australian Standard Geographical Classification (ASGC) system used by the ABS for collecting and disseminating geographically classified statistics has five spatial hierarchies, comprising in descending order: states/territories, statistical divisions (SD), statistical sub-divisions (SSDs), statistical local areas (SLAs) and census collection districts (CDs) (ABS 2004c: 7). At the time of the 2001 census, excluding its Overseas Territories, Australia was divided into 37 209 CDs, 1350 SLAs, 207 SSDs and 60 SDs which spread over the country's 6 States (News South Wales, Victoria, Queensland, South Australia, Western Australia and Tasmania) and two territories — the Northern territory and the Australian Capital Territory (ABS 2001). For the purpose of the study, this structure was used and sixty-four migration zones were accordingly identified. These regions for the most part correspond to statistical divisions as defined in the ASGC structure, the only exception being the Northern Territory balance statistical division in the Northern territory and the Kimberly statistical division in Western Australia (see shaded region in Figure 1). These two statistical divisions were deemed to be relatively sizable and inadequate as far as reflecting the social space of Indigenous Australians living in those areas; they were, thus, sub-divided into their constituting statistical sub-divisions, mainly to create homogenous migration zones. Although no geographic system is perfect for migration analysis (Clark 1986:18–19; Bogue, Hinze and White 1982: 5), it is expected that these regions represent effective migration zones for the intended analysis: they are generally small and fairly disaggregated, hence capture the unique social and economic landscape of each region; they are also large enough to avoid problems of empty cells that comes with finely disaggregated data. Figure 1 shows map of these regions.

[1] A person is considered a usual resident of a defined geographic region, if she or he lived or intended to live in the region for a period of a total of six months or more.

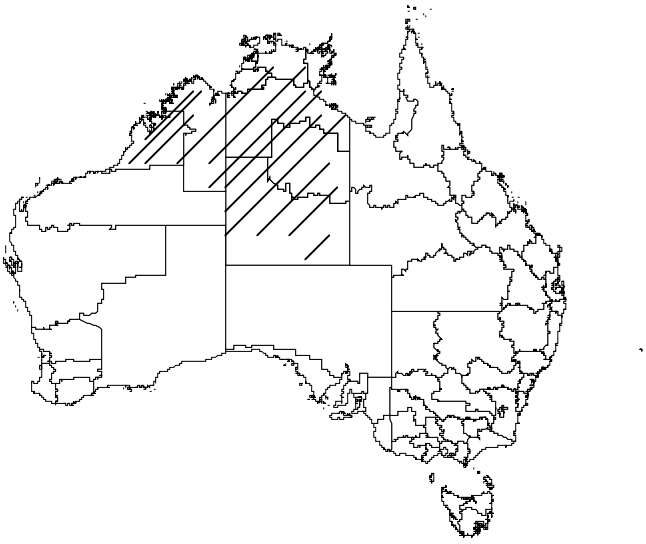


Figure 1: Migration regions: Australia 2001

Note: The shaded regions represent SSDs; these regions were created out of the Northern Territory balance SD and the Kimberly SD of Western Australia. All other regions represent SDs.

Although the 2001 census is the most recent and by far the most comprehensive source of migration statistics in Australia, four fundamental shortcomings, which may have a bearing on the foregoing analysis, need to be noted at the outset. First, it should be noted that as with other census data in Australia or elsewhere in the world, the 2001 census return does not capture multiple moves that may have occurred within the observation interval (Mulder 1993; Liaw and Nagnur 1985; Castro and Rogers 1982). Although this problem is expected to be less of an issue for the general population (mainly because of the short duration of the reference period applied in the source data used in the study), indications of existence of repeat and cyclical migration in some remote and regional Indigenous communities available from ethnographic studies mean that the census data may tend to under-represent the actual intensity of mobility among some segments of the Indigenous population (ABS 2004a; Peterson 2004; Povinelli 1993; Young and Doohan 1989).

An additional potential drawback of the data emanates from its inherent inability to deal with the life styles and living arrangements of some sectors of the population. For instance, it has been reported that some Indigenous Australians, largely due to historical and cultural reasons, maintain two or more residencies at 'outstations'[2] and at their ancestral land, and move between these places on a regular, seasonal or random basis either to access services or to attend to cultural ceremonies and other familial obligations. This multi-local living arrangement poses problem for migration analysis since it is difficult to accurately determine the usual residence and migration status of individuals in the census data.

There are also concerns regarding the validity of the very notion of 'usual residence' among some sectors of the Indigenous population, particularly those located in regional and remote parts of Australia. According to ethnographic accounts, in this population 'usual residence' is viewed largely in terms of an 'area' rather than a 'homestead' as used in census returns (Young 1990; Uzzell 1976). At present there are no publicly available large-scale data in Australia to test the

[2] These are settlements which were formed by Christian missionaries and/or state agencies as Aboriginal reserve areas prior to the relaxation of the control over the settlement and movement patterns of Indigenous Australians in the 1960s (Gray 2004; Smith 2004).

validity of these and related observations noted earlier in the wider Indigenous population of the country. In the absence of this information, the exact effects of errors on census based migration analyses, arising from failure to adequately reflect Indigenous Australians realities, therefore, remain unclear.

The census also suffers from additional problems of non-response and accuracy of response of which that pertaining to Indigenous status is of particular interest to the study. Given that in the 2001 census, as in other previous Australian censuses, the Indigenous origin of respondents is determined by self identification, it should be noted that neither the accuracy of this information nor the biases resulting from use of such data for migration analysis are known with certainty. However, this is a problem not just for Australian data, but is inherent in the analysis of Indigenous minority populations in North and South America, New Zealand and the Arctic rim (Pool 1986). In addition, in the 2001 Australian census, 456 789 persons, or a size as large as the census identified Indigenous population, did not state their Indigenous status, while, as noted earlier, some 3 per cent of the identified Indigenous population also did not state their usual residence one year before the census. For the present purpose, both of these records were omitted from further analysis.

Intensity and patterns of mobility

Table 1 presents selected measures of migration intensity and distance of movement computed for Indigenous Australians from the 2001 census. For purposes of comparison, similar measures obtained for the total population of Australia are presented in the same table. The crude migration intensity (CMI) reveals high level of mobility among Indigenous Australians — over one in four of the population reported a change of residence over the one-year period prior to the census, compared to about 18 per cent for the Australian population as a whole. The Indigenous population has a youthful age structure — with a median age of 21 in 2001 as against 32 for the Australian population as a whole — and because generally younger people are highly mobile than the rest of the population, it is expected that the high level of migration intensity among Indigenous Australians partly reflects the difference in age structure between the two populations. This is clearly evident from the standardized migration intensity estimates presented in the same table which show reduced difference in intensity between the two populations once the difference in age composition has been controlled for. However, as is evident from the same result, standardization does not eliminate the difference entirely. Actually, only about 43 per cent of the observed difference in crude intensity between the Indigenous and total population of Australia could be attributed to differences in age composition between the two populations, while differences in migration intensity contributing the remaining 57 per cent.

Table 1: Intensity of internal migration: Indigenous and all Australians, 2000–2001

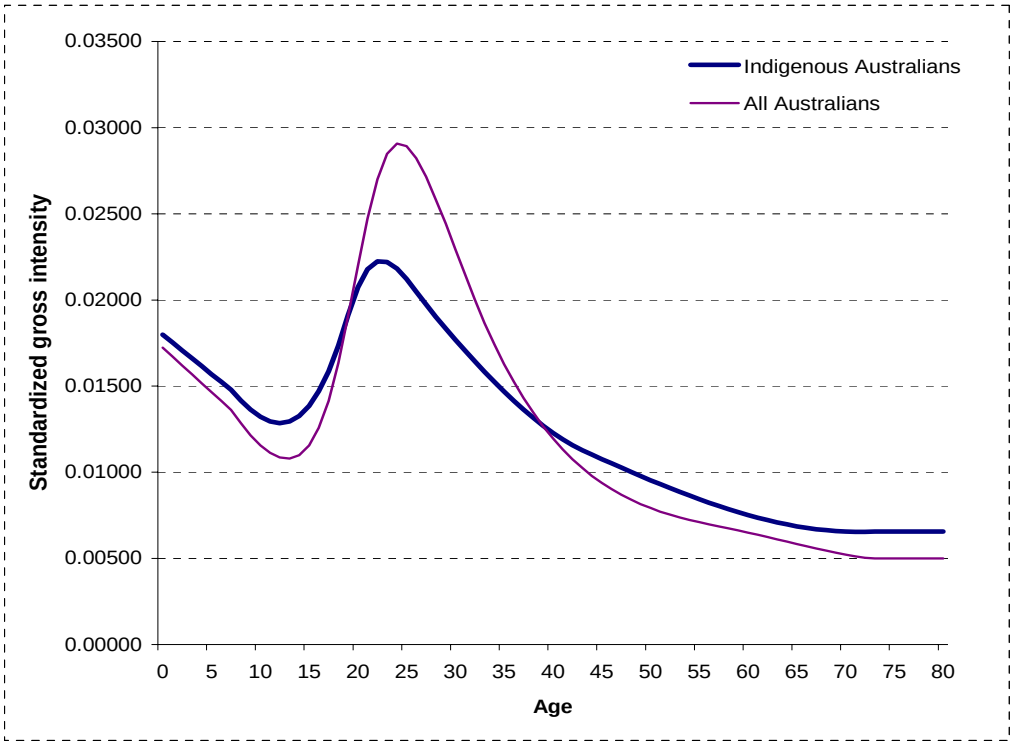
Measures of migration intensity	Indigenous Australians	All Australians
Crude migration intensity (CMR)	25.3	18.4
Age-standardized migration intensity *	22.3	18.4
Type of move (% moved, both sexes)		
Intra-regional	72.2	72.7
Intra-state	18.6	11.5
Inter-state	9.2	15.9

Source: Author's own calculation based on unpublished 2001 Population and Housing Census of Australia.
Note: * Standardized using the age-structure of the total population of Australia in 2001.

Consistent with Revenstein's (1885) first law of migration, the propensity of migration among Indigenous Australians exhibits a notable distance decay effect. The overwhelming majority of Indigenous migrants were engaged in relatively short-distance move — involving a movement within a migration zone — and only less than 1 in 10 were engaged in inter-state migration. This is also generally the case for the total population, although for this population inter-state migration is relatively more common than intra-state migration.

Like all other demographic processes, change of residence is associated with age and certain life-cycle statuses and transitions (Long 1992). To investigate the age patterns of migration, gross migration rates were calculated by age for the Indigenous and total population of Australia. These estimates are presented in Figure 2a, after they have been standardized (normalized) to unity to facilitate comparison between the two populations without the diluting effects of scale on the analysis.

Figure 2a: Normalized mortality unadjusted (gross) migration intensities by age: Indigenous and all Australians, 2000–2001



Source: Author's own calculation based on unpublished 2001 Population and Housing Census of Australia.

Over all, the results presented in Figure 2a for Indigenous and all Australians corroborates with the universal pattern first identified by Rogers and Castro (1981) and subsequently observed by other researchers in other populations (Rogers, Castro and Lea 2005; Long 1992; Rogers 1988; Castro and Rogers 1983; Rogers and Castro 1981; Rogers, Raquillet and Castro 1978). For both populations, the age profile of migration exhibits a pattern of high intensity at infancy, which subsequently tends to drop until age 15. Between the ages of 15 and about 25, migration intensity sharply increases attaining peak intensity between the ages of 20 and 24 years. For both the Indigenous and the Australian population as a whole, this reflects the influence of a number of life-cycle events, including departure from the parental home, the start of post secondary education, entry into the labor force and establishment of independent living arrangements (Bell 1995; Long 1992). However, the fact that migration intensity peaks at an earlier age among Indigenous Australians reflects that the patterns for this population may have been further

reinforced by other factors that may be specific to the Indigenous population. One such possible factor is the different settlement pattern between Indigenous and other Australians. As indicated earlier, relatively high proportion of Indigenous Australians live in remote and very remote parts of Australia where opportunities for mainstream employment and access to social services such as education are limited; this increases the necessity for early migration among Indigenous Australians. Given the links between childbearing and the establishment of independent living arrangements, the pattern of early peak observed among Indigenous Australians is also consistent with the evidence of low age at first birth documented for this population (Kinfu and Taylor 2005: 246).

Although the Indigenous migration schedule attains peak intensity earlier than for the total population, the intensity at young adult ages — between the ages of 22 and 38 years — is significantly lower for this population. As mobility in these ages are generally associated with career development and degree of engagement with mainstream institutions, it is interesting that the relatively low level of Indigenous migration observed in these ages are consistent with the patterns of low labor force participation and territory enrollment among young adult Indigenous Australians. For instance, as evidenced in a recent survey conducted in 2002, enrollment at higher institutions of learning among young adult Indigenous Australians was 2.3 times lower than the national average, while labor force participation for this population was 1.7 times lower and unemployment rate 2.5 times higher than the national average for comparable age groups (ABS 2004a).

However, it should be noted that relative detachment from the labor market may not always dampen geographic mobility. This is mainly because in the context of the existing system of high level of portability of government payments and benefits in Australia, non-participation in the labor market could offer unemployed persons some level of 'freedom' of movement and flexibility in their spatial choices. This appears to explain the patterns of Indigenous mobility beyond the middle Ages, where migration intensities are higher for the Indigenous population. As indicated earlier, the Indigenous population also has low rate of home ownership and low average income than the country's population as a whole (ABS 2002); this means that, for this population, tenancy is less stable and residential preferences had to often respond to changing rent levels, government housing provisions and landlord tests, all of which tend to prompt high level of mobility in the population.

The age-specific migration intensities presented in Figure 2a could be used to provide summary measures of the intensity of mobility in the population. Table 2 presents one simple such indicator, gross migration expectancy, obtained from these data. The gross migration expectancy (or the gross migra-production rate as known commonly) measures the total number of moves that an average individual could expect to undertake, if that individual were exposed to the annual rates of migration observed during the period of analysis (through out his or her life) and not exposed to death before undertaking the last move or reaching the last age group (Willekens and Rogers 1978). Thus, according to this measure, an average Indigenous Australian could expect to undertake 17 lifetime moves or roughly three moves more than the average for all Australians. The gross migration expectancy, however, overstates the actual intensity of mobility, because the analysis fails to capture potential losses of mobility associated with pre-mature death. This is particularly important given the significant difference in mortality that exists between Indigenous and other Australians — average life expectancy at birth among Indigenous Australians which is estimated at 62 years for both sexes in 1996–2001 is about 17 years shorter than the average for the rest of the Australian population (Kinfu and Taylor 2005: 248).

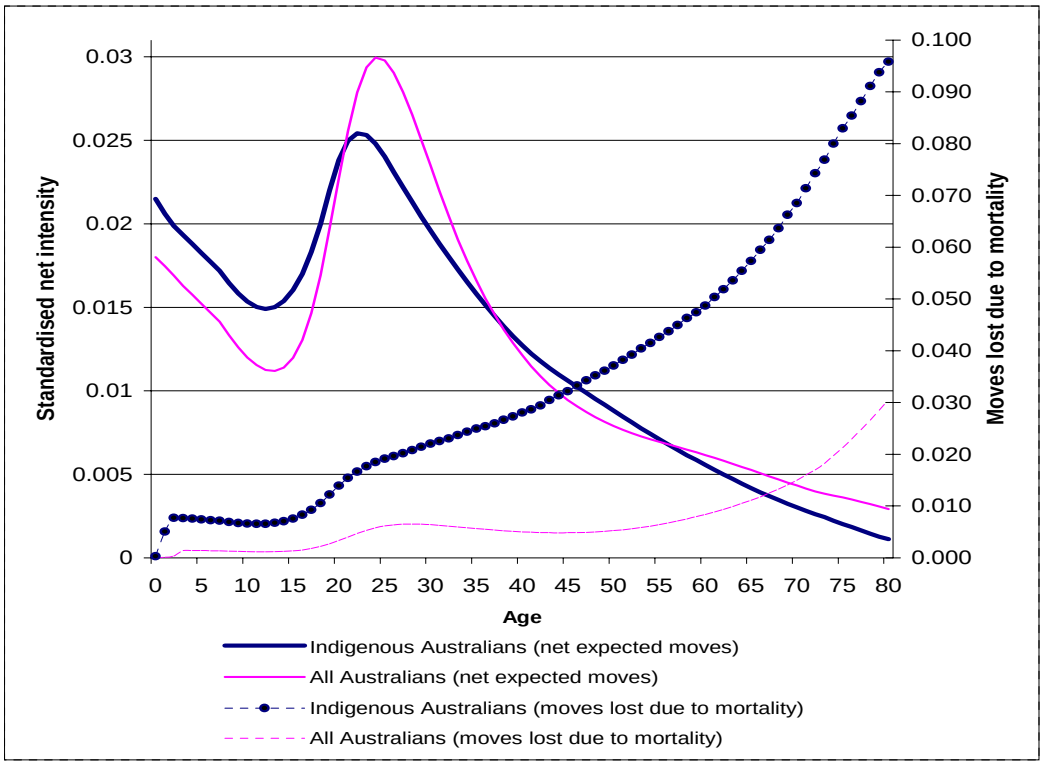
Figure 2b presents mortality adjusted age-specific migration intensities for the Indigenous and total population of Australia. These estimates represent the number of net moves expected at each age out of the total net moves expected at birth. The reader will note that these standardized (or normalized) estimates are comparable to those plotted in Figure 2a, except that they reflect net rather than gross age-specific migration intensities. Inspection of Figure 2b immediately reveal that while for both Indigenous and all Australians the overall pattern remains unchanged, the mortality adjusted migration schedules, unlike the mortality unadjusted estimates mapped in Figure 2a, exhibit relatively lower migration intensity at older ages for the Indigenous population, reflecting the greater impact of mortality on the mobility pattern of this population.

A more direct way to assess the differential impacts of premature mortality is to compare the age-specific net moves with those of the gross estimates recorded for the same age. The age-to-age differences between these two measures, thus, provide age-specific estimate of the number of moves lost due to mortality for the population. These estimates, shown in Figure 2b for the Indigenous and total population of Australia (see the doted and dashed lines), reveal that the number of moves lost due to premature mortality are generally higher for the Indigenous population and, particularly after age 20, increase more rapidly for this population than for the total population of Australia.

Table 2 presents mortality adjusted (or net) migration expectancy estimates for the Indigenous and total population of Australia. This shows that once the effect of mortality is accounted for, an average Indigenous Australian could expect to change residence about 14 times over his or her lifetime. Subject to the relevant period life table observed for the population, this suggests that an average Indigenous Australian could expect to change residence every 4.4 years which is about 1.5 years shorter than the average for the total Australian population[3]. On the whole, the 14 net life time moves that an average Indigenous person is expected to undertake would consist of at least one inter-state, about 3 intra-state and roughly 10 intra-regional moves. On the other hand, an average Australian could expect to undertake about 13 net life time moves, comprising of about 10 intra-regional, 2 inter-state and 1.5 intra-state moves.

[3] This estimate is obtained by dividing the life expectancy at age 0 estimated for the population by the net migration expectancy obtained for the same age for the population (Bell 2002: 81). See the footnote in Table 2 for the sources of the life table used in the analysis.

Figure 2b: Normalized mortality adjusted (net) migration intensities and lifetime moves lost due to premature mortality by age: Indigenous and all Australians, 2000–2001



Source: Author's own calculation based on unpublished 2001 Population and Housing Census of Australia.
Note: Life tables required for the calculation of net (adjusted) migration intensities were obtained from Kinfu and Taylor (2002).

To gain further insight into the dimension of mobility, two additional refined measures of migration, namely partial (age-specific) net migration expectancies and migration percentiles, were generated from distance-specific mobility life tables constructed for the Indigenous and total populations of Australia. Migration percentiles measure the ages at which members of a given cohort (hypothetical) attain 25, 50 or 75 per cent of their expected life time moves, while partial (age-specific) net migration expectancies show the actual number of moves the hypothetical cohort would expect to undertake in a given age interval as assessed at birth. Table 2 presents these two measures for the Indigenous and total population of Australia by movement type. The reader will note that since the partial net-migration expectancies are assessed at birth the denominators used in the calculation are the radix rather than the values of lx corresponding to the beginning of the respective age intervals for which the calculations are made. This means that the net migration expectancy at birth could be obtained as a sum of the partial migration expectancies estimated for the different age groups.

As can be seen from the values of m_{25} and ${}^{m}{}_{15}e_0$, Indigenous Australians tend to engage in permanent migration early in their life and could expect to experience relatively high level of migration at young age. Accordingly, an average Indigenous Australian would change residence roughly 4 times before turning 15 (see ${}^{m}{}_{15}e_0$), and is expected to undertake 3 additional moves before turning 25 (see ${}^{m}{}_{10}e_{15}$). However, between the ages of 25 and 45 years (see ${}^{m}{}_{20}e_{25}$) net migration expectancies are rather higher for the total than for the Indigenous population. After age 45 (see ${}^{m}{}_{\infty}e_{45}$), both the Indigenous and the total population are expected to experience similar number of lifetime migration — to the tune of some 3 moves.

Similarly, as shown in the same table, Indigenous Australians could expect to complete 25 per cent of their expected 14.2 lifetime moves before turning 16 (see m_{25}), and achieve half of their lifetime migration career (see m_{50}) by age 28. In contrast, the total population is not expected to attain 25 per cent of its life time move before age 19, though it tends to progress to the 50th and 75th migration percentile much quicker (or at an earlier age) than the Indigenous population. These results, therefore, suggest that while Indigenous Australians are essentially mobile through out their life, among the total population spatial mobility tends to be restricted to a relatively limited span of one's life.

Table 2: Gross, net and partial migration expectancies and migration percentiles: Indigenous and all Australians, 2000–2001

	Indigenous Australians				All Australians			
	All moves	Type of move			All moves	Type of move		
		Intra Region	Intra State	Inter State		Intra Region	Intra State	Inter State
Migration expectancy [years]								
Gross ($^{g}e_0$) (at birth)	17.0	12.4	3.1	1.5	13.8	10.0	1.6	2.2
Net								
$^{m}e_0$ (at birth)	14.2	10.3	2.6	1.3	13.2	9.6	1.5	2.1
$^{m}{}_{15}e_0$	3.7	2.7	0.7	0.3	2.8	2.1	0.3	0.4
$^{m}{}_{10}e_{15}$	3.1	2.3	0.6	0.3	2.8	2.0	0.4	0.5
$^{m}{}_{20}e_{25}$	4.7	3.4	0.9	0.5	4.9	3.6	0.5	0.8
$^{m}{}_{\infty}e_{45}$	2.7	2.0	0.5	0.2	2.7	2.0	0.4	0.4
Migration percentiles [age]								
m_{25}	15.8	16.0	15.4	17.8	18.8	18.3	19.7	19.0
m_{50}	28.3	28.4	28.2	28.6	27.0	27.0	28.1	27.0
m_{75}	46.7	47.5	45.0	49.5	40.9	35.3	46.1	31.8

Source: Author's own calculation based on unpublished 2001 Population and Housing Census of Australia.
Note: * The calculation of net migration expectancies were based on period life tables that applied for 1996–2001 — the latest period for which comparable life tables were available for the Indigenous and total population of Australia (Kinfu and Taylor, 2002).

Another way of characterizing the migration profiles of these populations is through the use of formal migration models. The mathematical migration model defined and elaborated by Rogers and his colleagues (Rogers, Castro and Lea 2005; Castro and Rogers 1983; Rogers and Castro 1981, 1982; Rogers, Raquillet and Castro 1978) has several attractive features: it allows the estimation of relatively concise and broadly comparable parameters; these in turn facilitate a formal statistical test of dis/similarity of migration schedules. The model also provides intuitively meaningful indices that can assist in classifying migration schedules into labor versus child dependent or early versus late peaking patterns, and allow comparison of these with internationally available estimates. The Rogers and Castro model is algebraically expressed as follows:

$$M(x) = a_1 \exp(-\alpha_1 x) + a_2 \exp\{-\alpha_2(x-\mu_2) - \exp[\lambda_2(x-\mu_2)]\} + R + C$$

where, $x = 0, 1, 2\ldots.\acute{\omega}$ and

$$R = a_3 \exp\{-\alpha_3(x-\mu_3) - \exp[\lambda_3(x-\mu_3)]\} \text{ OR}$$
$$R = a_3 \exp\{-\alpha_3 x\} \quad \text{OR} \quad R = 0$$

This model can be seen to be consisting of four elements: the pre labor force or childhood migration curve, the labor force curve, the post labor force (retirement) curve and the constant term. M (x) is the migration rate at age x. In the above equation, a_1 represents the infant migration level and α_1 is the decent parameter for the pre-labor force component. The second component,

associated with midlife mobility describes the curve's level (a_2), shape (α_2 λ_2), and position (μ_2) on the age axis. The third term in the model (R) may take on the value of zero; assume the shape of a positive exponential function or follow a double exponential function. Setting this term to zero provides a reduced form of the Rogers-Castro mode — a model with 7 parameters. This model is employed in the paper.

The parameters of the Rogers-Castro model can be estimated using either non-linear or linear estimation techniques, but in the paper the former approach is pursued primarily because this allows the estimation of variance-covariance matrices, that are instrumental in undertaking a formal statistical test of dis/similarity of migration profiles (Rogers, Castro and Lea 2005; Long 1997; Liaw and Nagnur 1985; Bracken and Bates 1983; Bates and Bracken 1982). Panel A in Table 3 presents the coefficients and the associated standard errors of the Rogers-Castro model parameters estimated for the Indigenous and total population of Australia by type of move, obtained using non-linear estimation procedure. As in the original work by Rogers and Castro, this involved minimizing the objective function through the *Marquardt-Levenberg* approach — a method which is equivalent to performing a series of ridge regressions (Rogers and Castro 1981). This technique has an advantage over alternative minimization procedures particularly when the estimated parameters have high correlation or their initial values could not be specified with accuracy, features which are typical of the Rogers-Castro model (Rogers, Castro and Lea 2005).

As can be seen from the estimated parameters shown for all moves, infant migration level is fairly high among Indigenous Australians: about 31 per cent of Indigenous children aged 0 are expected to change residence in any given year as against 24 per cent for the total population. The decent parameter for the pre-labor force component, α_1, shows that childhood migration declines gradually among Indigenous Australians. However, as can be seen from the high values of λ_2, the rate of ascent in the labor force ages is much faster for this population as compared to the total Australian population. The migration profile for all moves for Indigenous Australians also attains peak intensity earlier than that of the total population, although the intensity at peak age is much greater for the latter group. For instance, as can be seen from the values of α_1, at peak age of migration as many as 63 per cent of all Australians are expected to change residence at any one given year, and this is almost twice the level for Indigenous Australians. However, as evidenced by the high values of the decent parameter in the labor force ages, α_2, the intensity of migration beyond peak age drops much faster for the total than for the Indigenous population.

The model parameters for intra-regional migration schedules for both populations closely mirror that observed for all moves — a not surprising evidence given, as shown previously, as many as over 70 per cent of both Indigenous and all Australians are engaged in short distance (intra-regional) moves. However, the models fitted to inter-state migration schedules for both populations reveal distinct features. Compared to the parameters for all moves and short-distance moves, the estimated parameters for long distance migration (for both populations) generally reflect low intensity at infancy and depict a more gradual decline during childhood ages. In addition, these parameters also reveal an older migration profile than implied by the parameters for short distance migration with intensity of migration peaking at a relatively higher age. However, the intensity of migration beyond peak age tends to decline much faster for inter-state migration than short distance migration.

The primary parameters of the Rogers-Castro model can be combined to define secondary parameters; these are useful in further characterizing the migration profile of the study population (Rogers, Castro and Lea 2005; Rogers 1986; Castro and Rogers 1983; Rogers and Castro 1984, 1981). Rogers and Castro provide several such secondary parameters of which δ_{12}, σ_2, and β_{12} that respectively describe the degree of child/labor dominance; asymmetry and regularity of a

migration schedule are the most widely used. An additional parameter of interest is μ_2, which measures the early versus late peaking patterns of migrations schedules. Multi-country analyses of migration data showed that a migration profile can be said to be early peaking if its estimated value of μ_2 was 19 or lower; labor symmetric if its σ_2 value was less than 2, and regular if its estimated β_{12} value ranged between 0.8 and 1.2(Rogers and Castro 1984: 67). Similarly, a migration profile is said to be child dependent if its estimated δ_{12} value exceeded 0.4. Panel B of Table 3 presents these measures for the Indigenous and total population of Australia.

Table 3: Parameter estimates and standard errors (in parenthesis) for the Rogers-Castro migration model fitted to data for Indigenous and total Australian population by type of move: 2000–2001

	Indigenous Australians			All Australians		
	All moves	Type of move		All moves	Type of move	
		Intra Regional	Inter state		Intra regional	Inter State
Panel A: Rogers-Castro model parameters and standard error estimates						
	0.2123	0.1504	0.0214	0.1708	0.1291	0.0255
a_1	(0.0023)	(0.0024)	(0.0004)	(0.0023)	(0.0012)	(0.0005)
	0.0438	0.0518	0.0330	0.0559	0.0566	0.0458
α_1	(0.0018)	(0.0025)	(0.0023)	(0.0023)	(0.0016)	(0.0036)
	0.3441	0.2518	0.0388	0.6330	0.4407	0.1275
a_2	(0.0073)	(0.0070)	(0.0011)	(0.0118)	(0.0058)	(0.0028)
	0.0685	0.0708	0.0629	0.1103	0.1057	0.1273
α_2	(0.0019)	(0.0026)	(0.0024)	(0.0025)	(0.0016)	(0.0043)
	18.416	18.3153	19.8562	21.2570	21.1067	22.7831
μ_2	(.1101)	(0.1284)	(0.1686	(0.1559)	(0.0935)	(0.3064)
	0.3206	0.3582	0.2660	0.2518	0.2751	0.2105
λ_2	(.0118)	(0.0180)	(0.0115)	(0.0075)	(0.0058)	(0.0086)
	0.0950	0.0769	0.0048	0.0696	0.0495	0.0091
C	(0.0018)	(0.0015)	(0.0004)	(0.0012)	(0.0006)	(0.0004)
GMPR *	17.0	12.4	1.5	13.8	10.0	2.2
Panel B: Rogers-Castro model secondary parameters (indices)						
δ_{12}	0.617	0.597	0.550	0.270	0.293	0.200
σ_2	4.680	5.059	4.229	2.282	2.603	1.654
β_{12}	0.640	0.731	0.524	0.506	0.536	0.360
μ_2	18.4	18.3	19.9	21.3	21.1	22.78

Source: Author's own calculations based on unpublished 2001 Population and Housing Census of Australia. Note: The models for intra-state migration for both Indigenous and total Australian populations did not converge, hence were excluded from further analysis.

* GMPR represents gross migration expectancy (or gross migra-production rate).

These estimates clearly show that, both compared to the total Australian population and the international standard, the migration profiles for Indigenous Australians, irrespective of the type of movement involved, are generally dominated by child migration; they are labor asymmetric, highly irregular and early peaking. By contrast, the labor dominant features and late peaking patterns of the migration profiles of the total population are clearly evident from the low values of δ_{21} and high values of μ_2 obtained for this population. However, for both the Indigenous and total population of Australia inter-state migration exhibits relative labor dominance compared to total moves and moves within the same migration zone.

Are the differences between the Indigenous and total population of Australia, and between short and long distance migration observed for these populations statistically significant? One way to investigate this question is by making use of the parameters and the associated variance-covariance matrices already obtained from the Rogers-Castro model. Thus, if $\boldsymbol{\psi_i}$ represents a vector of the Rogers-Castro model parameters estimated for migration profile *i* and $\boldsymbol{\psi_j}$ represents the same information for the second profile, *j*, and $\boldsymbol{\xi_i}$ and $\boldsymbol{\xi_j}$ respectively represent the variance-covariance matrices associated with these parameters, then a formal paired test of similarity/dissimilarity between the migration profiles (i and j) can be undertaken using the following relationship (Zhang, Peddala and Rogol 2000; Cameron and Trivedi 1998; Long 1997; Bracken and Bates 1983):

$$\gamma_{ij} = \left(1/n\right)\left[\psi_i - \psi_j\right]^T \left[\xi_i - \xi_j\right]^{-1} \left[\psi_i - \psi_j\right]$$

where i ≠ j, and 'T" and '-1' respectively represent the transpose and the inverse of the relevant matrices represented in the equation.

When the sample size is large, as in the analysis here, the quantity $\boldsymbol{\gamma_{ij}}$ is asymptotically χ^2 distributed with degrees of freedom, *n,* equal to the number of constraints (i.e. the number of estimated model parameters). Hence, the hypothesis that i and j have similar profile is rejected at significance level, α, if the computed test statistic, $\boldsymbol{\gamma_{ij}}$, exceeds the tabulated value of χ^2 (n, α). Table 4 presents the test statistic, $\boldsymbol{\gamma_{ij}}$, calculated for paired migration profiles by movement type.

The calculated test statistic shown in Table 4 are all greater than the critical value of 18.5 (n= 7 and α = 0.01). This suggests that each of the migration profiles is distinct from one another. It is also interesting to note that the profiles for Indigenous Australians for all moves, inter-regional and inter-state moves are as much distinct from each other as they are from the respective profiles for the Australian population as a whole. This is also the case for the total Australian population migration schedules as the profiles for long and short distance migration are distinctively different from each other.

Table 4: Approximate χ^2 statistic (df = 7) for testing the similarity of migration profiles, Australia: 2000-2001

Migration profiles (j = 2, 3,…6)	Migration profiles (i = 1, 2, …5)				
	1	2	3	4	5
2	262				
3	2325	1266			
4	131	27	1387		
5	741	99	2327	247	
6	1838	967	99	972	1659

Source: Author's own calculation based on unpublished 2001 Population and Housing Census of Australia.

Notes: 1. Represent 'All moves' for Indigenous Australians;
2. Represent 'Inter-regional moves' for Indigenous Australians;
3. Represent 'Inter-state moves' for Indigenous Australians;
4. Represent 'All moves' for the total Australian population;
5. Represent 'Inter-regional moves' for the total Australian population;
6. Represent 'Inter-state moves' for the total Australian population. All values in the table are statistically significant as they are all above the table χ^2 value (i.e. 18.5) at the desired precision level (α = 0.01) and degree of freedom (n = 7).

Determinants of internal migration

If Indigenous migration behaviour is statistically different from the rest of the population what factor(s) then govern this distinct pattern? Although the study of the determinants of migration has a long history in both developed and less developed countries, such studies are generally scanty in Australia and inexistent for the Indigenous population (Beals et al. 1967; Greenwood and Sweetland 1972; McHugh 1988; Flood et al., 1991; Shen 1999; Finnie 2004). In what followed, based on data on aggregate migration flows between migration zones, an attempt is made to examine the determinants of inter-regional migration among the Indigenous population of Australia.

The dependent variable represents migration flows between regions and is measured in terms of number of migrants who moved between the 64 migration zones during the one year interval preceding the 2001 census[4]. The independent variables are composed of 11 variables that broadly reflected the social, economic, demographic and spatial characteristics of the migration regions. The selection of control variables is guided by theoretical consideration, availability of data and prior empirical research on migration analysis elsewhere. Table 5 presents the list of these variables and the measurements adopted in the analysis.

Table 5: Definition and measurement of variables for multivariate analysis of the determinants of inter-regional migration: Indigenous Australians, 2000–2001

Variable	Measure	Notations
Dependent variable		
Inter-regional migration flows	Number of movers from region j to region i during the reference period.	M_{ij}
Explanatory variables		
Economic characteristics		
Relative economic status	Differences in index of economic resources between the area of destination and area of origin *.	V01
Level of urbanization at origin	Equals 1 if origin is a State or Territory Capital.	V02
Level of urbanization at destination	Equals 1 if destination is a State or Territory Capital.	V03
Social network		
Relative degree of Indigenousity	Differences in the proportion of total population identified as Indigenous or Indigenous Australian between region j (the area of destination) and region i (area of origin).	V04
Migrant stock	Number of Aborigines who migrated from region j to region i during the pervious intercensal period, 1991-1996.	V05
Demographic and spatial characteristics		
Population size at area of origin**	Usual resident population aged 1 year or over at area of origin during the year prior to the census.	V06

[4] These produced a total of 4032 migration streams (64 X 63) as intra-regional moves were not considered in the analysis.

Variable	Measure	Notations
Population size at area of destination **	Usual resident population aged 1 year or over at area of destination during the year prior to the census.	V07
Physical size of origin **	Total land area in square km at area of origin.	V08
Physical size of destination**	Total land area in square km at area of destination.	V09
Contiguity	Equals 1 if region i and j are contagious.	V010
Physical distance between origin and destination zone	Difference in population-weighted centrroids between region i and region j	V011

Note: The variable is created using the socio-economic index for areas (SEIFA) calculated from the 2001 census data by the ABS. The SEIFA was constructed for each statistical locality in the country by applying principal component method on such census variables as household and personal income, rent, mortgage payment, education, occupation, and employment status (ABS 2003).
** Following the practice in previous research, these variables were measured in the model in a log scale.

Previous analyses of the determinants of internal migration have largely been based on the Ordinary Least Squares (OLS) procedure, but more recent studies are undertaken using the Poisson model (Flowerdew 1991; Stilwell and Condon 1991). The choice of the Poisson model over the OLS procedure is appropriate not only because the response variable, number of inter-regional migrants, used in most previous analyses, is a count variable (i.e., rather than a continuous variable) but also because the use of OLS procedure for count outcomes could result in inefficient, inconsistent, and biased estimates (Rodríguez and Aravena, 1991: 43; Raftery *et al.*, 1996: 132; Long 1997: 218; Alt, King and Signorino 2000).

One of the key assumptions of the Poisson regression procedure is that the expected mean and variance (conditional on covariates) of the response variable are equal (Cameron and Trivedi 1998: 59–61; Allison, 1999: 218; Long and Freese, 2003: 248). As applied to migration, the Poisson model also assumes that all streams have some non zero probability of migration flows. However, these assumptions, particularly the assumption of the equality of the variance and mean of the dependent variable (or in statistical jargon known as the equi-dispersion assumption), is rarely met in most demographic applications (Kinfu, 2001: 183; Winkelmann and Zimmermann, 1995: 2; Wang and Famooye, 1997: 274; Al-Qudsi, 1998: 442). This is also the case in the present data; a quick test shows that the sample variance (442.5) is much greater than the sample mean (6.4), an indication of the existence of over-dispersion in the data than that can be represented by the Poisson model[5]. The consequence of such statistical feature is an underestimation of the standard errors of the Poisson regression parameters and an over-estimation of the chi-squared statistics. These in turn mean that, although the parameters of the Poisson regression model are still consistent, they are statistically inefficient. In such circumstance, the negative binomial regression procedure, which is particularly designed to handle extra Poisson variations, would be more appropriate as it produces more efficient estimators (Winkelmann and Zimmermann, 1995: 6; Long 1997: 230; Cameron and Trivedi 1998: 70–71; Allison, 1999: 226; Long and Freese, 2003: 266).

[5] An indication of the magnitude of over-dispersion or under-dispersion can be obtained simply by comparing the sample mean and variance of the dependent count variable (Cameron and Trivedi 1998: 77). Although the conditional variance may decrease once independent variables are taken into account, it is expected that the data will continue to display over-dispersion even after inclusion of regressors if the sample variance is more than twice the sample mean.

However, real life migration data also display excess zeros that may not be adequately captured by the Poisson or negative binomial model. The excess zeros occur either because of total absence of movers between some of the migration streams (due to exorbitant costs of migration or unattractiveness of some destinations for potential migrants from specific regions) or due simply to lack of flows during the period under investigation. These two different sources of excess zeros imply that the data is a mixture, and it would be a misspecification to assume that the zero and nonzero flows come from the same data generating process or that all migration streams have some non zero probability, as generally assumed in standard count models (Gurmu and Trivedi 1996: 471; Long 1997: 242; Cameron and Trivedi 1998: 123, 127 Long and Freese: 2003, 274). The hurdle variants to count data models, proposed by Mullay (1986), and Zero-inflated count models, introduced by Lambert (1992) and Greene (1994), allow two separate data generating processes and/or sources of over-dispersion which make them effective in handling excess zeros. It is also important to note that while the negative binomial model has a more general variance specification than the Poisson model, the hurdle and zero inflated models differ from it in terms of the first moment specification as well and hence have additional attractive features for exploring the data. In the present analysis both the standard Poisson and negative binomial models and their hurdle and zero inflated variants have, therefore, been explored to determine the most appropriate specification to the data. The suitability of the various models was evaluated using the consistent Akaike information criteria (CAIC) (Gurmu and Trivedi 1996: 473). Table 6 provides the CAIC statistics calculated for each of the six count data models fitted to the 2001 inter-regional migration data for Indigenous Australia.

Table 6: Comparison of alternative count models using the Consistent Akaike information criteria (CAIC): Indigenous Australia, 2000–2001*

Type of model	No of Observations	No of Parameters	Log Likelihood	CAIC *
Standard Poisson	4032	11	-19323.5	38749.3
Zero inflated Poisson	4032	11	-12676.7	25455.7
Poisson hurdle	4032	11	-12630.9	25364.1
Standard negative binomial	4032	11	-7057.2	14216.7
Negative binomial hurdle	4032	11	-6468.5	13039.4
Zero inflated negative binomial	4032	11	-6391.3	12888.9

Source: Author's calculation based on unpublished 2001 Population and Housing Census of Australia.
Note: * CAIC = -2 (log-likelihood) + (no of free parameters) (log (N) + 1) (Gurmu and Trivedi 1996: 473).

As can be seen from the values shown in Table 6, the zero inflated negative binomial model (ZINB) provides the lowest CAIC statistic. This suggests that the ZINB model is the most appropriate specification. Also, the uniquely high CAIC value observed for the Poisson model, compared to alternative specifications, demonstrates that the continued use of the Poisson model for modeling aggregate census migration data is not justified, and focus need to be made on alterative models, particularly on zero inflated and hurdle variants of count data models (Flowerdew, 1991).

The ZINB model assumes that the data is consisting of two latent groups — one belonging to the 'Always 0' group and the second belonging to the 'Not Always 0' group. In the present context, the former category could be viewed as consisting of migration streams that have an outcome of 0 with a probability of 1, while the latter represents streams that might have zero flows, but there is a non-zero probability that they could also have a positive count. However, in the kind of data under consideration, it is too often difficult to distinguish whether a migration stream with zero flows is in the first or the second group. The ZINB model handles this in three steps.

In the first step, membership to the 'Always zero' and 'not always zero' group is predicted using either a logit or a probit model. Then, for those streams with non-zero flows, the volume of migration flows is predicted using negative binomial regression model. Finally, the full model combining the zero and positive flows is then obtained as a mixture of the probabilities for the two groups weighted by the proportion in each group (Long and Freese 2003; Cameroon and Trivedi 1998; Long 1997; Gurmu and Trivedi 1996). This produces a two-component regression output: a binary component that captures the probability of having no or zero flows and a count component that predicts the volume of flows between migration zones. The probability of a zero count is predicted using:

$$\Pr(y_i = 0 \mid x_i z_i) = \Omega_i + (1 - \Omega_i)\left(\frac{\alpha^{-1}}{\alpha^{-1} + \lambda_i}\right)^{\alpha^{-1}}$$

and the positive (count) component is estimated as:

$$\Pr(y_i = k \mid x_i z_i) = (1 - \Omega_i)\left(\frac{\Gamma(y_i + \alpha^{-1})}{y_i!\Gamma(\alpha^{-1})}\right)\left(\frac{\alpha^{-1}}{\lambda_i + \alpha^{-1}}\right)^{\alpha^{-1}}\left(\frac{\lambda_i}{\lambda_i + \alpha^{-1}}\right)^{y_i}$$

where y represents the dependent variable and x and z respectively represent the explanatory and inflation variables used in the model. The z-variables are referred to as inflation variables because they serve to inflate the number of 0s in the model. Although the z and x variables should not necessarily be the same, in the present analysis, as in most other studies, the same variables were adopted in both instances. Note that Γ is the gamma function, while λ_i and α are respectively the mean and precision parameter of the model. Also note that Ω represents the probability estimates derived in step one and in the present case were estimated following the following logit equation:

$$\Omega_i = \frac{\exp(\phi + \phi_1 z_1 + \phi_2 z_2 + \ldots \phi_n z_n)}{1 + \exp(\phi + \phi_1 z_1 + \phi_2 z_2 + \ldots \phi_n z_n)}$$

Table 7: An aggregate analysis of the determinants of inter regional migration among Indigenous Australians: Results of zero-inflated negative binomial regression model, 2000–2001

Variable	Binary equation (probability of zero flows)			Count equation		
	Coefficients	Std. error	P value	Coefficients	Std. Error	P value
Urbanization & Economic characteristics						
V01	-.0020	.0011	0.058	.0010	.0006	.076
V02	.0689	.1882	0.714	.0357	.0943	.705
V03	-.4661	.2080	0.025	.0483	.1001	< 0.01
Social network						
V04	-.0021	.0021	0.320	.0065	.0022	.002
V05	-.1245	.0176	< 0.01	.0213	.0016	< 0.01
Demographic and physical characteristics						
V06	-.8208	.0561	< 0.01	.3544	.0275	< 0.01
V07	-.9034	.0583	< 0.01	.5409	.0274	< 0.01
V08	.0632	.0381	0.098	.0155	.0196	.430
V09	.0756	.0432	0.080	.0364	.0231	.115
V10	-1.6403	.3017	< 0.01	.6636	.0672	< 0.01
V11	1.2159	.0811	< 0.01	-.4794	.0300	< 0.01
Constant	10.7227	.7557	< 0.01	-5.3553	.3465	< 0.01
α				.5347	.0273	
Log likelihood						-6391.31
Number of observations						4032
Non zero observations						(1435)
Zero observations						(2597)

Source: Author's own calculations based on unpublished 2001 Population and Housing Census of Australia.

Table 7 presents estimated coefficients of the binary and count components of the ZINB model and their associated standard errors for each of the independent variables employed in the analysis to predict the incidence and volume of inter-regional migration among Indigenous Australians. The binary component of the model indicates that the incidence of inter-regional migration is influenced by social network variables as well as by demographic, economic and physical features of areal units. As is evident from Table 7, the probability of zero flows is strongly and inversely associated with origin and destination population sizes and the size of migrant stock (i.e., the number of migrants that had previously settled in a destination area), findings which are all consistent with previous studies in other populations (Boyle and Flowerdew 1997; Cadwallader, 1992; Gardner, 1981). Controlling for the effects of all other variables, the result also reveals that compared to capital cities, non-capital city destinations have greater probability of non zero flows, suggesting the high level of engagement of non capital city residents in inter-regional migration in the country. Also, contagious pairs of regions are more likely to experience greater probability of non-zero flows than those that are located apart. On the other hand, relative economic disadvantage increases the probability of zero flows so is a region's land area size. However, the level of urbanization at area of origin and the relative numerical dominance of Indigenous people in an area have no effect on the incidence of inter-regional migration.

A similar picture also emerges from the count component of the ZINB model. In general, the results show that the volume of inter-regional migration increases with physical proximity and population sizes at area of origin and destination. Relative economic advantage and number of migrants previously settled in a destination area are also strongly and significantly associated with the probability of positive flows, while area size has no significant effect on migration turn over. Interestingly, differentials in the proportion of total population identified as Indigenous which had no effect on the incidence of inter-regional migration shows a strong and positive

impact on the volume of migration. Also, compared to capital cities, non-capital city destinations tend to have statistically significant positive flows of migrants, while the probability of out flow does not appear to be any different between capital city and non-capital city regions.

Concluding remarks

The Indigenous population of Australia has characteristics that distinguish it from the country's population. Although there had been attempts to examine the settlement structure and mobility patterns of Indigenous Australians, in the context of its unique experience, existing studies tend to be geographically restricted, methodologically less rigorous and provide very little or no information about factors affecting observed patterns (Taylor and Bell, 1999, 2004; Warchivker et al. 2000; Povinelli E.A. 1993; Young 1990; Young and Doohan 1989; Gray 1989; Uzzell 1976). The present paper addresses these shortcomings; it accesses new source of data, applies more refined techniques of analysis and, for the first time, examines the determinants of internal migration in the population.

The results of the study showed that the Indigenous population is highly mobile than the rest of Australia's population with a pattern of migration that is characterized by family rather than labor related mobility. This observation is consistent with previous studies on Indigenous migration in Australia (Smith 1980; Gray 1989; Taylor and Bell 1994, 1996, 2004; Young 1990) as well similar studies on Indigenous peoples in other first world contexts (Bedford and Pool 2004; Eschbach 2004; Snipp 2004; Norris et al. 2004). This phenomenon may broadly be linked to demographic, economic, institutional and socio-cultural factors. On average, Indigenous Australians have high fertility and high rate of marital dissolution (Gray 1983, Tesfaghiorgis 1996, Kinfu and Taylor 2002, 2005), and these demographic outcomes often require regular residential adjustments. The Indigenous population also has low rate of home ownership and low average income than the country's population as a whole (ABS 2001); this means that, for this population, tenancy is less stable and residential preferences had to often respond to changing rent levels, government housing provisions and landlord tests, all of which are likely to prompt high level of mobility in the population. In addition, the multi local residential life style of Aborigines, their continued detachment from the country's labor market, and extensive cultural engagement which involve attendance to ceremonies over extended periods could explain the high level of population mobility in this population.

At macro level, the volume of inter-regional migration is strongly associated with physical proximity, relative economic advantage of regions and number of migrants previously settled in a destination as well as with population sizes at area of origin and destination. Non-capital city destinations and destinations that had high proportion of their total population identified as Indigenous also have high inflows of migrants. Methodologically, the study demonstrates that the Poisson model is less efficient in modeling aggregate migration flow data, and future research need to focus on more refined approaches, particularly on zero inflated and hurdle variants of count data models used in the study. In addition, the techniques of estimating partial migration expectancies and age-specific moves lost due to mortality from period migration and mortality data as well as the method of testing the statistical independence of migration schedules demonstrated in the present analysis are also important methodological contributions on their own right.

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