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ECONOMICS OF THE AGEING: GENERATIONAL ACCOUNTING AND REGIONAL PUBLIC GOODS IN AUSTRALIA[1]

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ABSTRACT: The ageing of Australia raises many pressing questions for policy makers, not least is the formulation of economic policy that tackles difficult problems of equity and efficiency. Fortunately an embryonic Australian literature already exists that provides a solid basis for rational policy formulation, including the Commonwealth Government's (2002) *Intergenerational Report*. This paper seeks to add to this nascent literature by developing a model of generational accounting and extending it to incorporate regional public goods. The extended model can assist policy makers concerned with intergovernmental finance in approaching the problems posed by demographic change for Australian fiscal federalism.

1. INTRODUCTION

Sustained media attention has ensured that the potential problems associated with an ageing population are now firmly planted in the public consciousness. Australian policy makers have already begun to explore the ramifications of these demographic trends. For example, the Commonwealth Government's *Intergenerational Report* (2002) has laid a solid foundation for future policy discourse on the economic and social implications of an ageing population. However, actual policy formulation is still in its infancy. As Sims (2003) has argued in the recent Chifley Research Centre publication *Fiscal Policy Rules in Australia*, 'just how much policy should be "optimally" adjusted in the face of these demographic and technological trends raises difficult questions relating to both efficiency and equity' that have yet to be examined in any detail. The present paper seeks to extend this nascent literature by discussing possible modifications to generational accounting to accommodate the problem of regional public goods confronting Australian fiscal federalism.

Regional public goods must be distinguished from local public goods and

[1] The views expressed in this paper are those of the authors. They are being published as a contribution to public discussion of the issues. They should not be considered as necessarily representing the views of the Australian Treasury, the Treasurer or the Commonwealth Government. Accordingly, use of any material from this paper should attribute the work to the authors. Brian Dollery would like to acknowledge financial assistance from the Australian Research Council through an ARC Discovery Grant. The authors would like to thank anonymous reviewers for their helpful assistance with an earlier draft of the paper.

national public goods. In the institutional context of the Australian federation, an example of a regional public good would consist of a public road linking two urban centres in adjacent local government areas and could be contrasted with interstate highways as national public goods and small local roads as local public goods in residential suburbs within a local government jurisdiction that serve only local people living in these suburbs.

The paper itself is divided into three main parts. Section 2 outlines the theoretical framework for generational accounting and seeks to extend the original generational accounts framework developed in Auerbach et al. (1999). Section 3 attempts to adapt the basic model to incorporate regional public goods. The paper ends with some brief concluding remarks in section 4.

2. GENERATIONAL ACCOUNTING METHODOLOGY

Following Auerbach and Kotlikoff (1999:31) the government's inter-temporal budget constraint is expressed in equation (1) as:

$$_{k=t-D}\Sigma^{t}.N_{t,k} + (1 + r)^{-(k-t)}{}_{k=t+1}\Sigma^{\infty}N_{t,k} = {}_{s=t}\Sigma^{\infty}G_s(1 + r)^{-(s-t)} - {}^{g}W_t \qquad (1)$$

where N is the present value of the average remaining lifetime net tax payments for all individuals of the generation (say born in year k at the base year of the analysis, time t); D is the maximum length of life; t is time; k is the year of birth of a cohort; r is the real discount rate; s is the current year; g: is a super script to denote government; G is government consumption; and W is persons of working age.

The generational account is:

$$N_{t,k} = {}_{s=z}\Sigma^{k+D}T_{s,k}P_{s,k}(1 + r)^{-(s-z)} \qquad (2)$$

where z = max(t,k); T is tax payments net of transfers; P is the population of surviving members of a cohort and z is a time which is either t of k, whichever is the largest.

The constraint requires that (on the left hand side) the present value of future tax payments net of transfers of the current and future generations be sufficient to cover (on the right hand side) the present value of future government consumption and service the government's initial net indebtedness. The constraint and the generational account are related by the term $N_{t,k}$. All items in equation (1) and (2) are real values (i.e. measured at constant prices).

On the left hand side of equation (1), the first term is an envelope expression that adds together the generational accounts of existing generations. The generational accounts are the present value of the remaining lifetime net tax payments. $N_{t,k}$ represents the present value of the average remaining net tax payments for all individuals of the generation born in year k at the base year of the analysis, time t, which for expositional purposes is set at year 2002. In this summation, k is an index, which runs from t - D to t. Thus, for those aged D, the maximum length of life, then t = 0, and there are no further net tax payments. For those age 0, the new-born, then t = D, and the remaining net tax payments run from k = 0 to D and thus are equal to total lifetime payments.

We now turn our attention to the detail of the generational account for the individual, contained in equation (2). The term $T_{s,k}$ is the projected average net tax payment to the government made in the year s from the generation born in year k, and $P_{s,k}$ is the number of surviving members of the cohort in year s who were born in year k.

Consider members of the current generation; that is, for generations born prior to year t (k < t). In the Σ term, z = max(t,k) = t, since k < t. The summation begins in year t and runs for k + D periods. Each account is then discounted to year t by the real interest rate, r.

An example may serve to clarify this argument: First we focus on that part of equation (1) that refers to the current generation, ${}_{k=t-D}\Sigma^{t}\, N_{t,k}$, and from equation (2), the generational account, $N_{t,k} = {}_{s=z}\Sigma^{k+D} T_{s,k} P_{s,k}(1 + r)^{-(s-z)}$, then by substitution of (2) into part of (1), we have the double summation:

$$ {}_{k=t-D}\Sigma^{t}\, N_{t,k} = {}_{k=t-D}\Sigma^{t} \cdot {}_{s=z}\Sigma^{k+D} T_{s,k}\, P_{s,k}\, (1 + r)^{-(s-z)} \qquad (3) $$

Since we are dealing with the current generation, k < t, and thus z = max(t,k) becomes z = t. Equation (3) now becomes:

$$ {}_{k=t-D}\Sigma^{t}\, N_{t,k} = {}_{k=t-D}\Sigma^{t} \cdot {}_{s=t}\Sigma^{k+D} T_{s,k}\, P_{s,k}\, (1 + r)^{-(s-t)} \qquad (4) $$

Assume that we are interested in the cohort born in 1972 (=k). This cohort is presumed to live for (D=) 85 years, and the base year of the study is (t=) 2002. Taking the inner summation first, the summation runs from the year (s = t =) 2002 to (k + D = 1972 + 85 =) 2057, which is 55 periods and represents the expected remaining lifespan of the cohort born in 1972. The net tax payments, $T_{s,1972}$, are a stream of taxes less transfers, in some years positive and in other years negative, depending on the stage in the life cycle of the cohort for 55 periods. The term $P_{s,1972}$ is the population of the cohort born in 1972, the number of which will decline according to the rate of natural attrition until the cohort reaches 85 years old when life is assumed to expire for all those remaining in the cohort at that time. For those born in 2002, the base year, this cohort has a generational account of net tax payments over the whole of their lifetime. So they will live until (k + D = 2002 + 85 =) 2087. For those born in 1917 and are thus aged 85 years in 2002, they are assumed to have reached the maximum length of life, and so there are no further transactions. In this case the index runs from t = 2002 to(k + D = 1917 + 85 =) 2002. If we now examine the outer summation, then we can extend the preceding discussion to all of the current generation. We thus have a series of generational accounts, which include the outer limits of the current generation, that is, those born in 1917 and 2002, and a middle cohort, those born in 1972, expressed as follows:

$$\begin{array}{l} {}_{2002}\Sigma^{2002} T_{s,1917}\, P_{s,1917}\, (1 + r)^{-(s-2002)} \\ \vdots \\ \quad {}_{2002}\Sigma^{2057} T_{s,1972}\, P_{s,1972}\, (1 + r)^{-(s-2002)} \\ \vdots \\ {}_{2002}\Sigma^{2087} T_{s,2002}\, P_{s,2002}\, (1 + r)^{-(s-2002)} \end{array} \qquad (5)$$

The outer summation collects together the generational accounts for each cohort for the current generation; that is, for each of the cohorts born in 1917 through to 2002, noting that k is an index.

The second term in equation (1) is the present value of net tax payments for future generations, again with k representing the year of birth. Turning to the generational account in equation (2), for generations born after year t ($k > t$). Hence, in the Σ term, $z = \max(t,k)$ becomes $z = k$. Thus the inner summation begins in year k and runs for (D=) 85 years. The profile of the net tax payments and population for each cohort in future generations is assumed to be identical, so the model reaches a steady state. Regardless of the generation's year of birth, the discounting is always to year t. Consider the outer summation. If a member of a future generation were born in 2012, 10 years after the base year, then the summation would run from the ($k = t + 1 =$) 11th period to infinity. As the values are in terms of the year in which the cohort was born, the values must be brought back to the base year of the study, year $t = 2002$. Thus, the values are further discounted, according to r, the pre tax real discount rate.

On the right hand side of equation (1), the first term expresses the present value of the sum of government consumption (for all generations) from the base year (t=) 2002 to infinity, discounted back to the base year. Government consumption is not attributed to particular generations because this raises unnecessary complications. An implication is that the accounts do not show the full burden of any generation for government policy as a whole.

The second term is the government's net worth, ${}^{g}W_t$, in year t. Most of the conceptual literature refers to this term as net debt of the government (Cuddington 1996:3). The inter-temporal budget constraint does not assume that the government debt is ever fully repaid, merely that the debt grows less quickly than the rate of interest.

Taxes paid are net of transfers, where transfers cover payments to individuals (e.g. age pensions), health and education. All other government expenditures are treated as government consumption and remain part of the G_s term.

The inter-temporal constraint on fiscal policy can be observed from equation (1). Holding government consumption and net worth constant, a reduction in the present value of taxes by the current generation requires an increase in the present value of taxes by future generations.

3. FISCAL FEDERALISM: EXTENDING THE MODEL TO REGIONAL PUBLIC GOODS

Long term fiscal projections could be disaggregated between the Commonwealth, the states and local government to attribute the intergenerational fiscal imbalance to each tier of government, and measure the consequent pressure to adjust intergovernmental fiscal transfers (IFTs) in the fiscal-federal gap as the long term cost drivers emerge. This analysis could be further extended using Generational Accounting by disaggregating net taxes and population structure into geographic regions (using state or local government statistical districts), which would enable an examination of the impact of demographic change on the provision of public goods at the regional (state or local) level.

A key message of the fiscal federalism literature is that a central government can design a tax and IFT scheme to channel funds to a region to enable inter-jurisdictional spillovers to be internalized and thus maximize social welfare. Cullis and Jones (1998:319) present several rationales for IFTs. First, there may be external benefits for neighboring regions as a result of any one region's expenditures. Since these are benefit spillovers, the regional government responsible for such activity takes no account of it in decision-making. A second reason is the promotion of a merit good. Third, fiscal equalization, where, even if there is overall fiscal balance, some governments may be unable to finance their programs that other authorities find easy to fund. For example, a health program for Aboriginal children to address hearing impediments due to mites is a much greater fiscal burden in the west Kimberly region than it is on Canberra. Fourth, revenue sharing, where it is efficient for central government to act as a vehicle for collection of tax, and return it to the regions. The main theme for the rationale for an IFT boils down to the funding of a fiscal burden on a region where that burden can be defined as the valuation of the regional public good (both for the residents and the non-residents of the region) in excess of the current resident population's willingness to pay for the regional public good.

Demographic change intersects with fiscal federalism in at least two ways. In the first place, the preferences for and the utilization of public goods vary across different demographic groups, which influence the cost function. For example, a region may consist of a disproportionately large number of young persons who disproportionately consume education. Second, demographics affect the degree of the spillover and the capacity of the region to fund public programs, and hence affect the socially optimal amount of the IFT. For example, demographic groups have different mobility rates, and consume goods with varying degrees of spillovers. Retirees tend to drift to coastal urban and rural regions, particularly in northern NSW, Queensland and southern WA, and about two thirds of recent immigrants locate in Sydney and Melbourne. The central issue is that the level of the public good is fixed, and the voting power of the resident regional community will determine the level or quality of the public good.

A possible mathematical representation of a regional fiscal burden from the demographic perspective is as follows. Let region i be one of many regions in Australia, where the demographic structure of this region at time t is summarized by the vector ${}^{i}x_t = ({}^{i}P_t, {}^{i}p_t)$. The population size is denoted by ${}^{i}P_t$, and ${}^{i}p_t = ({}^{i}p_{1t,}\ldots\ldots{}^{i}p_{kt})$ is the vector of shares for k different population cohorts. These cohorts could have a range of characteristics, such as gender, race, ethnicity, but in the present context we will focus on age structure. If we assume that there are three cohorts in the vector, then the share of the population that is under the working age, that is the young, is denoted by ${}^{i}Y_t$, the working age, denoted by ${}^{i}W_t$, and the elderly or retired, denoted by ${}^{i}E_t$. The vector representation is thus $({}^{i}P_t, {}^{i}Y_t, {}^{i}W_t, {}^{i}E_t)$. A further assumption, for convenience, is that the total Australian population remains constant so that if there were six regions i = 0 to 6 then ${}^{i}\Sigma_{i=0}\, {}^{i}P_t = \bar{P}_t$, which denotes the total Australian population, fixed at time t. However, local population size and age structure is determined endogenously through the location choices of individuals, while the demographic characteristics of the total population are assumed to be exogenous.

Now suppose a regional government, i, in period t, produces a public good, the quantity and quality of which is denoted by ${}^{i}lg_t$, and faces a cost function of the form:

$$ {}^{i}RC_t = c({}^{i}p_t, {}^{i}lg_t,) \tag{6} $$

where R is a region and C the cost of the public good in question.

For instance, ${}^{i}lg_t$ might represent health services to young Aboriginals, which is delivered through some level of spending according to the regional cost function that depends on the demographic characteristics of the regional population. A variation on this example is to consider ${}^{i}lg_t$ as a composite of a variety of public goods provided by the region. The demographic composition of the community will determine how much of the public good is provided.

The size and composition of the regional population can enter the cost function for the regional public good in various ways[2]. First, the cost of providing a given level of ${}^{i}lg_t$ depends on the size of the population, ${}^{i}P_t$, in the region. Second, to the extent that the public good is targeted to certain demographic groups, expenditure on the public good depends on the size of the population shares in each cohort; that is, ${}^{i}Y_t$, ${}^{i}W_t$ and ${}^{i}R_t$. If there were no young Aboriginals in the region, then the public health services would have per capita expenditure of zero. Third, characteristics of the regional population may create externalities within the region that cause more or less per capita spending on the public good than would otherwise be the case. For example, for a negative externality, like widespread substance abuse in the regional population, may prevent young Aboriginals from attending school, thereby causing education of a particular quality for young Aboriginals to be much more expensive in the presence of these characteristics than in other regions.

Consider an inter-temporal spillover.[3] Let income in region i at some time in the future, say period t + 1, be denoted by, ${}^{i}RI_{t+1}$, and that future income is a function of three elements. In the first place, regional income depends on demographic composition of the region, ${}^{i}x_{t+1}$. Second, regional income depends on expenditures on public goods (such as education and infrastructure) by the government of region i in a previous period. Thus current public expenditures by region i may result in future income for residents of that region. Third, if we assume that region j invests in public education at time t and that some of the

[2] Unless lg is a pure public good, whereby there is no rivalry in consumption. The public goods considered here have some element of rivalry and involve some congestion.

[3] There are many types of regional spillovers that could be modelled relating to investment and consumption.

beneficiaries of that education migrate to region i when they reach working age at time t + 1, then the income of region i in period t + 1 is a direct consequence of the investment of region j in period t. Overall, income of region i at a time in the future, t + 1, is a function of the region's demographic composition in that period, the region's current expenditure on public goods and spillovers from current public good expenditures of region j, which is expressed as:

$$ {}^{i}RI_{t+1}. = RI({}^{i}x_{t+1}) + \alpha({}^{i}lg_{t}) + \beta({}^{j}lg_{t}) \quad (7) $$

Two inter-temporal expenditure spillovers are introduced through this regional income equation. First, for $\alpha > 0$, current public good expenditure in region i leads to higher income in region i tomorrow. This is an inter-temporal spillover. Second, for $\beta > 0$, current public good expenditure in region j leads to higher income in region i tomorrow. This is an inter-temporal interregional spillover. In both cases, the inter-temporal spillover can be interpreted to be an intergenerational transfer for suitably adjusted periods of time. For $\alpha < 0$ and $\beta < 0$, the spillovers are negative, and region i in period t+1 faces an intergenerational burden.

The implications of this model for the role of central government in the provision of IFTs are interesting. The fiscal burden on a region can be defined as the valuation of the regional public good (both for the residents and the non-residents of the region) in excess of the current resident population's willingness to pay for the regional public good. The model of intergenerational transfers (either benefit or burden) can be expressed for any region, but intergenerational fiscal benefit is easiest to specify for region i and intergenerational fiscal burden is readily defined for region j.

Accordingly, for region i, the intergeneration fiscal benefit in the future, that is period t + 1, can be represented as:

$$ {}^{i}IFT_{t+1} = {}^{i}RI_{t+1} - {}^{i}RC_{t+1} = RI({}^{i}x_{t+1}) + \alpha({}^{i}lg_{t}) + \beta({}^{j}lg_{t}) - c({}^{i}p_{t+1}, {}^{i}lg_{t+1}) \quad (8) $$

Suppose that the region can only use benefit taxes to raise revenue. Suppose further that there are many regions and that individuals sort themselves into regions based in part on their tastes for public goods. In this situation there are no spillovers, $\beta = 0$, and there is no role for central government in the provision of IFTs. For any value of α, regional finance can be used to cover the intergenerational transfer. For example, if $\alpha > 0$ then the region can issue bonds in period t to finance the public expenditure. The bonds are then repayable by future generations via benefit taxes, and no central government IFT is needed. This is a Tiebout equilibrium. Tiebout (1956) argued that citizens are mobile between jurisdiction in response to perceived trade-offs between local public good provision and local taxation to finance local public goods. The result will be an equilibrating movement of population that will be welfare enhancing by producing a pattern of local public good provision that meets different preferences by different groups of citizens.

An important assumption is that the next generation will have incomes from which benefit taxes can be paid to regional government to meet the cost regional public goods or repay loans for public expenditure for a previous period. Suppose in period t + 1 the region has managed to attract many young educated workers (like interstate migration to Brisbane). Regional income will be high and public expenditure will be low (except for infrastructure congestion). So overall, the future generation of region 1 enjoys high incomes and has a lower call on central government to finance public goods.

Consider the future generation in region j. The intergenerational fiscal burden in period t + 1 is represented by:

$$^{j}IFT_{t+1} = {}^{j}RI_{t+1} - {}^{j}RC_{t+1} = RI({}^{j}x_{t+1}) + \alpha({}^{j}lg_{t}) + \beta({}^{i}lg_{t}) - c({}^{j}p_{t+1}, {}^{j}lg_{t+1}) \qquad (9)$$

If $\beta > 0$ for region i, then the rents to region i cannot be captured through benefit taxation in region j. This form of taxation refers to taxing residents of a given fiscal jurisdiction in accordance with the benefits they receive from the consumption of public goods and services rather than taxing these residents in proportion to their ability to pay. Thus benefit revenue from region j is not sufficient to finance the optimal amount of public expenditure in education from the perspective of regions as a whole. In this case, there is a role for an IFT from the central government to region j. A matching IFT would cause the regional government to internalize the spillover. As in the case of region i, region j can use finance to cover any portion, α, of public good expenditure by the previous generation in period t that has benefit to the future generation. Assume that the population of region j has aged so that it comprises of entirely of elderly people; that is, $^{j}P_{t+1}, = {}^{j}E_{t+1}$. Because the elderly are assumed not to earn income, benefit taxes cannot be imposed without causing social hardship, so regional income, $RI({}^{j}x_{t+1})$, is low. On the expenditure side, there is a high demand for regional public services because the population share, $^{j}E_{t+1}$, of the total population is high and the elderly are intensive users of public services to the elderly. Consequently, regional public expenditure $c({}^{j}p_{t+1}, {}^{j}lg_{t+1})$ is high. This factor provides the second reason for the role of central government in the provision of IFTs to region j. The financing of the transfer can be accomplished by the central government raising income taxes from both regions and sharing the income between each region in a proportion reflecting the fiscal burden of region j.

We argued earlier that generational accounting is a model of fiscal sustainability. This concept of fiscal balance requires that each generation should raise taxes to pay for public expenditure when the expenditure is incurred. Thus generational accounting informs the policy maker about what magnitude taxes would need to rise for current generations so that future generations do not face the fiscal burden of current generations. By extending generational accounting to the regional level, thereby introducing the relationship between demographic change and the provision of public goods, intra and inter intergenerational spillovers could be brought into the theoretical framework, thus enabling the generational accounting model to be utilized as a model of intergenerational equity. Thus, the extended model will enable the cost of public expenditures to be distributed overtime in a way that reflects the intergenerational spread of benefits generated by those expenditures.

4. CONCLUSION

Generational accounting is a method of long-term fiscal analysis based on a balance budget rule over both current and future generations and can be used to estimate the extent of fiscal burdens faced by current and future generations. Generational accounting can be extended in several ways. In the first place, by disaggregating population shares and net taxes into various cohorts for statistical districts (at either the state of local government level), fiscal projections can be developed at the regional level. In this paper we have sought to show that the fiscal burden on a future generation in a region is a function of; (i) the projected demographic structure, which affects differentially the income earning capacity and the demand for regional public goods according to the relative weighting and characteristics of the cohorts within the region; (ii) the effect of investments in education and infrastructure by the current generation, which is an intergenerational spillover of an intra-regional type; and (iii) spillover investments by the current generation from another region, which is an intergenerational transfer of an inter-regional type. While regional public goods should be financed by benefit taxes, it was then argued that this may not maximise social welfare and there is thus a role for central government in the provision of IFTs where a region faced a fiscal burden. Furthermore, it was shown that positive (intra and inter) intergenerational spillovers enable generational accounting to be extended as a model of intergenerational equity in addition to its original purpose as a model of fiscal sustainability.

Finally, it is necessary to add a caveat to the analysis. The model presented in this paper works best when regions are sufficiently large such that only a negligible proportion of residents of one region would be users of public goods in a neighbouring region to which they do not contribute to its revenue-raising activities. In general, in the Australian institutional milieu this implies that the model is less relevant to the local government level than the state or territory level. This caveat is amplified by the fact that the notion of benefit taxes and regional bond issues outlined in the third part of the paper suggests the model described is more relevant at the state level than the local authority level. Given real-world political considerations, a regime of regional bond issues at the local government area level is obviously problematic.

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URBAN FREIGHT IN AUSTRALIA: SOCIETAL COSTS AND ACTION PLANS

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ABSTRACT: The effective and efficient movement of freight is critical to Australia's economy and must be assured in the face of changing local and global conditions. However, the tensions between facilitating economic activity and the impacts on traffic and the environment are heightened due to the intensely competing demands evident in urban areas. These conditions give rise to many issues which local authorities are starting to address within their traffic management plans. This paper reports on societal costs and other direct costs of urban road freight in Australia. This paper reviews recent Australian and international data on the costs of increasing traffic from trucks, vans and service vehicles within urban communities. It also presents examples of actions and policies that local government is implementing to protect their communities and the urban environment.

1. INTRODUCTION

In 2000, freight logistics activities represented $57 billion or approximately 9 percent of Australia's gross domestic product (GDP). Of these activities, approximately $31 billion were performed 'in-house' by Australian businesses. The remaining $26 billion represented those activities undertaken by the freight logistics industry as services to the business community, of which $23 billion worth of services were provided by transport logistics suppliers. The trend towards increased e-business has important consequences for the transport system. As a result of e-business, companies are beginning to operate with reduced inventories, more orders, smaller order sizes and more customisation. Transport logistics will change to delivering smaller quantities of goods more often (just-in-time processes). Early ballpark figures suggest that by 2005, e-business in Australia could double kilometres travelled by light commercial vehicles and increase articulated truck trips by 50 percent (but not necessarily tonnage) (NTS, 2002).

The effective and efficient movement of freight is critical to Australia's economy and must be assured in the face of changing circumstances, such as an increased emphasis on global markets, shifts in domestic economic activity to the suburbs and suburban malls, new transportation patterns for improved logistics efficiency, growing congestion on the nation's roads, heightened concerns about transportation security and capacity, and increased maintenance requirements. However, in many cases, the tensions between facilitating economic activity and the impacts on traffic and the environment are heightened due to the intensely competing demands evident in urban areas.

This paper presents the major societal costs directly imposed by urban freight traffic in Australia and how local government is responding to the concerns of community and environment. The costs are quantified mainly from impacts on road and traffic, and human health. Major impacts on roads and traffic are identified as delays caused by congestion, disruption caused by crashes and incidents, and pavement damage caused by heavy vehicles. Major impacts on health and amenity include disease due to air pollution, and stress due to noise. However, because of space limitations, environmental impacts will not be discussed. These include impacts on the built and natural environment such as visual pollution, damage to buildings and vegetation from air pollution, full transport lifecycle costs, and finally, global warming due to greenhouse gas emissions.

2. EVALUATION METHODOLOGIES

The causal chains linking the initial urban freight travel with its final impacts on society are complex and usually non-linear, making assessment challenging. In numbers of cases, there are set thresholds which should not be exceeded or set targets for reduction. To enable the impacts to be compared, a common base is needed. Thus, in all cases, estimates of the monetary costs of impacts were sought from the literature. Unfortunately as many societal costs are "externalities" that are not traded in the market, valuation is not simple and no single method is appropriate for all cases.

A number of approaches to valuing the external costs of transport exist. Detailed discussion of methodologies can be found in the documentation for Envalue (1995), the NSW EPA environmental valuation database (NSW EPA, 1995) and in Tsolakis and Houghton (2003), who report the latest trends in transport externality evaluation. In brief, the methodologies fall into three categories:

1. *Market- Based*: costs and prices from conventional markets which then fall into two further subcategories:
    a. *Damage Costs*: that measure the actual costs of damages or of repairing the damage;
    b. *Avoidance Costs*: that reflect the cost of preventing the damage;
2. *Surrogate Market-Based*: where actual impacts can't be measured, so proxies such as changes in property values (hedonic pricing) in areas of high traffic noise or extreme air pollution, are used.
3. *Opinion-Based*: values taken from responses to surveys or expert opinions. These methods include a range of stated preference

techniques, which test the communities' willingness to pay for an environmental gain or willingness to accept an environmental loss.

In general, tangible costs such as medical treatment costs are assessed using market-based methods, whereas intangible costs, such as loss of quality of life or pain and suffering, are better assessed by opinion-based techniques.

3. ROAD AND TRAFFIC

3.1 Congestion

Traffic Congestion: When the amount of traffic exceeds the capacity of the road space on which it is travelling, congestion occurs. Large freight vehicles take more road space than passenger vehicles. Traffic engineers use passenger car units (PCU) to estimate that extra space requirement as 1 rigid truck = 2 passenger cars and 1 articulated truck = 3 passenger cars. Light commercial vehicles equate to only 1 PCU. In the latter case, and possibly in all cases, this is an underestimate of the extra impacts of freight vehicles on traffic. Truck characteristics such as slower starts in "stop-start" traffic also impact congestion.

Impacts of Congestion: Congestion, as an economic externality, imposes significant costs on society. They stem from two sources:

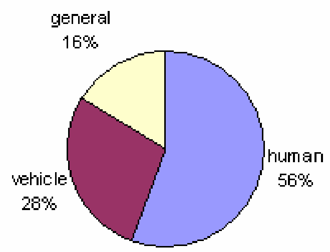
1. *Travel Delays*: due to slow speeds and stops and associated unreliability in trip timing
2. *Higher Fuel Use*: Fuel consumption per vehicle under congested traffic conditions is approximately twice that under free-flow conditions.

Social Costs Due to Congestion: These costs come from impacts imposed on other road users (e.g. delays and extra fuel costs) and on society at large. Additional costs borne by society include the impacts of extra fuel use leading to emissions of noxious pollutants and greenhouses gases, which can be twice as high under congested conditions. BTRE estimates, based on the BTRE modelling of urban network congestion (detailed in BTCE, 1996a; 1996b ch.18), suggested that as much as 40 percent of the fuel used by road vehicles in Australia's major cities is the result of interruptions to the traffic flow. Society also bears some of the costs to business of travel delays. BTE (1999) estimates costs due to traffic congestion in Sydney at around AUD6.0 billion per annum in 1995. Under a business as usual scenario, these costs would rise to AUD9 billion per annum by 2015.

3.2 Crash Damages and Delay

Accidents involving trucks and other freight vehicles exact a heavy toll on Australian society and the economy. In fact, road crashes have been described as an "anti-industry", subtracting from, rather than adding to the economy. Various local and international research show that the occurrence of truck crashes results in a severe crash outcome with respect to property damage and cargo losses, and injuries and fatalities to truck occupants (FORS, 1997; NHTSA, 2002). While the crashes, which cause death or injury to either the trucks drivers themselves or to other road users, are of major concern, crashes resulting in property only damage (POD) and other incidents, such as breakdowns, are also important societal costs in urban areas. Because more traffic and more intersections increase the risk of crashes, truck crashes, just like car crashes, are more numerous in urban areas. However, only a minority of truck-related fatal crashes occurs in urban areas (Hassall, 2002).

While property only accident and incidents are far more numerous than serious crashes, there has been less attention given to estimating their impacts or their monetary costs. BTRE estimates of the total cost of road accidents, as presented in Figure 1 show the importance of travel delay ($1445 million) and vehicle repairs ($3900 million). This is an excellent example of detailed bottom-up costing that includes both market goods, such as repair costs and hospital costs, and intangibles such as quality of life.



HUMAN COSTS	$M
Medical/Ambulance/Rehabilitation	268
Long term care	1990
Labour in the workplace	1663
Labour in the household	1522
Quality of life	1769
Legal	813
Correctional services	17
Workplace disruption	313
Funeral	3
Coroner	1
Total	8359

VEHICLE COSTS	$M
Repairs	3900
Unavailability of vehicles	296
Towing	42
Total	4238

GENERAL COSTS	$M
Travel delays	1445
Insurance administration	926
Police	74
Property	30
Fire	8
Total	2483

Figure 1. BTRE Estimates of the Annual Cost of Road Crashes in Australia (BTRE, 2000)

3.3 Road Damage and Infrastructure Costs

Pavement Damage: Road damage externalities occur when a vehicle contributes to the wear and tear of the road, which reduces speed on the link and increases vehicle wear and tear for other road users. Damage to the road pavement results from the number of axle loads across a section of highway. This damage is proportional to the number of trucks operating on a section of road. More importantly, the damage caused by an axle load is disproportionate to the mass of the axle load. Heavy axle loads cause much more damage to the road pavement than axles with light loads. Thus pavement damage is largely caused by heavy vehicles, while the damage from passenger cars can be considered negligible (BAH, 2001).

Damage Rises Exponentially With Weight: The American Association of State Highway and Transportation Officials' (AASHTO) Road Test Study concluded that the relationship between vehicle weight and pavement damage follows an exponential geometric relationship closely resembling a fourth power (FHWA, 1998). Recent research in the area of mechanistic-empirical pavement performance predictions indicates that the exponential factor used to predict damage may be considerably higher than a fourth power relationship (Taylor et al., 2000). In any case, it is clear that a slight increase in truck loading results in orders of magnitude more damage to the road structure. To illustrate, one 80,000-pound five-axle truck does the same road damage as 9,600 cars. A seven-axle triple does as much damage as more than 27,000 cars (Dull, 2002).

Overloading Impacts: Truck operators in an environment of stiff competition and very slim operating margins are tempted to overload their trucks and evade weigh stations. Research performed in Idaho by Parkinson et al. (1992) showed that the average overload on a truck was 12 percent in excess of the legal allowable load and the increased pavement damage incurred would be in the order of 57 percent greater than originally accounted for in the design projections.

Costs of Road Wear: Road wear depends on weathering and road use, predominantly by heavy vehicles. It also depends upon the quality of the road surface; thus care must be taken when considering the relevance of international studies, for example, in estimating inter-urban highway damage in Australia's major cities. The BTE estimates the avoidable cost of road-wear attributable to a 6-axle articulated truck, carrying a 20–tonne load, at 0.63 cents per net tonne-km for arterial roads. Average fixed costs allocated to heavy vehicles mean an additional 0.34 cents per net tonne-km for the same vehicle configuration. Average total cost attributable to heavy vehicles is thus approximately 1.0 cent per net tonne-km. To put this in context, the annual tonne kilometres for road freight travelling just within Sydney is 1,528 million (ABS SMVU, 2001). Not all freight is carried by heavy vehicles but the prominence of bulk goods, as shown in Figure 2, suggests a road damage cost of around $10.0 million per annum due to intra-urban freight trips.

4. HUMAN HEALTH

4.1 Health Impacts of Air Pollution

Emissions produced by vehicles and related sources have a variety of effects on human health, varying from eye irritation and nausea to chronic lung diseases, cancer, or heart failure.

In a recent study estimating the impact on total health costs resulting from vehicle fuel consumption, CSIRO, BTRE, ABARE (2003) considered the most recent published estimates of the unit health costs of vehicular pollutant emissions and made assumptions about the location of production and combustion. Health cost estimates were derived for Australian conditions by Watkiss (2002) and are presented in Table 1. Watkiss' unit health costs are based on European health cost estimates, derived as part of the ExternE project (http://externe.jrc.es/), but adjusted for Australian urban areas. Watkiss provides separate unit health cost estimates that vary according to population densities ('Bands' 1 to 4). Noteworthy is the cost estimate for particulate matter (PM) used by Watkiss, which is higher than the majority of previous Australian studies (Beer, 2002; Coffey, 2003; and Amoako et al., 2003).

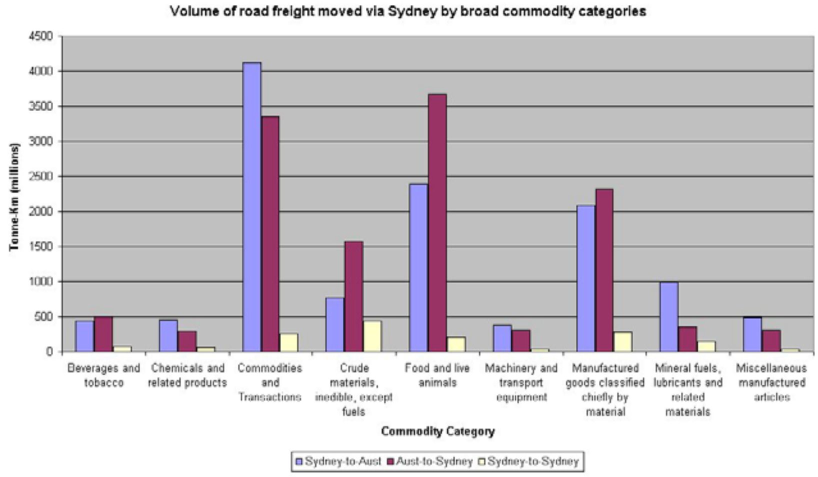


Figure 2. Freight Tonne Kms by Goods Category into and out of and within Sydney

Table 1. Assumed Unit Health Costs for Pollutant Emmissions in $AUD per Tonne of Pollutant

Emission	Band 1	Band 2	Band 3	Band 4
NO_x	1,750	1,750	260	0
CO	3	0.8	0.8	0
NMVOCs	850	880	180	0
SO_x	11,380	4,380	2,800	50
PM	341,650	93,180	93,180	1,240

Band 1 = Inner areas of larger capital cities (Sydney, Melbourne, Brisbane, Adelaide and Perth); Band 2 = Outer areas of larger capital cities; Band 3 = Other urban areas, including other capital cities (Canberra, Hobart and Darwin) and other urban areas; Band 4 = Non-urban areas.

Sources: CSIRO, BTRE and ABARE, 2003 after Watkiss, 2002.

Combining these figures with estimates of air pollutant emissions from a recent study of emission due to urban freight in Sydney under alternative scenarios, Zito and Taylor (2003) provided estimates of health costs in Inner Sydney area (band 1) of 0.08 -0.09 AUD/km for light commercial vehicles, 0.14-0.17 AUD/km for rigid trucks and 0.3 -0.34 AUD/km for articulated trucks.

Based on the benefit transfer to 2001 Australian dollars from the Infras/IWW (2000) European study, the total human health effects in AUD per 1000 tonne-kilometres estimated for light duty vehicles were in the range $30 - $130 with an average of $80 and for heavy duty vehicles $8 - $24 and an average of $16. Note that, although pollution per kilometre is higher for heavy-duty vehicles, they produce less pollution per tonne-kilometre as they carry much larger loads. The average values of air pollution health costs are about half the European values from which they are derived. This is consistent with expected lower emissions per urban hectare in Australia compared to Europe.

Overall, in Australia, the current estimates of the health costs due to all vehicle emissions range from 0.01 to 1 percent of GDP, some AUD5.3 billion a year (Brindle *et al.*, 1999).

4.2 Death and Injury Due to Crashes

Heavy Vehicle Crashes: A study of urban heavy vehicle crashes undertaken for the Federal Office of Road Safety in the early 1990s (Sweatman et al, 1995) found that there were then around 1000 serious heavy vehicle crashes per year in urban areas, costing the community in the vicinity of $100 million per year. These crashes formed 50 to 75 percent of serious rigid truck crashes and 25 to 50 percent of articulated truck crashes but only a small proportion of overall fatal crashes.

Valuing Life: The principal methods for valuing the fatality and injury components of road crashes are *human capital* (based on loss of productivity) and *willingness to pay* to avoid risk (based on real or preference data). As with estimating impacts of air pollution on human health, values placed on human life and the methods chosen to estimate these values are important in determining the outcome (BTRE, 2000). The human capital approach has been used by Australia's Bureau of Transport and Regional Economics (BTRE) (see Figure 1). The average cost of a fatality used was AUD1.5 million, a serious injury has AUD 325,000 and a minor injury equates to AUD12,000. Comparable results have been obtained from other countries; for example Canada for 1998 (Anielski, 2001), USA (NHTSA, 2002) and UK (Vickerman, 2000).

4.3 Traffic Noise

Cars and trucks are the major cause of noise in urban areas. It has been estimated that more than 70 percent of environmental noise is due to road traffic. As traffic changing speed is noisier than steady traffic, congestion adds to noise. The noise from heavy trucks changing gear is a particular problem. Increasing levels of traffic and increasing goods movements lead to increasing magnitudes of violation of transport noise level guidelines.

Dollar Costs of Noise: Unfortunately, it is difficult to estimate the health impacts of traffic noise which is recognised to have both physiological and psychological impacts. Even the costs of noise-related stress are difficult to estimate because the effects are cumulative over time. Instead the dollar costs of noise pollution from trucks or other traffic are most often estimated by hedonic pricing. The NSW EPA Environmental Database Envalue (1995) cites numbers of studies on the impacts of noise on house prices but notes only one study meets Envalue's method and data criteria. In Australia, a Noise Depreciation Index of 0.5 percent of property value per dB (A) is typically applied for noise levels in excess of a threshold level of 50dB(A) - 55dB(A) (Nairn et al, 1994).

In contrast, the INFRAS/IWW (2000) study uses a different methodology and estimates total noise costs as the sum of a willingness to pay component and an estimated health cost component. INFRAS/IWW cites health effects of noise exposure, such as disturbance and other stress reactions, as producing a 20 percent increase in mortality for transport noise above 65dB(A) based on two empirical studies conducted in the UK by Babisch et al (1993; 1994). Monetary estimates (AUD per 1000 tonne-kilometers) for noise impacts of freight transport, both urban and non-urban, estimated by Tsolakis and Houghton (2003), are in the range $16-$32 (average $23) for light duty vehicles and $2- $4 (average $3) for heavy duty vehicles.

5. LOCAL GOVERNMENT ACTIONS

Local governments in Australia recognise the need to both maintain and promote urban and regional development while encompassing economic, social and environmental values. Local authorities know that the safe and efficient movement of road freight is important to the community. The community also wants the transport system protected from security risks, such as terrorism and the distribution of terrorist materials. In many areas, local government also recognises that, as freight tonnages increase and the transport industry moves towards larger vehicles and longer working hours, further control of B-Double trucks and other heavy vehicle combinations may need to be considered, in consultation with the community and industry (QDOT, 2001).

Action plans have been developed and are being implemented by various local councils across Australia, in cooperation with state and federal agencies, in order to minimise the negative impacts of heavy freight in urban areas. These action plans are part of an overall land use transport strategy aimed at supporting and fostering economic development, investment, and employment and contribute to sustainable development and livable communities. A review of current transport strategies shows that these action plans can be broadly categorised into the following areas:

- Integrated transport research and planning,
- Investments in road infrastructure,
- Investments in rail and other infrastructure,
- Education, training and accreditation,
- Traffic management measures, and

- Environmental monitoring and health surveys.

5.1 Integrated Transport Research and Planning

To ensure that appropriate planning controls are in place that facilitate the efficient movement of goods, whilst minimising impacts on amenity and safety, access requirements (geographical and operational) for road freight need to be identified and understood. Thus, action plans are being implemented to:

- Undertake strategic roads analysis to identify expectations of road users and achieve the type of transport system that would best serve a particular community (QDOT, 2004);
- Undertake a review of the transport requirements including B-Doubles, over-dimension, dangerous and hazardous goods routes through industrial areas and connection to the port, railhead, highways and other manufacturing centres (QDOT, 2002a; DPI, 2000);
- Undertake detailed investigations into the provision of alternative freight routes around urban areas to address the impacts of through transport of freight or relocation of hazardous good movements. (QDOT 2001; 2003; 2004; and DPI, 2003);
- Plan for the creation of 'Compatible Use Zones' on key freight routes that will minimise conflict between heavy freight activity and adjacent land uses (DPI, 2003); and
- Establish hours of operation agreements or conditions with major freight originators, cargo interests and warehouses. This will help freight traffic avoid peak hour road congestion, avoid roads used by school buses and will make better use of port infrastructure and services (which operate 24 hours per day, seven days a week) (DPI, 2000; QDOT, 2002b).

5.2 Investments in Road Infrastructure

Various action plans upgrade or maintain the road infrastructure and improve standards for the economic life of the road, in accordance with state and local asset management policies and programmes. These action plans:

- Implement the "freight road" network by upgrading existing roads and/or constructing new roads where justified (DPI, 2000; 2003;QDOT, 2001; 2002a; 2002b; 2003; 2004; DOI, 2004);
- Identify road upgrading proposals and establish priorities (QDOT, 2001; 2004);
- Undertake safety audits for roads, as required (QDOT, 2001); and
- Develop appropriate areas for off-road breakdown, storage and servicing of heavy vehicles and for roadside rest areas (QDOT, 2003; 2004).

5.3 Investments in Rail and Other Infrastructure

In order to maximise the transfer of road freight to rail and alternative modes where viable, initiatives for improving rail infrastructure and decreasing freight on roads are being explored. These include:

- Removing competitive road advantages by implementing pricing mechanisms which incorporate externality costs such as environmental and social impacts, the costs of traffic congestion and damage to roads, in order to make the road haulage industry pay the true costs of its operations and to encourage transition to the greater utilisation of a rail freight system;
- Improving rail infrastructure such as rail access to ports, increasing sidings and multi-modal terminals (DOI, 2003; 2004);
- Facilitating efficient freight trains operation through continual upgrading to Fast Freight Train standards, crossing loops to provide more flexible and resilient operations, track realigning to enable time competitive freight and passenger journey times;
- Identifying alternatives to inland road freight depots (DPI, 2003);
- Assessing other barriers to effective on-rail competition and recommend the means to overcome them (DPI, 2003); and
- Exploring the advantages, disadvantages and future potential for the use of pipelines.

5.4 Education, Training and Accreditation

Programs are being implemented for the education of freight operators on safe and efficient freight operations and the training and accreditation of drivers. Some examples are:

- Western Australia (WA) has introduced heavy and multi-combination competency standards into driver training and licensing to produce safe, responsible and competent drivers. Transport and Main Roads WA have contributed to the development and implementation of the TruckSafe Industry Accreditation Program in conjunction with the Australian Trucking Association (DPI, 2000);
- The Code of Practice on Fatigue Management for Commercial Vehicle Drivers provides operating standards for work and rest in the Western Australian road transport industry (DPI, 2000);
- VicRoads has developed an integrated education campaign, the Freeway Truck Travel Benefit Program, to encourage freight operators to use the West Gate Freeway/Bolte Bridge for nighttime journeys to and from the Melbourne Ports and Rail Freight Terminals (DOI, 2004); and
- The Department of Minerals and Energy has developed a preliminary "dangerous goods road map" in conjunction with Guidance Note T117 "Recommendations for route selection for the transport of dangerous goods in the Perth metropolitan area" (DPI, 2000).

5.5 Traffic Management Measures

Congestion levels can be efficiently reduced (and social amenity improved) by a variety of measures ranging from traffic efficiency measures such as Intelligent Transport Systems, optimal use of road space (for example banning parking), quick response to incidents and major causes of delays under congested condition with no redundancy, or building new infrastructure. Various traffic management measures are being put in place to promote efficient heavy vehicle movement on designated freight roads. These include:

- Implementation of local area and arterial road traffic management measures such as traffic signal priority, the provision of turns at major intersections, limited direct property access where possible, kerb-side parking controls, turn bans and extended peak hour clearways (DOI, 2003);
- Installation of infrared traffic monitors and infrared height detection monitors (DOI, 2004);
- Enforcement of night-time and weekend truck curfews prohibiting all non-local heavy vehicles, and time restrictions in urban localities - particularly near schools and other sensitive areas where appropriate (QDOT, 2001; DOI, 2004);
- Promotion of programs to reduce overloading on the road network, such as the use of road-friendly suspension. (QDOT, 2003);
- Utilisation of intelligent access systems to guide freight movement (DPI, 2000); and
- Development of "Guidelines for Managing Truck Movements in Urban Areas" to manage the movement of freight traffic. These guidelines include strategies to make primary freight roads attractive to trucks and to encourage their use (DPI, 2000).

5.6 Environmental monitoring and health surveys

Along with the development of strategies to reduce the effect of noise from heavy vehicles on the community (QDOT, 2003; 2004), effects on air quality and visual amenity (both road and rail) are now being monitored as part of an overall environmental impact study (DPI, 2003). For example, the EPA monitored local air quality and noise levels, predominantly from traffic on Francis Street, Yarraville, at various times from March to May 2002. Measurements were taken both before and after a truck curfew was implemented on 4 April 2002. The traffic noise measurements at Francis Street were found to be lower during curfew periods. Also, the particle concentrations in 2002 were lower than those in 2001 (DOI, 2004).

6. CONCLUSION

It is widely accepted that urban freight brings billions of dollars worth of benefits to urban areas and is a critical component of the national economy. Efficient freight transport is essential to the well being of businesses and communities in Australia. At the same time, these communities want to minimise the negative impacts of urban freight on safety, congestion, health and the environment. To help better understand the magnitude of these impacts, this paper presented the societal costs of urban freight, quantified mainly from impacts on road and traffic, and human health. The paper also presented a summary of action plans currently being trialled by various local authorities and government agencies. It is hoped that these action plans will significantly contribute in achieving the delicate balance between safe, dynamic economic progress and changing lifestyle expectations and environmental considerations.

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UNDERSTANDING REGIONAL POVERTY IN INDONESIA: IS POVERTY WORSE IN THE EAST THAN IN THE WEST?

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ABSTRACT: This paper aims to investigate whether or not poverty is worse in the Eastern than in the Western part of Indonesia; and to understand the determinants of poverty in those regions. In this paper, cross-sectional and panel data techniques are applied to a provincial level data set for 1993 to 1996. The main findings of this paper are as follows. First, poverty is significantly worse in the Eastern than in the Western part of Indonesia. Second, an improvement in regional growth for the short- and medium-term does translate to poverty reduction, and third regional income inequality is the crucial factor determining regional poverty.

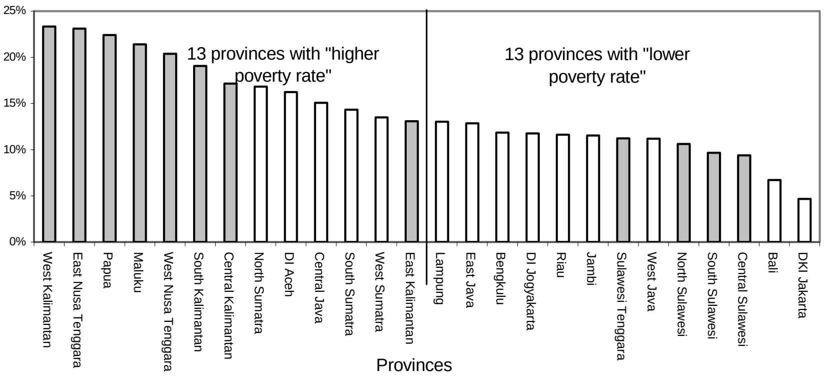
1. INTRODUCTION

Indonesia is one of the most diversified countries in the world. There are approximately 15 thousand islands, the main ones being Sumatra, Kalimantan, Sulawesi, Papua, and Java. Indonesia comprises approximately 31 administrative provinces and more than 400 districts or kabupatens, and approximately 230 million people from more than 300 ethnic groups.

From 1970–1996, Indonesia was able to achieve an average annual economic growth of approximately 7 percent, which was said to lower and reduce levels of income inequality and poverty. However, income inequality measured by the Gini Index only slightly decreased from approximately 0.4 between 1970 and 1980 to approximately 0.3 between 1980 and 1985 (Miranti, 2000). On the other hand, poverty reduced significantly. The percentage of the population living on under $1 a day (1985 PPP$) decreased from 87.2 percent in 1975 to 21.9 percent in 1995. Nevertheless, there is a disparity in the process of economic development among regions in the country (Tadjoeddin et al., 2001; Esmara, 1975), with the Western part of Indonesia, comprising Sumatra, Java and Bali, developing faster than the Eastern part, or rest of Indonesia. It is suspected that the poverty level is higher in the East than in the West of Indonesia. Figure 1

[4] The authors would like to thank Chris Manning, Robert Breunig and Paul Chen of the Australian National University for valuable comments and discussion. However all mistakes are the authors' responsibility. Authorship is in alphabetical order; both authors contributed equally and share equal responsibility for the writing of this paper.

shows the average annual provincial percentage of the population living in poverty from 1993 to 1996, according to the Indonesian Central Body of Statistics.[5] It can be seen that most provinces in East Indonesia are among the 13 provinces with a higher percentage of the population living in poverty. However, further investigation is needed to prove that the poverty level is significantly higher in the East than in the West and, if so, why.



Note: The white bars are the provinces in the Western part of Indonesia, while the grey bars are provinces in the Eastern part of Indonesia.

Figure 1. Average Annual Percentage of People Living in Poverty, 1993-1996.

The main goals of this paper are:

- to prove statistically whether or not the poverty level in East Indonesia is significantly higher than in the West, and if so, to determine whether or not the poverty gap is widening;
- to observe whether or not regional poverty reduction keeps pace with an increase in regional growth; and
- to investigate the determinants of regional poverty, particularly whether or not regional growth and regional inequality are the main determinants.

This paper will also observe how regional poverty responds to its determinants. In particular, does regional poverty respond the same way to its determinants in the East and in the West?

The paper is organised into six sections. The introduction in Section 1 sets out the background. Section 2 investigates the literature review of the relationship between growth, inequality and poverty as well as the determinants of poverty. Section 3 presents the methodology utilised. Section 4 gives details of the data sources. Section 5 presents the results and a discussion. The final

[5] This is the head count poverty index. The definition is in Section 4 of this paper.

section discusses shortcomings and provides the conclusion.

2. LITERATURE REVIEW

The literature review conducted in this section aims to understand the links between inequality, growth and poverty. There are at least two channels of linkages in the literature. Channel A, which is from inequality to economic growth and then poverty (*growth effect*) (Deininger and Squire, 1996 and 1998; Ravallion, 2001; Dollar and Kraay, 2000) and channel B, which is from economic growth to inequality and then to poverty (*inequality effect*) (Kuznet, 1955; Lewis, 1954; Fields, 1980).

Theoretical and empirical evidence suggest that the growth effect of Channel A is stronger than the distribution effect of Channel B. There is little empirical evidence of the distribution effect of poverty reduction. White and Anderson (2001) use data from 143 growth episodes to decompose the growth and distribution effects. They found the growth effect in most cases dominates, while distribution is important in some significant cases. Deininger and Squire (1998) also mention that 80 percent of the variation in the incomes of low income people is due to variation in overall income per capita incomes, and only 20 percent is due to differences in income distribution over time or over countries.

However, Bruno, *et al.* (1996) finds that rates of poverty reduction respond more elastically to the rates of change in the Gini Index than to mean consumption. By regressing the change in the log of the proportion of the population living on less than $1 per day on the change in the log of the survey mean, and in the log of the Gini Index across 20 countries within the 1984–1992 period, and obtaining an elasticity to Gini index of 3.86 which is statistically significant (while the elasticity to the mean is -2.28), Bruno, *et al.* (1996) conclude that modest changes in inequality can affect change in the incidence of poverty. A fall in inequality has a positive effect on poverty. For any given rate of economic growth, the more inequality falls, the greater the reduction in poverty.

In the context of regional analysis, especially for Indonesia, not many studies in the literature discuss poverty on the left hand side as a dependent variable with economic growth and inequality as independent variables. Bidani and Ravallion (1993) construct a regional poverty profile for Indonesia in 1990, which assures the poverty lines used for different regions reflect the same purchasing power over basic consumption needs. They estimate poverty levels, split into urban and rural across each province, as a function of differences of mean consumption and the Gini index, using Ordinary Least Squares and Instrumental Variable estimations. Regional differences in poverty are explained by the basic needs purchasing power of mean consumption and the Gini index of Inequality Consumption.

Balisacan, *et al.* (2003) construct panel data from the 1993, 1996 and 1999 National Socioeconomic Survey on the country's 285 districts (kotamadya/kabupaten). Fixed Effect and Random Effect estimates are derived from this panel data, using overall average per capita income as a proxy to reveal the impact of growth on welfare to the poor, as well as using per capita expenditure as a proxy exclusively. They then estimated the determinants of welfare for the poor, using the mean per capita expenditures of the poorest 20 per cent. The results confirmed that, besides growth, other factors directly influence the welfare of the poor, namely infrastructure, human capital, agricultural price incentives and access to technology.

3. METHODOLOGY

Regional analysis in this paper is at the provincial level and involves three types of analysis. **The first type concerns the inferences about μ_{west}-μ_{east},** where μ_{west} is the mean of provincial poverty measures in the Western part of Indonesia and μ_{east} is similarly defined for the Eastern part. The assumptions adopted in this analysis are of different sample size with unequal variance.

The a priori expectation is that the mean of provincial poverty in the West is less than that of the East. A t-statistic test is used to check whether or not the a priori expectation can be rejected.

The second type concerns the estimation of growth elasticity of poverty based on Ravallion's model (2001). In this analysis, the provincial growth elasticity of poverty is calculated. The hypothesis developed is that when the initial inequality is low, the poor will benefit more from economic growth than when it is high. In this case, the inequality lowers the growth effect on poverty reduction; i.e. it is not the rate of growth that matters but the distribution-corrected rate of growth.

The two equations estimated for this analysis are:

$$p_r = \beta\,(1\text{-}I_r)\,g_r + \gamma\,L_r + e_r \qquad (1)$$

$$p_r = \beta\,(1\text{-}I_r)\,g_r + \gamma\,L_r + \lambda\,D_r + e'_r \qquad (2)$$

where:

r is the index for regions or provinces,

p_r is the compound annual provincial poverty reduction during the interval year under consideration,

I_r is the initial level of provincial inequality (provincial Gini coefficient),

g_r is the compound annual growth during the interval year under consideration,

L_r is the initial level of provincial population,

D_r is the regional dummy, West = 0 and East = 1,

e_r & e'_r are the random errors, and

β is the growth elasticity of poverty (the expected sign is positive).

These two estimations are carried out using cross sectional Ordinary Least Squares (OLS).

The third type concerns the estimation of the determinants of poverty using a modification of the model developed by Balisacan et al. (2003). An attempt is made to assess the impact of certain variables, known as explanatory variables, on provincial poverty. These variables are categorised into three different groups, namely the structure of the economy (such as the roles of agriculture and mining), the structure of society (such as levels of education, dependency ratio, and income inequality) and the quality of public services. The interaction between these explanatory variables in each group and the level of provincial poverty can be categorised into two types of interaction (Figure 2):

- direct interaction, in which the explanatory variables directly influence poverty, and
- indirect interaction, in which the explanatory variables influence poverty through their impact on growth.

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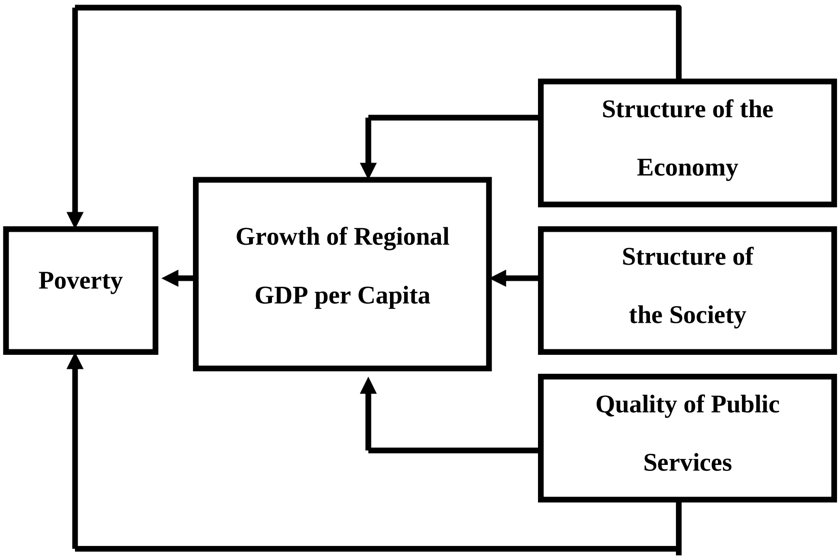

Figure 2. Framework Interaction between Poverty and Regional Conditions

Note that time and regional East-West dummies will also be included in this method. Based on this interaction framework, panel data estimations are carried out, where unobserved heterogeneity of provinces is controlled. The equation estimated for this analysis is:

$$P_{rt} = b\, x_{rt} + \eta\, t_{rt} + \lambda\, D_{rt} + \gamma\, D_{rt}\, x_{rt} + \alpha_r + + u_{rt} \qquad (3)$$

where:

r	is the index for regions/provinces,
t	is the index for year,
P_{rt}	is the level of provincial poverty in each year,
x_{rt}	are the explanatory variables including growth,
D_{rt}	is the regional East-West dummy,
t_{rt}	are dummies for years,
α_r	is the provincial fixed effect (unobserved heterogeneity), and
u_{rt}	is the random error.

Two types of estimation model are used. The first one assumes that growth is an exogenous variable. Random Effect (RE) and Fixed Effect (FE) estimations of panel data are then conducted. The *Hausman Test* is utilised to determine whether FE or RE is more suitable.

The second type assumes that growth is an endogenous variable. Growth in the previous year is then utilised as the instrument variable. Two Stage Least Squares (2SLS) Random Effect and Fixed Effect estimations are applied. The *Endogeneity (Wu Hausman) Test* is carried out to check whether or not the endogeneity treatment results in an inconsistent estimator.

4. DATA SOURCES AND DEFINITIONS

The data are taken from various publications of the Indonesian Central Body of Statistics (BPS) covering the period of 1993–1996. In this data set there are 26 provinces, excluding East Timor. There are 14 provinces in the islands of Sumatra, Java and Bali; i.e. in the Western part of Indonesia. The other 12 provinces are in the Eastern part of Indonesia, comprising the islands of Sulawesi, Kalimantan, Maluku, Nusa Tenggara. Variables utilised in this paper are as follows.

4.1 Poverty Measurement Variables

There are three measurements utilised in this paper (see Foster-Greer-Thorbecke (1984) as cited in Bidani and Ravallion (1993)). The first is the P0 or *headcount index or incidence of poverty*, which is the fraction of poor people in the total population in a province in a certain year. A person is poor when his consumption is less than a certain threshold, referred to as the poverty line. In defining this poverty line, BPS adopted the basic need approach; i.e. the 2,100 calorie per person per day requirement. The second is the P1 or *poverty gap index*, which is the mean distance of individual income below the poverty line in a province in a certain year. The mean is derived from the entire population, counting the non-poor as having a zero distance. The gap is expressed as a proportion of the poverty line. The third is the P2 or *squared poverty gap* or *severity of poverty*. This measurement takes into account not only how far the poor are from the poverty line but also considers inequality among the poor by giving a greater weight to those poor furthest from the poverty line in a province in a certain year.

Meanwhile, variables of compound annual poverty reduction utilised for the second analysis are defined as follows:

$$p_{i,r} = (P_{i,r,1996}/P_{i,r,1993})^{1/3} - 1 \qquad \text{for } i = 0, 1, 2 \tag{4}$$

4.2 Growth Variables

Growth is then calculated using data on the annual regional gross domestic product (RGDP) at 1993 prices; i.e.

$$G_{r,t} = (RGDP_{r,t} - RGDP_{r,t-1})/\ RGDP_{r,t-1} \tag{5}$$

Then the compound annual growth variable in the second analysis is

$$g_r = (RGDP_{i,r,1996}/\ RGDP_{i,r,,1993})^{1/3} - 1 \tag{6}$$

As much of the literature points out, for example Bruno, *et al.* (1996), Dollar and Kraay (2000), and Balisacan, *et al.* (2003), it is expected that RGDP growth will reduce poverty.

4.3 Structure of the Economy Variables

There are two variables utilised to represent the economic structure of a province: the provincial role of agriculture and the provincial role of mining sectors. The role of the agricultural sector in a province is calculated as a percentage of its share of the RGDP. Warr (2001) believed that growth of agriculture is important for poverty reduction, since the majority of the poor, in developing countries, live in rural areas and are employed in the agricultural sector. Accordingly, it is expected that the increasing share of the agricultural sector in the RGDP will induce a reduction in poverty.

The role of the mining sector in a province is calculated as a percentage of the oil and gas sectors' share of the RGDP. Balisacan, *et al.* (2003) argue that signs of this variable are not that obvious. It is most likely true that the oil and gas sectors in Indonesia have been the main engines of economic growth through their contribution to exports and to domestic labour markets by employing millions of workers. However, these sectors need relatively highly skilled workers. Therefore, when the level of education in the mining area is so low that only non-skilled labour is available, the impact of oil and gas activities on poverty reduction diminishes.

4.4 Structure of Society Variables

Population, levels of education, the dependency ratio and income inequality are used to represent the structure of society. Previous studies have not usually included a population variable in their equations. This paper will investigate whether or not provincial poverty is associated with the level of population in a province. For the level of education, this paper uses years of schooling for the primary working population (15–64 old years) as the variable for the provincial level of education. Several studies, for example Byron and Takahashi (1989) in the case of poverty in Java, found that increasing the level of education is significant in reducing poverty.

The level of dependency ratio is the ratio of the population under the age of 15 and over 64 as a percentage of the working age population (15–64 years old). The Asian Development Bank (1997) shows that increases in the growth rate of the population under the age of 15 are associated with decreases in an economy's growth rate, since this creates a negative relationship to current production. However, no significant association exists between economic growth and elderly people. For this paper, the impact of the dependency ratio on poverty, which covers both young and elderly individuals, will be investigated.

As for the level of income inequality, the Gini coefficient/index based on household expenditures is utilised. A prior expectation is that Gini inequality increases poverty (Bruno et al., 1996).

4.5 Quality of Public Services Variables

The level of financial decentralisation is defined as the ability of a province to raise its own revenue. The more successful it is, the higher the level of financial decentralisation in the province. In this paper, the level of financial decentralisation is utilised to explain the quality of public services. The assumption is that a higher level of financial decentralisation in a province leads to a more efficient allocation of public resources (Davoodi and Zou, 1998) and also promotes a better local preference in the development process (Oates, 1993). Hence, the more decentralised regions are more capable of providing better public services. Therefore decentralisation is believed to induce growth and by extension poverty reduction. The formula to measure the level of decentralisation in a province is 1 minus the portion of the total grant received from the central government to the total provincial expenditure; i.e. the portion of own total provincial revenue to the total provincial expenditure.

5. RESULTS AND DISCUSSION

The results of the estimations can be seen in Tables 1, 2 and 3, which are discussed in detail below.[6]

5.1 Is East Indonesia poorer than West Indonesia?

As can be seen from Table 1, there is a significant difference between the mean of poverty in West and East Indonesia, using the three poverty measures for 1993–1996, with the exception of P1 and P2 in 1993. Poverty measures in provinces in the West are almost always statistically less than poverty measures for provinces in the East. These findings prove that the East is poorer than the West. Furthermore, observing the situation in 1993 and in 1996, one can conclude that the gap between poverty in the East and the West worsens over time.

5.2 Does provincial poverty reduction keep pace with improvements in provincial growth?

In the case of poverty incidence reduction or p0, the answer is yes, when taking into account the initial level of inequality (see equations (1) and (2) in Table 2). The result is significant at the 1 percent confidence level. Please note that, in this analysis, poverty incidence reduction is the average annual poverty incidence reduction from 1993 to 1996, growth is the average annual growth of provincial RGDP from 1993 to 1996 and the initial inequality is the provincial Gini coefficient in 1993. Another important finding is that the East-West dummy is significant at α=5 percent, meaning growth is more effective in reducing poverty in the West than in the East.

Meanwhile, for the cases of poverty gap reduction (p1) and severity poverty reduction (p2), there is not enough evidence that these two poverty measures keep pace with improvements in provincial growth.

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6 Stata version 7.0 is utilised in carrying out the econometric estimations.

Table 1. Annual Poverty Measures in the East and in the West of Indonesia

	P0			
	1993	***1994***	***1995***	***1996***
μ_w	13.64	15.22	10.56	9.5
μ_e	17.83	19.04	15.59	14.49
$\mu_w - \mu_e$	-4.19	-3.82	-5.03	-4.99
t stat	-1.87	-1.79	-2.68	-2.74
Df	21	19	16	15
t 0.05	-1.72	-1.73	-1.75	-1.75
Reject H_0	yes	yes	yes	yes
	P1			
	1993	***1994***	***1995***	***1996***
μ_w	1.7	1.69	1.56	1.62
μ_e	1.88	1.92	1.81	1.83
$\mu_w - \mu_e$	-0.18	-0.23	-0.25	-0.21
t stat	-1.5	-3.55	-3.26	-2.55
Df	16	22	19	22
t 0.05	-1.75	-1.72	-1.73	-1.72
Reject H_0	no	yes	yes	yes
	P2			
	1993	***1994***	***1995***	***1996***
μ_w	4.6	4.58	3.98	4.27
μ_e	5.51	5.72	5.04	5.23
$\mu_w - \mu_e$	-0.91	-1.13	-1.06	-0.96
t stat	-1.33	-3.39	-2.69	-2.25
Df	14	21	19	21
t 0.05	-1.76	-1.72	-1.73	-1.72
Reject H_0	no	yes	yes	yes

Note: μ_{west} is the mean of provincial poverty measures in the Western part of Indonesia and μ_{east} is the mean of provincial poverty measures in the Eastern part of Indonesia.

5.3 What are the determinants of poverty, and do regional poverty in the East and in the West respond differently to their determinants?

Table 3 summarises the results of the third analysis. Since the Hausman test concludes that Fixed Effect estimation is the correct specification, results for the RE estimation are not presented in Table 3.

The paper carries out a 2SLS estimation to capture the potential endogeneity of the growth variable. The endogeneity test rejects the null hypothesis that the difference in coefficient of FE and 2SLS FE are not systematic for P0 and P2. Therefore, there is no need to have the 2SLS estimation. However, the endogeneity problem exists in P1, therefore the 2SLS FE is the correct specification.

From Table 3, equations 2 and 6 show that the annual growth of RGDP is a significant variable in determining P0 and P1. However the sign for P1 is unexpected, namely that growth contributes positively to poverty. In the case of

P0, the finding confirms the result in the second analysis. The findings conclude that growth, both short-term (in the third analysis) and medium-term (in the second analysis), is significant in explaining poverty. Recall that growth in the second analysis is the average annual growth of provincial RGDP from 1993 to 1996, while, in the third analysis, growth is the annual provincial growth of RGDP.

Table 2. Growth Elasticity of Poverty

	p0		p1		p2	
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
(1-I)g	1.625 ***	2.584 ***	0.179	0.255	0.212	0.273
	(6.56)	(5.88)	-1.07	(1.17)	-0.69	(0.44)
East-West Dummy		-7.908 **		-1.085		-1.604
		(-2.6)		(-0.47)		(-0.37)
Population		-0.00022		0.000013		0.000059
		(-1.57)		(0.12)		(0.30)
R-squared	63%	72%	4%	6%	2%	4%
N	26	26	26	26	26	26

Notes:
*means significant at α=10%; **means significant at α=5%;*** means significant at α=1%
Figures in parentheses are the t-ratios
p0 = compound annual provincial incidence of poverty reduction, 1993-1996,
p1 = compound annual provincial poverty gap reduction,1993-1996,
p2 = compound annual provincial severity of poverty reduction,1993-1996,
I = provincial Gini, 1993
g = compound provincial RGDP,1993-1996.

Variables representing the provincial roles of the agricultural and mining sectors are not significant. This finding supports that of Balisacan et al. (2003), that variables representing natural wealth are not significant in reducing poverty. The result is also the same for population and education. They do not appear significant in explaining poverty in all specifications.

On the other hand, income inequality, which is the provincial Gini coefficient, is statistically a significant variable in determining the three measures of provincial poverty. A higher level of provincial poverty is associated with a higher provincial inequality represented by a higher Gini coefficient. This result supports the findings of Bruno et al. (1996) that Gini inequality is more responsive to poverty than to growth. Another interesting finding is that the level of provincial decentralisation is not significant in determining any measure of poverty.

The fact that most of the explanatory variables are not significant in explaining poverty might indicate, at least in the case of P0, that their affects on poverty have been captured by the provincial economic growth, such as the case of human capital in Balisacan et al (2003) and Balisacan and Pernia (2002) and decentralization in Davoodi and Zou (1998). Further studies on this are certainly needed. Finally, one should note that except for P2, the interaction between inequality and the East-West dummy is not significant; meaning that, first, the average difference between the poverty situation in the East and in the West (shown in the first analysis) can be explained by the variability of provincial economic growth, Gini coefficient and fixed effect coefficients; and second, after taking into account the fixed effect coefficients, poverty in the East and in the West does not respond differently to economic growth and income inequality conditions.

Table 3. Determinants of Poverty

	ln(P0)			*ln(P1)*		
	FE		*2SLS FE*	*FE*		*2SLS FE*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
ln(pdrb)	-0.153	-2.205*	1.011	-0.003	0.322	1.849*
	(-0.20)	(-1.93)	(0.54)	(-0.01)	(0.48)	(1.81)
ln(population)	-0.484	-1.873	-6.323	0.335	-0.656	0.181
	(-0.30)	(-0.88)	(-1.78)	(0.39)	(3.79)	(0.09)
ln(Gini)	1.224***	1.716***	1.571***	0.803***	1.229***	0.806**
	(2.85)	(3.08)	(2.67)	(3.57)	(3.79)	(2.49)
ln(agriculture)		-0.236	-0.657		0.712	0.181
		(-0.28)	(-0.46)		(1.43)	(0.23)
ln(mining)		0.455	0.058		0.058	-0.159
		(1.62)	(0.09)		(0.36)	(-0.47)
ln(education)		-0.233	-0.646		0.194	0.377
		(-0.22)	(-0.58)		(0.31)	(0.61)
ln(dependent)		-0.625	-2.648*		-0.361	-0.371
		(0.58)	(-1.76)		(-0.57)	(-0.45)
ln(decentralization)		0.02	0.141		-0.004	-0.177
		(0.06)	(0.32)		(-0.02)	(-0.74)
d.ln(pdrb)		1.935	0.502		-0.547	-1.109
		(1.59)	(0.17)		(-0.77)	(-0.68)
d.ln(population)		-2.841	1.51		0.246	0.576
		(-0.82)	(0.19)		(0.12)	(0.13)
d.ln(Gini)		-0.671	-0.216		-0.67	-1.111
		(-0.83)	(-0.18)		(-1.43)	(-1.63)
d.ln(agriculture)		-0.792	0.326		-0.816	-0.828
		(-0.72)	(0.15)		(-1.27)	(-0.71)
d.ln(mining)		-0.466	-0.02		-0.057	0.105
		(-1.54)	(-0.03)		(-0.32)	(0.3)
d.ln(education)		0.279	0.591		0.432	1.505
		(0.21)	(0.31)		(0.55)	(1.43)
d.ln(dependent)		2.343	3.561		-0.043	0.996
		(1.36)	(1.46)		(-0.04)	(0.74)
d.ln(decentralization)		0.075	0.027		0.178	0.31
		(0.22)	(0.05)		(0.91)	(1.04)
Prob > F	0.00%[a]	0.00%[a]		0.10%	3.00%	
Prob > chi2			0.00%[a]			0.00%[a]

Table 3 (contd)

	ln(P2)		
	FE		2SLSFE
	(7)	(8)	(9)
ln(pdrb)	-0.256	0.479	3.781
	(-0.35)	(0.39)	(1.95)
ln(population)	0.372	-1.093	1.034
	(0.23)	(-0.47)	(0.28)
ln(Gini)	1.450***	2.339***	1.446**
	(3.44)	(3.86)	(2.35)
ln(agriculture)		1.219	0.308
		(1.32)	(0.21)
ln(mining)		0.065	-0.362
		(0.21)	(-0.56)
ln(education)		0.1	0.742
		(0.09)	(0.64)
ln(dependent)		-0.556	-0.175
		(-0.47)	(-0.11)
ln(decentralisation)		-0.127	-0.588
		(-0.38)	(-1.29)
d.ln(pdrb)		-0.895	-1.335
		(-0.68)	(-0.43)
d.ln(population)		-1.162	-2.715
		(-0.31)	(-0.33)
d.ln(Gini)		**-1.471***	**-2.191***
		(-1.68)	(-1.69)
d.ln(agriculture)		-1.269	-1.097
		(-1.06)	(-0.50)
d.ln(mining)		-0.029	0.28
		(-0.09)	(0.42)
d.ln(education)		1.184	2.864
		(0.81)	(1.43)
d.ln(dependent)		-0.431	1.171
		(-0.23)	(0.46)
d.ln(decentralisation)		0.426	0.724
		(1.17)	(1.28)
Prob > F	0.20%	3.55%	
Prob > chi2			0.10%

Notes: *means significant at α=10%; **means significant at α=5%
Constant and year dummies are included in all specifications

6. CONCLUSION

This paper utilises a provincial data set from 1993 until 1996 in order to:

- discover whether the poverty is more severe in the Eastern than the Western part of Indonesia,
- observe whether or not provincial poverty decreases as provincial growth improves, and
- understand the determinants of provincial poverty in Indonesia.

There are several shortcomings in this paper. One of the most important weaknesses is the data set is too short. It only covers a period of four years. Another weakness is that some of the variables utilised, such as the ones representing the roles of agriculture and mining, the level of education and the quality of public services, might not be the best proxies for the true intended variables.

Nevertheless, several important findings can be drawn from this paper relating to provincial poverty in Indonesia in the mid 1990s. First, in all three measures of poverty (incidence of poverty, poverty gap, and severity of poverty), provincial poverty in the East on average is statistically worse compared with that in the West. The difference has widened over the period 1993 to 1996. Second, provincial economic growth and income inequality are the important variables determining the incidence of provincial poverty. Furthermore, a medium time horizon observation has also shown that the incidence of provincial poverty reduction has been consistently keeping pace with the improvement in medium-term economic growth, after taking into account the initial level of inequality in the province. Third, after taking into account provincial fixed effects, there is no significant evidence that the incidence of provincial poverty in the East and in the West respond differently to provincial economic growth and income inequality conditions. Finally, this paper can only show that income inequality is the variable explaining the provincial poverty gap and the severity of poverty.

Unfortunately, policy implications from the above findings are relatively limited, but some are as follows. If Indonesia wants to combat poverty, it must first focus its poverty alleviation programs in the eastern part of the country; and second, programs to alleviate poverty should be accompanied by programs to improve economic growth and income inequality.

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EXPLAINING CONTINUITY IN NEW ZEALAND'S LOCAL LABOUR MARKET AREAS 1991 TO 2001

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ABSTRACT: Regional labour market analysis is ideally based on functional rather than administrative areas. Travel-to-work data obtained from the 1991 and 2001 Census are used to define a set of functional labour markets for New Zealand. Comparison of the labour market catchments in 1991 and 2001 is undertaken to test the effectiveness of the statistical procedures and to examine the extent to which travel to work patterns have changed. Labour catchments are compiled from data amalgamated to Census area units. The 2001 labour catchments are calculated using 1991 area unit boundaries to test the algorithm used to compile catchments. A reduction in the number of labour market catchments from 140 to 106 occurs but changes tend to preserve the broad structure of catchment boundaries identified in 1991. The overall stability in the identified catchments suggests that they provide a robust basis for regional analysis. Allowing for the reduced reliability of the 2001 Census it appears that catchment boundaries are responding to expected changes in commuting patterns.

1. INTRODUCTION

New Zealand's five yearly Census of Population and Dwellings collects information about place of residence and work. These data enable the identification of travel to work catchments. The potential benefits of identifying such functional labour market areas in New Zealand to monitor sub-national employment change have long been recognised (Morrison, 1989). For example, the interpretation of migration data based on administrative boundaries is restricted by the uncertainty over how much of this movement involves a change of employment (Maré and Choy, 2001). In comparison, migration across travel to work catchments is less ambiguously related to changes in employment (Green, 1994). For these types of study, it is widely recognised that travel to work catchments are the preferred spatial framework for studying local labour markets (Owen and Green, 1989; Crampton, 1999; Casado-Díaz, 2000). Even so, it was only in 2001 that the first set of travel to work areas was published for New Zealand (Newell and Papps, 2001). Those areas were based on 1991 Census data. The 1991 catchments are compared with a set based on 2001 in the study reported in this paper. This comparison provides a basis for evaluating whether there is sufficient stability in labour market catchments to support their use for regional labour market analysis.

Defining labour markets by travel to work catchments can appear an out of date practice. They assume that from any centre of population, journey-to-work time and cost constrain the spatial area over which residents commute to work (Ball, 1980; Coombes and Openshaw, 1982). Increased reliance on telecommunications, changes in household structure, rising incomes, changes in job tenure and more capacity for long distance travel all suggest that such constraints might be diminishing. This possibility is a further reason for the present study. Comparing travel to work catchments in 1991 and 2001 enables the impact of any decline in local commuting to be identified. Consequently, as well as defining travel to work catchments for the total population the extent that boundaries hold for different social groups is examined.

The study finds that the boundaries of labour market catchments have remained relatively stable and that travel to work distances do not vary significantly according to occupation, ethnicity, income, hours worked or age. On this basis, it is concluded that the catchments provide a robust basis for studying local labour markets. This conclusion is potentially of value to researchers in locations where a comprehensive set of local labour markets has still to be identified, such as Australia. In New Zealand, the total number of areas appears to fall from 140 to 106 but this is attributable largely to a decline in the quality of the Census data from 1991 to 2001. Consequently, an additional significance of the investigation is to illustrate the importance of maintaining consistent Census data to enable comparable catchment boundaries to be identified.

The paper commences with further justification for the use of travel to work patterns as a basis for identifying local labour markets followed by an outline of the method adopted for defining catchment areas. The comparison of the 1991 and 2001 catchments is then presented and the sources of difference evaluated. As noted above, interpretation of the catchment changes is complicated by differences in data coding and data quality between the 1991 to 2001 Census. The sources and impact of the changes in data quality are explained in the final section prior to the conclusion that makes some recommendations on how the study of catchments might be modified further to suit the labour markets found in smaller economies with significant land-based employment activities.

2. TRAVEL TO WORK AND LOCAL LABOUR MARKETS

The hierarchy of administrative areas provides the most frequently used sub-national boundaries for labour market analysis. This is to be expected from the wide recognition of administrative boundaries and relationship with public agency responsibilities. The case for generating a new set of boundaries to study labour markets is based on their advantage over the use of administrative boundaries and their capacity to provide a basis for comparative analysis over time. Four issues contribute to this case.

First, few if any set of areas in a national administrative hierarchy provide fully comparable units for spatial analysis (Coombes, 2000). For example, the four main New Zealand urban regions as defined by regional council boundaries vary in total population from 1.16 million (Auckland) to 181,540 (Otago). The Auckland and Wellington regions each encompass four cities with separate administrative jurisdictions. In contrast, the two South Island regions with urban concentrations are distinguished by their geographical extensiveness. Going down the urban hierarchy identifies a group of 15 cities with a larger population range than regional councils and much variation in their proximity to other population centres. The absence of comparably defined areas is a constraint when seeking to analyse urbanisation processes. Many patterns and processes are shaped by the distribution of urban and rural areas. Consequently, to provide meaningful and comparable units for analysis, a set of areas need to be defined in relation to these settlement features. This problem increases when seeking to make cross-national comparisons. Many statistics (such as inter-regional migration rates) are sensitive to the size of region selected. The comparatively small population size of New Zealand regions makes it difficult, for example, to interpret the relative importance of regional labour market adjustments that occur in response to employment shocks (Choy et al., 2002). New Zealand apparently has a comparatively high migration response but this may be because the regional units being compared typically contain a small population. What counts as inter-regional migration in New Zealand may be counted as intra-regional migration in a large country with more populous regions than New Zealand. Similarly, it has been argued that travel to work catchments are the most appropriate spatial area for identifying industry clusters, as followed in Italy's census of industrial districts (Paniccia, 2002). This makes travel to work catchments relevant to contemporary local economic development policy (Perry, 2005).

Second, the use of consistently and appropriately defined area boundaries is especially important for comparing local unemployment rates. Unemployment reflects a shortfall in labour demand relative to labour supply. The respective location of workers and employment opportunities is, therefore, a critical determinant of local unemployment rates. Low-income workers are both the most likely to be unemployed and to have the most restricted residential options among employment groups. As a result, the extent to which a particular administrative boundary embraces or excludes a low-income housing area potentially has a significant impact upon reported unemployment rates. In this context it is particularly important to ensure that unemployment rates are expressed for a comparable set of areas. A further extension of this arises where welfare assistance depends on the 'job testing' of applicants. Claims about the inability to find suitable employment require evaluation against the geographical area within which it is reasonable to expect employment search to be confined.

Third, the use of travel to work catchments minimises the opportunity to selectively present spatial statistics. Much employment policy intervention seeks to ensure that workforce characteristics reflect the attributes of the population from which the workforce is potentially drawn. This is typically motivated by a wish to raise the employment of specific social groups such as disabled persons, ethnic minorities, new migrants and long-term unemployed. When monitoring progress against these goals for sub-national populations, results can be sensitive to the area boundaries that are used. Ethnic groups, for example, tend to cluster in particular residential areas rather than being well distributed administrative areas. In these circumstances, travel to work catchments that straddle administrative boundaries can be an appropriate basis for monitoring outcomes for individual social groups.

Fourth, defining travel to work catchments can establish a standard for spatial data analysis in a context where the dependence of data users on administrative boundaries is reducing (Coombes, 2000). GIS-based software is increasing the ease of aggregating data to non-standard areas and encouraging data users to demand greater flexibility in the release of official statistics. This may be a challenge to statistical agencies that in the past have determined the appropriate areas for which data should be released. This decision has usually involved selecting the lowest tier of the administrative hierarchy providing sufficient statistical reliability and confidentiality protection. Responding to the expectations of increased data flexibility gives a risk of statistics being misused and of reduced comparability between individual investigations. Identifying standards with respect to the types of area appropriate for analysis is a way statistical agencies can respond to user expectations while maintaining a role in controlling the use of official statistics.

Of course, any system of boundaries is likely to have some limitations. A potential shortcoming of travel to work catchments is the lack of continuity between boundaries over time. Reform of administrative systems causing a change in boundaries potentially occurs less frequently than changes in journey to work patterns. This arises partly because of the impact of investment in housing and transport infrastructure and the changing cost of personal mobility. As well, travel to work areas are sensitive to the economic conditions that exist when input data are collected.

Job search may be expected to occur over a wider geographical area in times of comparative labour surplus than in times of comparative labour shortage. At times of low labour demand, the catchment may be distorted by not including the potential journeys of those out of work. The extent of this depends on the distribution of unemployment among occupational groups and variation in mobility between occupational groups. An assumption may be that unemployment is concentrated among low income workers who have lower mobility than high income workers. Later analysis suggests that this may not be the case in New Zealand but further investigation of the impact of unemployment on travel to work is warranted.

Related to the potential instability generated by unemployment, the acceptability of generating boundaries based on the average behaviour of the working population is a further potential weakness. Boundaries may vary, for example, according to whether male or female journey to work is measured. Use of travel to work patterns requires evidence of the comparative stability in the areas and high self-containment between social groups. Prior to exploring how well the New Zealand boundaries perform against these criteria further explanation of the method by which they are generated is provided.

3. METHOD FOR DEFINING TRAVEL TO WORK AREAS AND TESTING FOR SELF CONTAINMENT BY SOCIAL GROUP

A well-defined local labour market catchment area should possess two characteristics. First, labour catchments should have a high degree of self-containment with minimal travel to work across catchment boundaries. Second, catchments should be internally integrated with a high degree of intra-area movement (Goodman, 1970; Ball, 1980; Coombes and Openshaw, 1982). To achieve these attributes, the 'best practice' method developed by Coombes et al. (1986) and Coombes (2000) for the UK was adopted for the original analysis based on 1991 data (Newell and Papps, 2001) and followed in the present study. Customisation of the method was possible because the approach taken in the UK is limited by travel to work data being available from only a 10 percent sample of the Census population. In New Zealand, all Census respondents provide the data and this enables identification of smaller catchments than recommended in the UK. New Zealand's small and low density population makes this a desirable modification.

Variability in the minimum population size of catchments draws attention to the absence of any universal rule for determining how to allocate employment between catchments. The search for self-containment needs to be balanced against the practical need to minimise the number of separate areas. The importance of the rural sector and their associated communities to the New Zealand economy justifies recognition of labour markets with small populations. On the other hand, if the population threshold is set too low the number of catchments can significantly increase. For example, Stewart Island (located in the far south) is amalgamated with Invercargill or not depending on the threshold population coefficient used in the algorithm. One compromise would be to exclude isolated communities such as Stewart Island from the analysis. In the interests of maintaining national coverage, this step was not taken. Instead a balance was struck to recognise small catchments but leaving some small communities such as Stewart Island to be placed within a larger labour market even though it has a high level of self containment.

Census area units are the starting point for the analysis. These units typically have a population of 1,000 to 3,000 persons but across the country as a whole they are highly variable in population and geographic size. Most area units remain unchanged between each Census but some boundaries alter and new areas may be added. A principal purpose of the present study was to examine the stability of the 1991 boundaries by comparing them with those based on 2001. To maximise comparability, the 2001 data were applied to 1991 area unit boundaries. Where necessary 2001 data were reallocated to 1991 area units by disaggregating 2001 data to the individual meshblocks from which area units are defined. In the process of making this adjustment, the reduced proportion of Census responses providing a workplace address coded to a meshblock or area unit in 2001 compared with 1991 presented a need for further adjustment as discussed in section 6.

Catchments are defined by reaching one of three criteria. Most catchments emerge by meeting the minimum thresholds of 70 percent self-containment and 2,000 employed at local workplaces. These criteria interact such that a lower workplace population would be acceptable where self containment levels were correspondingly higher than the threshold and vice versa.

A computerised algorithm processes the source data in four stages:

- Area units are ranked according to the proportion of local residents working in the area unit (referred to as supply side or residential self containment) and those in the upper 20 percent or with a high rate of in-commuting are selected as starting points ('foci') to aggregate area units around. In-commuting is measured by the "job ratio" meaning the ratio of jobs at local workplaces to locally resident workers.
- Foci that have high levels of commuting between them are linked together.
- All the non-foci area units are assigned incrementally to the foci that they are most strongly attached to. This process commences with the areas that have the strongest commuting links to the foci and ends with the area with the weakest links to other areas.
- The 'proto travel to work catchments' are ranked according to the size and self containment criteria. Starting with those proto catchments furthest away from meeting the criteria of 70 percent self containment and 2000 minimum population, area units are reallocated to the emerging labour market area that has satisfied the size criteria or not as yet been rejected. This process continues until all remaining catchments meet the set criteria.

Applied to New Zealand, the modified Coombes algorithm produces labour markets with comparatively high levels of self-containment (typically at least 85 percent) and small workforces. In 1991, the average labour market size was 9,000-10,000 employed persons but roughly half had fewer than the proscribed minimum 2,000. The number of separate labour markets identified is more sensitive to the self-containment criteria than the population criteria (Newell and Papps, 2001). Most areas exceed the minimum self-containment level of 70 percent but modifying this value produces significant variation in the number of local labour markets.

The second part of the methodology is to analyse how far different social groups conform to the catchment boundaries. One way of doing this is to run the algorithm for different subsets of the population and compare the results. Another approach is to estimate and compare the level of self-containment (effectively the goodness of fit) of each labour market catchment for employment sub groups that may exhibit different travel to work patterns from the workforce as a whole. In this second approach, higher levels of self-containment are interpreted as indicating shorter commuting distances, although this may be a simplification depending on the particular geography of the catchment area and adjoining areas.

The former approach would require data below the spatial level that may be released from the Census under the confidentiality protection procedures that Statistics New Zealand operates. It would also require refining model parameters for each category. In contrast, the estimation of sub group self-containment is relatively straightforward.

The approach adopted here is to estimate residential self-containment values for a range of employee attributes. Letting T_{ij} denote the number of commuting trips from area i to area j, self-containment levels are identified as follows:

Residential (supply side) self-containment of area i

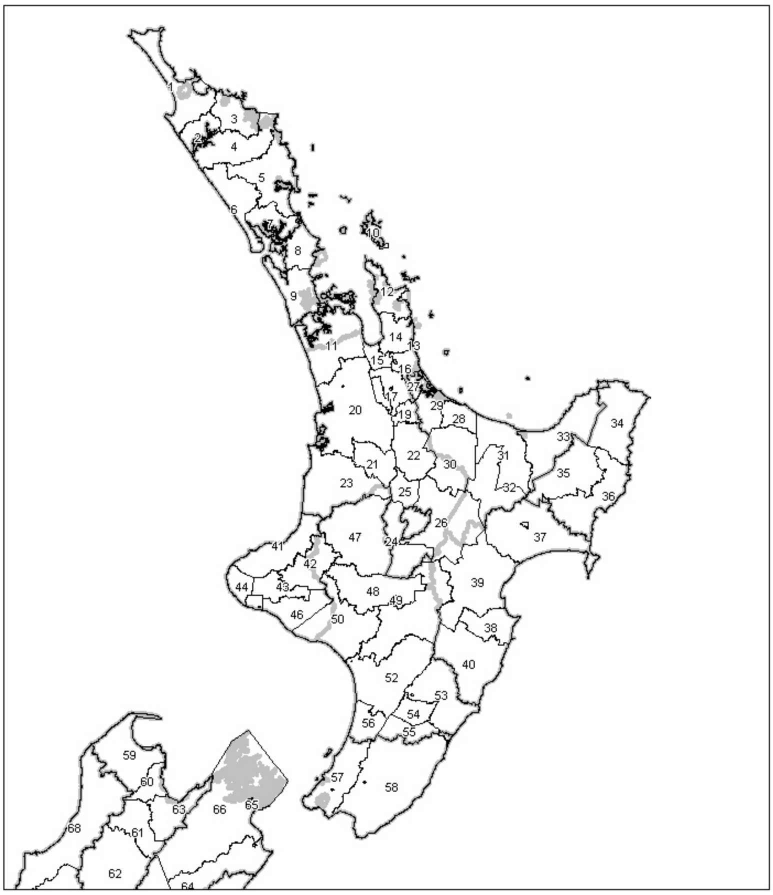
$$= \frac{T_{ii}}{\sum_{j=1}^{n} T_{ij}}.$$

Any variation in residential self-containment needs to be interpreted with care as travel to work patterns vary according to whether the labour catchment is in an urban or rural environment. Urban labour market catchments are typically larger and less self-contained than rural areas. At the same time some labour market groups may be more strongly represented in an urban than rural area. Where such uneven representation occurs, the impact of a group's mobility choice needs to be distinguished from the impact of the labour market type.

4. RESULTS: 2001 LABOUR MARKET CATCHMENTS ON 1991 AREA UNIT BOUNDARIES

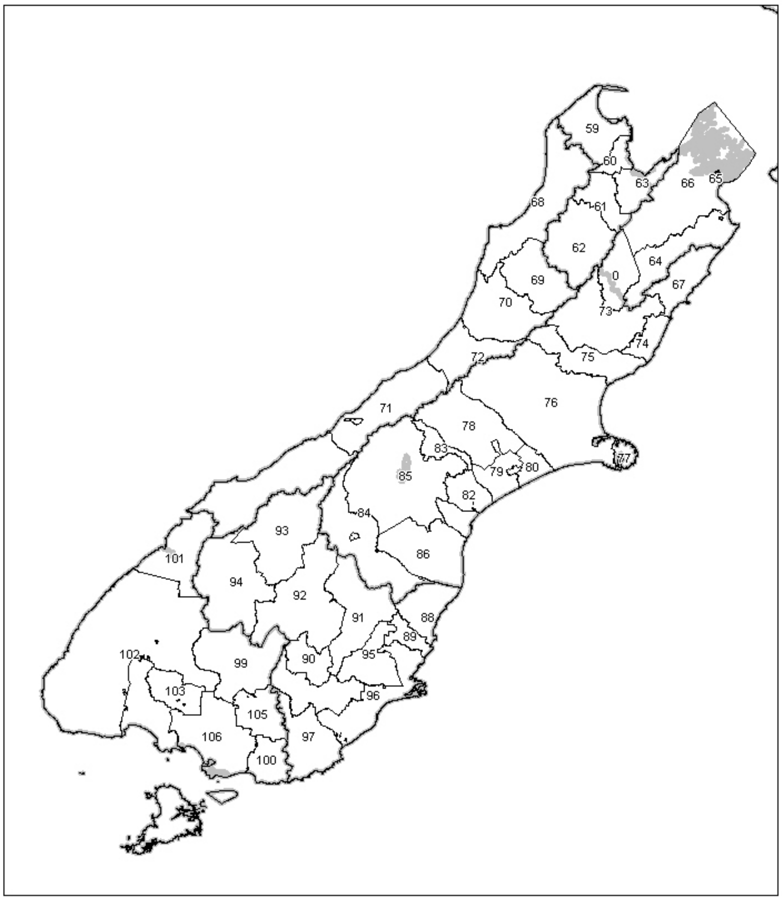
As noted in the introduction, a fall in the number of local labour markets from 140 to 106 was found. The 106 labour markets identified in 2001 are shown in Figures 1 and 2. Before reviewing the changes, the main features of the 1991 boundaries to be noted are as follows (for further details see Newell and Papps, 2001):

- The labour markets vary in employment size from 273,603 (Central Auckland) to 36 areas with fewer than 1,000 employees.
- The geographical area of labour catchments varied between 6 square kilometres (Waiouru) and over 11,200 square kilometres (Te Anau).
- The main urban centres have extensive labour markets. T he Auckland metropolitan region, for example, was divided into two catchments split around Onehunga-Panmure south of the central city. The Christchurch labour market stretches inland to Arthur's Pass but excluded part of the Banks Peninsula.
- For the most part, labour market areas are geographically contiguous. Exceptions partly reflect physical geography and transport infrastructure, such as Featherston's inclusion in the Wellington labour market while the sparsely populated area surrounding Featherston forms part of a separate southern Wairarapa labour market.
- Considerable difference existed between labour market catchments and territorial local authorities. Usually this involved a local authority area being comprised of multiple labour markets but discordance also existed, including the labour market catchments of all 15 cities.



North Island :
Regional Council and Local Labour Market Catchment Boundaries for 2001 on an AU1991 base

Figure 1. 2001 Labour Market Catchment Areas in the North Island based on 1991 Area Units (Labels refer to the local labour market catchment areas listed in Table 1).



South Island :
Regional Council and Local Labour Market Catchment Boundaries for 2001 on an AU1991 base

Figure 2. 2001 Labour Market Catchment Areas in the South Island based on 1991 Area Units (Labels refer to the local labour market catchment areas listed in Table 1).

Table 1. Labels for 2001 Labour Market Catchments on 1991 Area Units shown in Figures 1 and 2

1 Kaitaia	37 Wairoa	73 Amuri
2 Hokianga North	38 Hastings Zone	74 Parnassus
3 Kerikeri	39 Napier Zone	75 Hurunui
4 Kaikohe	40 Central Hawke's Bay District	76 Christchurch
5 Whangarei	41 New Plymouth District	77 Okains Bay
6 Dargaville	42 Douglas	78 Mt Somers
7 Rehia-Oneriri	43 Stratford	79 Hinds
8 Warkworth	44 Kahui	80 Chertsey
9 Central Auckland Zone	45 Kapuni	81 Ashburton
10 Great Barrier Island	46 Hawera	82 Orari
11 Southern Auckland Zone	47 Taumarunui	83 Timaru
12 Whitianga	48 Tangiwai	84 Twizel Community
13 Whangamata	49 Waiouru	85 Mackenzie
14 Thames	50 Wanganui	86 Waihao
15 Hauraki Plains	51 Pohonui-Porewa	87 Aviemore
16 Waihi	52 Palmerston North	88 Oamaru
17 Ngarua	53 Dannevirke	89 Waihemo
18 Morrinsville	54 Pahiatua	90 Teviot
19 Matamata	55 Nireaha-Tiraumea	91 Maniototo
20 Hamilton Zone	56 Levin	92 Alexandra
21 Maihiihi	57 Wellington Zone	93 Wanaka
22 South Waikato District	58 Masterton	94 Queenstown
23 Waitomo District	59 Golden Bay	95 Silverpeaks
24 Turangi	60 Motueka	96 Dunedin
25 Marotiri	61 Golden Downs	97 Clutha
26 Taupo	62 Lake Rotoroa	98 Tuapeka
27 Katikati Community	63 Nelson	99 Waikaia
28 Te Puke Community	64 Ward	100 Toetoes
29 Tauranga	65 Picton	101 Te Anau
30 Rotorua District	66 Blenheim	102 Mararoa River
31 Whakatane	67 Kaikoura District	103 Wairio
32 Matahina-Minginui	68 Westport	104 Te Waewae
33 Opotiki District	69 Inangahua	105 Gore
34 East Cape	70 Greymouth	106 Invercargill
35 Tarndale-Rakauroa	71 Franz Josef	
36 Gisborne	72 Hokitika	

The consolidation of catchments has been largely a North Island phenomenon. In the North Island, the number of areas dropped by 36 percent from 91 to 58 whereas the South Island had a net loss of one catchment to 47. Higher population densities in the North Island than the South Island produce greater opportunity for changes in travel to work patterns.

The mean self-containment of labour market catchments was less in 2001 than 1991 alongside a growth in the average employment size of catchments (Table 2). The same pattern holds for area units, the statistical divisions from which the catchments are constructed. The expansion of the proportion of the population of working age in paid work, as well as increases in population for the underlying building blocks, is likely to be the main explanation for the growth of catchment populations.

Table 2. Comparison of catchment and area unit attributes 1991 and 2001 (based on 1991 area unit boundaries).

	Labour market catchments		Area units	
Area attributes	Mean	Standard deviation	Mean	Standard deviation
1991 catchments				
Residential self-containment	87.0%	7.9%	30.9%	24.8%
Employment self-containment	89.4%	6.3%	46.2%	26.8%
Employed population	9,131	28,157	782	537
Number of jobs	9,131	28,225	781	1,991
2001 catchments				
Residential self-containment	84.5%	7.9%	26.4%	20.3%
Employment self-containment	81.3%	9.8%	38.6%	23.7%
Employed population	11,384	36,509	842	630
Number of jobs	11,384	36,211	842	2044

Around a third of the labour markets identified with 1991 area unit boundary data remained unchanged in 2001. Expressed as a share of total employment in 2001, 10.5 percent of employment is located in unchanged labour catchments. Given the extent of change suggested by these figures it is important to further explore the influences affecting apparent boundary movements.

At the outset it should be noted that boundary changes are only one type change and that catchments with unchanged boundaries have typically undergone significant growth and reduced self-containment since 1991. Employment self-containment reduced by over 10 percent in almost a quarter of cases and by from 5 to 10 percent in a similar proportion of areas. This reduction is usually associated with a significant growth in the area's employment, although there are catchments that experience high employment growth with little change in their self-containment. Despite a predominance of catchments with reduced self-containment the overall levels remain high, including more than half having an employment self-containment level of 0.85 or more.

With respect to boundary changes, slightly over half (23 of 44) of the unchanged labour market areas are found in the South Island. A further 22 areas experience minor changes either through expansion or contraction. There are then a range of catchment changes from the merger of adjoining areas to more complex fragmentation and rebuilding. The distinction between merger and fragmentation is blurred where the original labour market area receives all of one formerly separate area and part of another. It is also possible for an area to absorb one neighbouring area while losing part of its original area to a new or previously existing catchment.

The most frequent form of change involves the merger of two or more former separate and adjoining labour markets. These mergers preserve the external boundaries that delineate the enlarged labour market but result in the collapse of 59 formerly separate areas to less than half this number of areas in 2001. In a smaller number of cases (15), a labour market area becomes part of two or more enlarged labour markets in 2001.

Merger of labour market areas can result from urban area extension and decentralisation around neighbouring centres. Around Auckland, for example, three labour markets (Pukekohe, Waiheke Island and Waiuku) have become absorbed into the two dominant areas of Central and Southern Auckland. The net change in the number of areas is reduced by the emergence of Great Barrier Island as a separate labour market. At the same time, immediately to the north of Central Auckland, the Warkworth labour market has expanded through absorbing part of the former Central Auckland labour market and parts of its other neighbouring market. Similarly, the Hamilton and south Waikato region has seen a loss of 12 labour markets and concentration in a significantly enlarged Hamilton catchment and two new areas (South Waikato and Waitomo) formerly comprising six separate travel to work areas. In contrast with the changes around growing urban centres, rural labour market catchments are more likely to have remained unchanged or grouped as a unit with adjoining catchments (Table 3).

Table 3. Summary of Apparent Changes to Labour Market Catchment Groupings by Urban / Rural[1] Type between 1991 and 2001.

	Main urban	Secondary Urban	Minor Urban	Rural	Sub Total
Same	3	1	16	24	44
Same Almost	4	2	3	1	10
Merged Whole[2]	7	5	16	31	59
Expanded	4	1	2	0	7
Shrunk	1	0	2	2	5
Split	0	4	8	3	15
Sub Total	19	13	47	61	140

Notes. 1. The urban rural classification of each unit reflects the percentage of each catchment's population living in each 1991 urban / rural types.

2. This is where two or more 1991catchment areas are grouped into one in 2001.

Alongside the changing geography of employment around urban areas, changes in the composition of the workforce may also be influencing catchment modification. From late 1991, when New Zealand had its highest unemployment rate in over 50 years, a period of employment growth followed. Total employment grew by 18.4 percent from 1.48 million in June 1990 to 1.76 million in June 2000. Over the same period the working age population increased by 15.1 percent from 2.51 million to 2.89 million. These trends allowed unemployment to fall given only a modest change in the labour force participation rate (from 63.9 to 64.8 percent). Alongside employment growth was a redistribution of employment between males and females. In 1987, 71.2 percent of males of working age participated in full time work: in 1990 the rate was 63.7 percent and by 1999 it was 60.2 percent (figures cited in Morrison, 2001). Female participation rates increased during the 1990s but significantly so for part time participation only.

Clearly given compositional changes in the workforce, evolution should be expected in catchment areas. Indeed, the changes in employment perhaps suggest the potential for travel to work patterns to have changed more than they appear to have done. One constraining influence is that much employment growth is concentrated in urban areas where travel-to-work catchments are comparatively large. Another influence is that differences in the mobility of employed persons appear to be modest, as explained in the following section.

5. SUB-GROUP LOCAL LABOUR MARKETS IN 2001

Accessibility to jobs is not just a function of workplace location and residence. The nature of the skills and experience of each person and their relationship to the distribution of corresponding job opportunities is also a major factor. The cost of travel in relation to employment returns will also vary in relation to wage rates and hours worked, affecting the area over which an individual will seek work. To recognise this the study examined how well the catchments based on all employed persons hold for different social groups.

Gender

A different pattern of commuting for female and male workers may be expected given differences in the participation in household responsibilities and occupation profile. In practice, giving equal weight to each labour market area shows minimal variation in catchment self-containment levels between females and males (Table 4). There is a slightly higher level of self-containment for females and more variation in the self-containment levels for females than males. This difference suggests less geographical mobility among females but that overall the labour market areas do not contain a substantial gender bias. The pattern differs in the case of the largest urban labour market (Central Auckland) where the residential self containment level varies from 0.81 for males to 0.89 for females. In contrast, the next three largest labour markets (Southern Auckland, Wellington and Christchurch) have less gender variation than the country as a whole.

Table 4. Residential self-containment of 2001 labour markets by gender.

	Male	Female	Total
Residential self containment	0.882	0.906	0.894
Standard deviation of self containment levels	0.093	0.095	0.091
Number employed	709,452	679,578	1,389,057

Occupation

A preliminary assessment of the variation in self-containment by occupation was conducted at the two digit level of the NZSCO90 which distinguishes 23 occupations. Overall a high level of self-containment is maintained for all occupational groups with variations readily explainable by the nature of work. The lowest level of self-containment is found for drivers and mobile machinery operators (0.84) followed by industrial plant operators (0.85). The highest level of self-containment exists among market-orientated agricultural and fishery workers (0.93) and salespersons (0.91).

Ethnicity

Overall those of New Zealand European ethnic origin are more self-contained than other ethnic groups (Table 5). Mäori have a lower level of self-containment mainly as a consequence of reduced male self-containment. Smaller ethnic populations exhibit the lowest levels of self-containment.

Table 5. Residential self-containment of 2001 labour markets by ethnicity and gender.

	Residential self containment		Standard deviation of self containment levels		Number employed	
	Male	Female	Male	Female	Male	Female
NZ European Only	0.891	0.913	0.092	0.094	538,476	512,979
NZ Mäori	0.859	0.893	0.100	0.099	65,883	67,095
Other European	0.867	0.901	0.113	0.105	36,876	35,496
Samoan	0.865	0.873	0.095	0.101	13,362	13,215
Chinese	0.835	0.857	0.133	0.135	12,891	12,501
Indian	0.819	0.851	0.116	0.115	11,862	9,825
Cook Island Mäori	0.856	0.866	0.127	0.123	5,124	4,962

Income

Those in the highest and lowest personal income pentiles have lower self containment than those in middle income groups (Table 6). In the case of low income workers, the reduced self-containment is most evident among males. This may in part reflect the different occupational distribution of male and female workers.

Table 6. Residential self-containment of 2001 labour markets by income and gender.

	Residential self containment		Standard deviation of self containment levels		Number employed among all income earners	
Income group pentile (5=highest)	Male	Female	Male	Female	Male	Female
1	0.888	0.914	0.085	0.080	17,592	19,470
2	0.922	0.934	0.056	0.062	43,023	75,249
3	0.909	0.928	0.067	0.074	49,320	107,667
4	0.901	0.917	0.075	0.090	115,869	162,978
5	0.885	0.894	0.093	0.115	203,529	177,576

Hours worked

Individuals working less than full time or excessive hours in their main job are generally more self-contained than those with 'normal' full time hours of work. Thus for both female and male work of less than 20 hours per work the self containment levels are over 0.9. The aggregate self-containment level drops to 0.86 among those working 45-49 hours per work.

Age

Levels of self-containment by age group largely follow expected patterns. The youngest working people (15-17) show high levels of self-containment (0.93) with older age groups showing more mobility up to the 50 to 54 year cohort, after which self-containment increases to 0.95 for those aged 75-79. Self-containment is lowest for persons aged 25-29 (0.87). An unusual finding is the comparatively low self-containment of working persons of over 85 years (0.87). This group numbers 627 and while it may include particular forms of employment, such as semi-retired business owners, it is probably another reflection of the poor quality of some aspects of the 2001 Census data that are elaborated on below.

6. ISSUES IN COMPILING 2001 CATCHMENT AREAS

Differences in data coding and data quality between the 1991 and 2001 Census are another source of comparison, in this case unrelated to actual changes in travel to work. The effect of increased "noise" in the data, due to coding or data entry mistakes, would be expected to have its greatest effect on catchment areas with small working populations. A small number of coding gaps or errors can shift the allocation of area units to catchments more readily for small populations than large populations. The sensitivity of the result to changes in self containment is illustrated by the fact that of the 25 labour market catchments in 1991 that experienced a decrease in workplace self containment of more than 18 percent, 80% percent (20) were merged with other catchment areas between 1991 and 2001, versus only 34 percent for other catchments. Similarly, 58 percent of the 12 labour markets in 1991 with workplace employment numbers of less than 500 merged with others in 2001 compared with only 40 percent other labour market catchment areas.

The high incidence of change among small catchments illustrates their sensitivity to changes in data quality. Evidence of a shift in data quality exists in respect of the proportion of Census returns collected from working persons that identified both a residential and workplace address that could be allocated to a Census meshblock. There is complete coding of residences to meshblocks in each Census. In contrast, of respondents identifying themselves as employed, only a proportion provide sufficient information or were interpreted sufficiently to code their workplace location to a meshblock. In 1991, over 90 percent of employed Census respondents were coded to a meshblock for both their place of residence and work; in 2001 the proportion had dropped to 78.2 percent.

A related difference between the 1991 and 2001 Census data is the proportion of long distance commutes such as a journey to work from the south of the South Island to Auckland in the north of the North Island. Such commutes were more frequent in the 2001 than in the 1991 data and present a problem for the analysis.

One issue is that it seems likely that many of these observations are illusory, a result of miscoding of the workplace location. Moreover, the idea of a travel to work area is to capture the area within which the working population habitually seeks employment and where local employers recruit most of their labour. In this sense, idiosyncratic travel patterns arising through unusual circumstances or existing as a temporary transition to relocation might be ignored. It is also possible that respondents in 'field' roles may identify a head office work location rather than the area they work within as their workplace address. The manner in which the workplace coding by Statistics New Zealand relates workplaces to the business survey frame may also mean that some workplaces may be allocated to out of region workplace addresses. On the other hand, an increase in long-distance commuting on a weekly if not daily basis may be an aspect of changing work patterns. For example, flexible employment practices such as extended shift hours to facilitate shorter working weeks or a combination of home-based and workplace activity are made possible through information technology. Dual income households, contract-based employment and high incomes also make an increase in long distance commuting possible.

Adjustments were made for both data issues. As explained, the 2001 analysis required regrouping of some data from the meshblock level to enable a comparable set of area units to be identified. A problem thus arises where the gap involves respondents residing in meshblocks that need to be reallocated to a different area unit. If an entry was not coded to the meshblock level it sometimes could not be unambiguously assigned to 1991 area units and was left out of the initial dataset. On this basis, only about 84 percent of those identifying themselves as employed in 2001 could be coded to a 1991 workplace area unit compared with 92 percent in 1991.

In view of the change in population size arising from data gaps, an adjustment was required to ensure that the 2001 analysis represented the same proportionality to the total working population as the 1991 analysis. To achieve this comparability, 2001 data were scaled to the same level of completeness as the 1991 data assuming that missing workplace addresses exhibited the same distribution of locations as the coded addresses. When this scaling up was applied, the algorithm produced 90 separate catchments compared with the 140 in 1991.

A separate adjustment was made to screen out travel to work combinations that were considered unusual on the basis of geography and 1991 travel to work data. Although the proportion of these problematic trips is small they have a large influence on some catchment boundaries (Table 7). Consequently, when the data were filtered and scaled back to the same level of capture as 1991 data, a further 16 labour markets additional to the 90 identified in the initial processing of 2001 data were identified. This brought the final total of 106 labour markets in 2001.

Table 7. Proportion of journeys to work eligible for omission due to distance travelled.

	Proportion (%) of trips eligible for screening due to long distance	
Region of trip destination	1991	2001
Northland	0.5	2.04
Auckland	0.29	0.88
Waikato	0.32	0.92
Bay Of Plenty	0.74	2.9
Gisborne	0.63	2.75
Hawke's Bay	0.5	2.38
Taranaki	0.68	1.68
Manawatu-Wanganui	0.29	1.61
Wellington	0.37	1.88
Marlborough	0.67	5.78
Nelson	1.03	4.43
Tasman	0.33	3.42
West Coast	0.72	3.62
Canterbury	0.31	1.23
Otago	0.35	1.7
Southland	0.21	2.16
All regions	0.41	1.59

The long distance observations that were screened out represented 1.6 percent of all trips in 2001. By contrast, only 0.4 percent of 1991 travel to work observations would have been screened out under this protocol. Marlborough is the most affected region with 5.8 percent of observations screened out for 2001 whereas, had the procedure been applied in 1991, 0.7 percent of trips would have been screened out. Given the possibility of travel between Marlborough and Wellington (the locations are separated by the Cook Strait but connected with regular air and sea transport) on a weekly or shorter basis, it is possible that the 2001 Census results are reflecting real changes in commuting behaviour for some journey to work combinations. On the other hand, the reduced rate of coding of workplace addresses to meshblock areas may be indicative of increased data inaccuracy in the 2001 Census results. Investigation of the occupations held by those reporting long distance commuting would be a useful check on the 2001 data. Prior to such investigation, the screening procedure seemed justified.

7. CONCLUSION

This paper has summarised how the aggregate working population has been apportioned to relatively self-contained labour market areas. The general conclusion is that the algorithm modified from the method developed by Coombes, and first applied in New Zealand with 1991 Census data by Newell and Papps (2001), provides a robust basis for delineating local labour markets. This is judged by the overall stability in labour market boundaries and the consistently high levels of aggregate self-containment for labour market sub groups. That said, four qualifications to the success of the method are acknowledged that provide opportunities to extend the analysis so far completed.

The 2001 update has been constructed from area unit data. The original intention of utilising mesh block data was abandoned because of the high proportion of Census returns that do not have a workplace address coded to a mesh block. This study has provided further evidence to suggest the importance of looking at the structure of catchments from meshblock level data. This is because an expansion of area unit populations tends to result in an expansion of catchment populations. The study also suggests the value of looking at underlying changes within major catchments through an analysis of employment foci within individual catchments.

A further shortcoming is that the 2001 Census has a much higher proportion of responses with incomplete workplace information than occurred in 1991. Catchments are thus compiled from area units with the proportion of journeys estimated from those for which there are complete data. Some uncertainty, therefore, exists as to how far the estimation procedures and unresolved shortfalls in data quality are influencing the results. The quality and completeness of the data or "noise level" has a significant impact on the accuracy of the identified labour markets. It is an open question at this point what the relative influence of high noise levels in the 2001 data and real labour market catchment adjustments have been on boundary changes between 1991 and 2001. In retrospect, an analysis of changes in labour market catchments between 1981 (or 1986) and 1991 would have been more insightful than the comparison between 1991 and 2001. Pre 1996, Census data quality was both high and consistent from one Census to another.

Use of the self-containment level to determine the retention of catchment areas among different labour market groups provides a partial assessment of the variation in mobility between social groups. An alternative method is to generate specific sub group catchments, using scaled down size requirements. This approach would provide more insight into the daily labour markets of individual groups than the aggregate self-containment statistics. Particularly in the case of the large urban labour markets there is justification for exploring the catchment variation between social groups in more detail than presented in this study.

Even using the existing boundaries there is considerable scope to examine changes in labour market catchment areas from 1991 to 2001. A preliminary comparison, as presented here, suggests the contribution of urbanisation processes but there are also some rural areas that have experienced catchment changes. The sources of boundary changes and role of different sub groups in promoting change should form part of the larger evaluation of the usefulness of travel to work areas as a basis for monitoring local employment change.

The apparent increase of long distance commuting was highlighted as potentially an aspect of modern labour markets that challenges the existence of localised catchment areas. It was found that the treatment of long distance commutes has a significant impact on the number of catchments generated. A problem is that the marked increase in long distance commuting exists alongside the evidence of quality deficiencies in the 2001 Census capture of workplace information. The present study has removed selected long distance commutes that seemed improbable or potentially temporary. Further examination of long distance commuting is desirable to determine whether they are associated with particular occupations that may permit the geographical flexibility implied. If a real increase in long distance commuting is sustained, there is a need to consider how this affects the use of catchments that essentially envisage commuting as a daily occurrence. Better understanding of apparent long distance commutes in the data may also permit a more selective filter that takes account of industry and occupation as well as distance in the separation of noise from real observations.

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DEVELOPMENTS IN REGIONAL LABOUR MARKETS IN GERMANY: A COMPARATIVE ANALYSIS OF THE FORECASTING PERFORMANCE OF COMPETING STATISTICAL MODELS

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ABSTRACT: The aim of this paper is to forecast regional employment patterns in West German regions. After a brief exposition of key labour market issues, Artificial Neural Network (ANN) techniques are proposed as a new tool to generate reliable short-term employment forecasts at a regional level. A variety of ANN models are developed and compared. Comparison with methods commonly applied to panel data, such as GMM (Generalised Method of Moments), confirms the ability of ANNs to capture complex data structures in a multi-regional context.

1. ISSUES OF REGIONAL LABOUR MARKET ANALYSIS

In recent decades several western economies have faced high rates of unemployment characterised by strong regional differences, either between core and peripheral regions or between urban centres and their hinterlands. Regional disparities in employment have increased considerably in many countries during the 1970s and the 1980s, and have either stabilised or continued to increase between 1985 and 1997 (OECD, 2000). To understand the mechanisms behind the development of regions that structurally lag behind the national, European or world average, nowadays increasing attention is being given to regional development issues and to related specific labour market disparities. For example, the European Union (EU) spends almost 35 percent of its budget on regional policy initiatives. Various structural funds have been established with the aim of reducing gaps in development between the regions of the EU, as well as disparities in the standard of living of their inhabitants. The funds contributions amounted to 8 billion euros per year in 1989, and rose to 32 billion euros per year in 1999. In the period 2000-2006, 28 billion euros per year (at the prices of 1999) are planned to be spent for the same purpose (see e.g. the EU web site: http://europa.eu.int/comm/regional_policy/).

The economy can be described as a system of spatial clusters – regions – often characterised by an uneven distribution of activity among locations (Krugman, 1991, 1998a, 1998b). The tendency of regions to specialise in specific industries and economic sectors will ultimately influence local labour market behaviour by causing a subdivision of regions into urban agglomerations and rural areas, or into core and peripheral regions. In addition, regional labour markets may be affected by shocks on the demand side that can influence employment in a more or less transitory way, depending on both the degree of regional specialisation and the willingness of workers and firms to migrate to other regions (Decressin and Fatás, 1995).

Regional performance is also connected with changes in technology. Fischer and Nijkamp (1991) have pointed out the complexity of these relationships and emphasised the necessity to focus the analysis at a meso- (local labour markets and sectors) or micro- (firms) level. Since they produce specific ranges of goods, regions are affected by different specific fluctuations (see, e.g. Blanchard and Katz, 1992 for the US; and Decressin and Fatás, 1995 for EU regions). This implies that different shocks to labour demand, which eventually lead to permanent changes in employment growth, are region- rather than country-specific.

The increasing accessibility of statistical information at both the macroeconomic and the microeconomic level, along with the availability of more powerful computers, facilitates the analysis of employment from a more disaggregated perspective. The availability of detailed information clearly demonstrates the need for more advanced and complex models that are able to properly describe the behaviour of labour market variables, and to offer reliable regional forecasts enabling policy makers to develop effective labour market policies. It may be difficult to design a simple system of integrated and operational spatial models that link the available information in a theoretically and methodologically satisfactory way. Conventional models may become very complicated, and may impose many constraints that could reduce the scope of the analysis.

New tools emerging from the field of Artificial Intelligence, such as Artificial Neural Network (ANN) models, are recently gaining popularity due to their flexibility and their ability to solve complex problems. An ANN is a computational paradigm that imitates the functioning of the human brain in solving problems. Like the human brain, ANN models are able to ‘learn’ from a set of examples and generalise them to find the right solution to ‘new’ problems from the same category as the examples presented. Unlike many conventional statistical methods, ANNs do not require any kind of a priori hypothesis about the underlying model structure.

This paper proposes an ANN approach as a tool to forecast regional employment developments, with a particular focus on the West German labour market. The paper is organised as follows: after a brief overview of the German labour market in Section 2, a short introduction to ANNs is given in Section 3.

Section 4.1 illustrates our case study on West German employment. Results of ANN models are given in Sections 4.2 and 4.3. Section 5 compares the results of the ANN models with estimation techniques derived from panel data analysis, while Section 6 offers concluding remarks.

2. GERMAN REGIONAL LABOUR MARKET POLICY: AN OVERVIEW

Compared with other European countries, Germany has a relatively high rate of people out of work (see Blien et al., 2002). The German labour market has been characterised by high and increasing levels of unemployment until 1997. Since then, there has been a slight improvement; according to data from the German Labour Force Survey, in 2000 the unemployment rate was just below the average of the EU. The annual average number of people registered as unemployed was approximately 3.9 million in 2000, while it was 4.4 million in 1997. This corresponds to an unemployment rate of 9.6 percent in 2000 and of 11.4 percent in 1997 (national definition: registered unemployed as a proportion of the civilian labour force).

The development of unemployment over the course of time is especially worrying, since, even after an economic upswing, unemployment has remained high. During the economic recovery in the late 1980s and early 1990s, unemployment decreased less than employment increased. As a consequence of the persistent employment crisis, a process of selection among the unemployed has taken place and a hard-core group of unemployed people has developed. A large proportion of them are structurally or long-term unemployed. In addition to the long-term unemployed there is also a high number of hard-core unemployed people, whose employment is repeatedly interrupted by periods of unemployment.

The German labour market is characterised by considerable regional discrepancies, especially between its Western and Eastern parts. Long after unification in 1990, unemployment remained high in the East. In 2000 the unemployment rate in Western Germany was 7.8 percent, whereas the figure for Eastern Germany was 17.4 percent. Table 1 illustrates the volume of employment covered by social security in Western and Eastern Germany.

Table 1. Employment Covered by Social Security in Germany (End of Year)

	1996	1997	1998	1999	2000
Employment (West)	22126949	22043258	22223461	22694019	23075334
Change in %		-0.38	0.82	2.12	1.68
Employment (East)	5298337	5097548	5143506	5061546	4904773
Change in %		-3.79	0.90	-1.59	-3.10

Source: Employment Statistics of the Federal Employment Services.

The unemployment problem is at least partly due to the fact that, after reunification, in Germany conditions have not been as favourable to the development of employment as in other European countries as, for instance, the Netherlands. Table 1 above shows that there have been only small employment gains in the Western part of Germany during recent years, and losses in the East. Since the economy began to recover in 1998, employment performance in Western Germany has improved. However, with the onset of the recession, this favourable development came to a halt in 2001/2002.

In recent years, the traditional German recipe for success – a reliance on technological innovation with a well-trained workforce – has ceased to produce the positive results that it produced in the past. This might at least partly be due to the fact that German industry has specialised in segments of the world product markets that are characterised by a low rate of technical progress, by inelastic demand or by both (Appelbaum and Schettkat, 1993; Möller, 2001).

In its regional aspects, Germany is characterised by a situation that is unique in the world. The transformation process that the regional economy in the former German Democratic Republic has undergone – from state socialism to a market economy or to capitalism – has not materialised previously in any independent state. In the East the process of transformation was pushed through very quickly, and Western institutions were already established there during the early 1990s. Wages in the East doubled within a few years, and their level is now about 75 percent of that of the West. Since productivity is lower in the East (about 65 percent of that of the West), there are still severe labour market problems in Eastern Germany.

Within both parts of the country, marked regional disparities in the labour market are visible. In the former West Germany, the southern parts of the country are developing more rapidly than the north. In addition, there are great differences with respect to important indicators that can be measured only on a small scale: it is necessary to look at relatively small regional units to be able to observe great differences in employment and unemployment.

To counteract disparities in regional labour markets, a relatively large amount of spending is budgeted by the political institutions responsible for labour market policy. Every year, about 22 billion Euro (approximately 22 billion US$) are spent on active labour market policy measures, i.e. training and job creation measures, wage subsidies and other schemes to improve regional labour market conditions. To use these funds efficiently, the responsible for the budget needs reliable regional labour market forecasts. In many cases, however, forecasts are unavailable, and decisions are normally based on statistical information from the past, which is only available after a certain time lag. The actual size of the labour market funds tends therefore to be based on information about the past, rather than on information about the future, which is only available from forecasts. Furthermore, it is necessary to create forecasts for small regions, since substantial labour market disparities can be found at this level. This paper proposes a new methodology to generate short-term regional labour market forecasts. This is of relevant political interest, since the amount of money to be distributed, though at present large, is ultimately restricted.

The use of forecasting techniques is intended to improve the allocation of funds for regional labour market policy. The funds for active labour market policy are distributed according to a uniform allocation formula developed at the German Institute for Employment Research (Institut für Arbeitsmarkt und Berufsforschung – IAB) (see Blien, 1998 for more details). One of the most relevant indicators on which the monetary distribution is based, is the past development of employment. If reliable forecasts were available, the distribution of funds could be oriented towards resolving foreseeable problems in order to cope with labour market imbalances more effectively. Furthermore, reliable insight into the regional labour market situations is needed from the financial viewpoint to generate sufficient social security funds.

There is also a scientific motivation for the development of forecasting experiments. A major purpose of research is to identify the underlying structure of causality in a given field of interest. Forecasts are appropriate for testing analyses of this kind. The structure of causality identified in research about the past can be extrapolated to a future situation. If these forecasts are reliable, the researcher can be confident of being able to identify the main influences that are being sought. It is possible to evaluate *ex post* the results of a forecast, which serves as an additional test of whether the model used adequately represents the causal structure inferred from a theory.

Both motivations for inquiry, the one related to labour market policy and the other concerned with the scientific explanation, are relevant in the present context, which deals with regional forecasts for employment in Western Germany for a time period of one and two years. The purpose of our analysis is to forecast not the global employment at the country level, but the development of regional employment relative to the national average.

We use innovative methods of forecasting to see whether their results are better than those obtained with more conventional methods (see Blien and Tassinopoulos, 2001).

3. NEURAL NETWORK TECHNIQUES: A BRIEF OVERVIEW

The term Artificial Neural Networks (ANNs) refers to a wide group of models that was originally inspired by human brain organisation, in which calculation is based on the principle of distribution of activity to a high number of simple calculation units, strictly related and working in parallel. For an historical review of ANNs we refer to Taylor (1997); for a review of ANNs from a statistical perspective we refer, among others, to Cheng and Titterington (1994) and Kuan and White (1994). For further information of ANN techniques see Rumelhart and McClelland (1986), Sarle (1997) and Bossomaier (2000). The ANN approach has been applied to economic problems and tested against conventional methods in Reibnegger et al. (1991), Altman et al. (1994), Dougherty and Cobbett (1994), Kuan and Liu (1995), Camastra and Colla (1997), Himanen et al. (1998) and Reggiani et al. (2000).

Labour market forecasts using ANNs have been made by Swanson and White (1997a, 1997b) and Stock and Watson (1998), who find that ANNs perform at most slightly better than other time series techniques. We differ from such papers in the data we use, which has a panel rather than a time series structure.

For simplicity, in this section we only illustrate the general characteristics of ANN models and some features of the specific kind of ANN used in our application.

As shown in Figure 1, an ANN is made of neuron cells (also called units), internal connections between neurons (weights), and input/output connections with the external world. In Figure 1 the neurons are represented by circles and the weights are represented by arrows. In a "three-layer ANN" the neurons are organised in three layers: input, output, and one hidden layer. While the number of neurons of the input and output layer is defined by the problem concerned, the number of neurons in the hidden layer (as well as other ANN parameters) is chosen by the researcher via a process of trial and error, which does not follow exact rules.

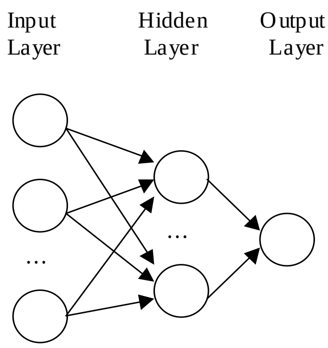

Figure 1. Example of an ANN Structure.

As in statistics, where there is a bias-variance trade-off, it is considered good practice to keep the ANN complexity low. An ANN that is too complex with respect to the data analysed will overfit the data, thus causing generalisation problems. On the other hand, an ANN that is too simple or too inflexible will have a large bias and will not be able to reach a good approximation of the structure underlying the data.

A three-layer ANN model may be formalised in the following way (see Fischer, 2001):

$$y = \psi \left(\Sigma_j \, w_j \, \phi_j \left(\Sigma_n \, w_{jn} \, x_n \right)\right) \qquad (1)$$

where y is the dependent variable; x are the independent variables (input units); w_{jn} are the weights connecting the j^{th} hidden unit with the n^{th} input unit; and w_j are the weights connecting the j^{th} hidden unit with the output unit. Each input unit x sends signals ($w_{jn}x_n$) to each unit j belonging to the succeeding layer (the hidden layer). Each hidden unit j computes the sum of all signals coming from the input units, and then amplifies or attenuates them via the transfer function

(ϕ_j). This value is then sent as input signal to the output unit, which computes the sum of all signals originating from the hidden units and amplifies or attenuates them via the transfer function ψ, thus obtaining the output y. Both transfer functions are implemented as sigmoids.

The expression $\Sigma_n w_{jn} x_n$ is therefore the internal value assumed by the j^{th} hidden neuron. As clear from equation (1), one advantage of ANN models consists in the possibility to relax the linearity assumption implicit in conventional regression models.

The computation of the weights starts from an initial – randomly chosen – set of weights. Given the set of weights we compute the preliminary output and then modify the weights by means of a recursive algorithm called backpropagation. Such algorithm is made of two steps. In the first step the error is back propagated through the network, while in the second step the weights are modified on the basis of a function of the difference between the desired and the actual output. The algorithm stops when for each example belonging to the training set the error is smaller than a certain percentage τ, or when the algorithm has reached a certain number of iterations.

We use ANN models to generate regional employment forecasts for the German regional labour market with a time span of one or two years. We use two kinds of models, one tuned to generate forecasts with a time span of one year and the other one tuned to generate forecasts with a time span of two years. We will then make predictions for 2000 and 2001. To test for the robustness of these results, the predictive power of ANN models will also be compared with more conventional models based on panel data techniques.

4. FORECASTING REGIONAL EMPLOYMENT IN WEST GERMANY

4.1 Data Sets and Experiments

We apply the ANN technique to generate short-term forecasts of regional employment in West Germany. The data provided by the IAB is organised as a panel of 327 West German regions over a period of 13 years, from 1987 to 1999, and contains data on the number of people employed in the 327 Western German regions, subdivided into 9 economic sectors (primary sector; industry goods; consumer goods; food manufacture; construction; distributive services; financial services; household services; and services for society). Data on average daily wages earned by full-time workers is also available for each region.

To (roughly) deal with the problem of spatial heterogeneity of regions, we used the BfLR/BBR (Bundesforschungsanstalt für Raumordnung und Landeskunde / Bundesanstalt für Bauwesen und Raumordnung) definition of "type of economic region", which can be used to cluster the regions into nine different groups depending on their degree of urbanisation. The classification, which is represented by a number ranging from 1 to 9, is computed according to population and the centrality of the location of each region (see Bellmann and Blien, 2001 for details). The nine degrees of urbanisation of regions are:

- A. Regions with urban agglomeration: 1. Central cities (including 39 regions); 2. Highly urbanised regions (including 42 regions); 3. Urbanised regions (including 23 regions); 4. Rural regions (including 14 regions);
- B. Regions with tendencies towards agglomeration: 5. Central cities (including 21 regions); 6. Highly urbanised regions (including 61 regions); 7. Rural regions (including 37 regions); and
- C. Regions with rural features: 8. Urbanised regions (including 43 regions); 9. Rural regions (including 47 regions).

Other relevant variables might become available in the future from other sources with a different level of precision and with a different time lag. However, since the aim of the present paper is to forecast rather than to explain changes in employment, we focus only on the information readily available about sectoral regional employment. By analysing employment only from the demand side, and by neglecting the possibilities of inefficiencies in the matching between demand and supply, we assume that regional employment growth is mainly driven by the industrial structure of each region. We therefore identify winner and loser regions (in terms of future employment development) on the basis of their industrial structure.

Since the use of the variable ‘number of employees’ in absolute numbers might lead to unclear results, usually referred to as spurious regression results, we based the ANN learning on growth rates of employment.

Another problem of the ANN learning process consists of the choice of the best network architecture. To find the best architecture for an ANN, the data set is usually split into three randomly-chosen sub-sets: the training set; the validation set; and the test set. While the training set is used to find the best set of weights, the validation set is used to tune the ANN parameters and to find the best architecture. The purpose of the test set is to assess the performance of the models proposed. Since in our case the information is organised as pooled cross-section and time-series data, we do not have much freedom in choosing the three sets. Rather than choosing them randomly, we selected the three sub-sets according to the time periods. In addition, the ANN structure of the network is not given a priori: as mentioned in the previous section, many parameters have to be tuned via a process of trial and error to find a good architecture. Because it is not possible to know whether a global minimum of the error function has been reached in the forecasting context, many phases are necessary to reach stable results. For this reason we have carried out the experiments in three different phases. In the first phase, we trained the models on the data set ranging from 1987/88 to 1996/97 and tested them on the remaining two years (1997/98 and 1998/99) to decide on the best architecture for the ANN. Once a good architecture was found, the models were retrained on the data set ranging from 1987/88 to 1997/98 and then tested on the remaining year: 1998/99. In this second phase of the experiments, the resulting *ex post* forecast was used to compare the models proposed and their generalisation features. In the third phase the whole data set was used as a training set to generate employment forecasts for 2000.

The major problem of the first phase of the analysis was the choice of the number of training epochs. Our ANN results seemed to be quite sensitive to changes in these parameters: when the number of epochs is low, the indicators for both test sets (1997/98 and 1998/99) improved. In a second stage, the statistical indicators for the first test set (1997/98) declined in quality, but the statistical indicators for the second test set (1998/99) continued to improve.

We may choose the number of training epochs in three ways. The first option consists of choosing a number of epochs that minimises the first test set (1996/97), while the second option consists of choosing a number of epochs that minimises the second test set (1997/98). The number of epochs necessary to reach the minimum for the second test set is always higher than the number of epochs necessary to reach the minimum for the first test set. The third option consists in choosing a number of epochs that falls somewhere between those in the previous two cases. Although no exact rules for making a choice exist, this third method seems to offer the best results in the *ex post* forecast. In all the models presented here, the number of training epochs was therefore chosen according to this third method.

The models were ultimately computed to forecast employment on the basis of available information about the number of employees, subdivided into the 9 economic sectors.

4.2 Forecasts for the Year 2000: Models Adopted and Results

The ANN models proposed in this section differ in the variables used; the growth rates of employment in the 9 economic sectors are the only input variables that have been used in all models.[7]

In panel data models it is common practice to allow for regional- and time-specific characteristics by adding regional and time dummies. We tried to adopt the same modelling strategy for our ANNs. In Model A we use the 'conventional' approach of adding time dummies to correct for time-specific regional-invariant characteristics; in Model B we substitute the time dummies with a single variable that can have values between 1 and 13 (the total number of years available).

Table 2 compares the performance of Model A and Model B in the phase of ANN calibration. The models are compared using the following statistical indicators:

Average Relative Variance: $\text{ARV} = [\Sigma_i\, (y_i - y_i^f)^2] \,/\, [\Sigma_i\, (y_i - y^a)^2]$;
Mean Absolute Error: $\text{MAE} = 1/N * [\Sigma_i\, |y_i - y_i^f|]*100$;
Mean Square Error: $\text{MSE} = 1/N * [\Sigma_i\, (y_i - y_i^f)^2]$;
Mean Absolute Percentage Error: $\text{MAPE} = 1/\text{N} * [\Sigma_\text{i}\, |\text{y}_\text{i} - \text{y}_\text{i}^\text{f}\,| *100/\, \text{y}_\text{i}]$.
where y_i is the observed value (target); y_i^f is the forecast of the ANN model; y^a is the average of the observed values; and N is the number of observations/examples. The interpretation of the indicators is that the estimation is better, the closer the value to zero.

[7] The ANN models have been estimated using Neuralyst version 1.41.

The model in which time is introduced as dummies (Model A) shows a smaller difference between the two test sets (1997/98 and 1998/99) than the model in which time is defined as a qualitative variable (Model B). Model A therefore seems to have a more stable behaviour than Model B.

Table 2. Identification of the NN Structure for the Models Forecasting 2000.

	Model A		**Model B**		**Model C**		**Model D**	
Ex post Forecasts:	**97/98**	**98/99**	**97/98**	**98/99**	**97/98**	**98/99**	**97/98**	**98/99**
ARV	0.921	0.941	1.6155	2.441	0.971	0.957	0.9065	0.914
MSE	2.522	2.925	4.413	7.570	2.658	2.973	2.480	2.841

	Model E		**Model AW**		**Model DW**	
Ex post Forecasts:	**97/98**	**98/99**	**97/98**	**98/99**	**97/98**	**98/99**
ARV	0.928	0.956	0.890	0.959	0.852	0.995
MSE	2.541	2.971	2.436	2.979	2.333	3.093

Notes: The indicators refer to the growth rates. For a summary of all models proposed see Table A1 in the Appendix.

Because the year 1991 represents a structural break in our series, we have also carried out a set of experiments in which data previous to 1991 is eliminated. These models did not show an improvement over the previous ones, and are not shown here.

We then tried to add regional dummies as further inputs to improve the performance of Model A. However, since the introduction of 327 dummies is not feasible, we added to Model A one variable that can have values ranging from 1 to 327. The resulting Model C is also shown in Table 2.

As an alternative to the use of the regional variable, we added information on the degree of regional urbanisation to Model A, which seems to be the best one up to this point in the process. The degree of urbanisation is added either as a single variable with values from 1 to 9 (see Model D), or as 9 dummies (see Model E). Both models are shown in Table 2. Adding information on the degree of urbanisation to Model B does not lead to improved forecasts; such results are not shown here.

Finally, we added the variable 'daily wages' to all models, obtaining Models AW, BW, DW and EW (where W stands for wages). Good results were obtained from Model AW and DW, while Model BW and Model EW yielded disappointing results. This suggests that information about wages does not help in improving the performance of the models proposed. Since different industrial sectors pay different wages (see, e.g., Krueger and Summers, 1988), wages in our models are likely to be correlated with the industrial structure of the region. On the other hand, the failure of the NN model may simply be due to a wrong choice of the NN architecture and not be related to the specific inputs used. We can compare the results from the combined Models AW and DW with those from Model A and D. While Models A and D show homogeneous values of the statistical indicators in the two test sets, the two models using information on wages (Models AW and DW) show rather different values for the statistical indicators of the first and the second test sets. Although Models AW and DW might on average perform slightly better than Models A and D, the figures in Table 2 suggest that they might also show higher variability in their forecasts. Models A and D might therefore be preferred for their stability.

As already mentioned, in the second phase of the analysis we retrained the models on the set ranging from 1987/88 to 1997/98 and tested them on the remaining year (1998/99). The resulting *ex post* forecast can then be used to compare the models and analyse their generalisation characteristics. To facilitate the comparison between models, we reconverted the predicted growth rates into the total number of employees by applying the regional growth rate given as output by the models to the observed total number of employees in that region in the previous year. The results are shown in Table 3.

Table 3. Comparative Analysis of the Adopted Models

Training Set	**Model A**	**Model B**	**Model C**	**Model D**	**Model E**	**Model AW**	**Model DW**
MSE	1636633	3921973	1740527	1507558	1627749	1707834	1503297
MAE	733	1167	737	697	723	747	697
MAPE	1.226	1.872	1.226	1.177	1.208	1.254	1.182
Test Set	**Model A**	**Model B**	**Model C**	**Model D**	**Model E**	**Model AW**	**Model DW**
MSE	1890058	1743597	2728751	2269495	15802724	2807580	3398917
MAE	709	705	830	773	2496	808	950
MAPE	1.161	1.156	1.278	1.228	5.360	1.211	1.435

Notes: The indicators refer to the total number of employees.

Model D and Model DW are the ones that best fit the training data. However, when the results are 'generalised' to the test set both models show poorer results than Models A and B. Model B, and to a lesser extent Model A, seem to perform better in the test set than in the training set. This result might suggest that Model A and Model B are quite robust in generalising the data set presented during the training phase. From Table 3 Models A and B seem to be the best models to generate one-step-ahead forecasts of regional employment in West Germany. The poor performance of Model D and Model DW in generalising the training set might result from several causes. First, their results in the training phases are very unstable, and vary drastically if the number of training epochs is changed. Second, the additional variables introduced in Models D and DW might add noise in the forecasting of regional employment. Finally, the poor performance of these models might be due to a wrong choice of the ANN architecture.

Figure 2 compares the forecasts for 2000 computed using all models proposed so far.[8] All models predict similar growth rates from 1999 to 2000, although Model E seems to greatly overestimate the growth rate of employment between 1998 and 1999. Further graphical analyses of the models' behaviour in each region gave us additional evidence that Model E tends to systematically overestimate the change from 1998 to 1999. The forecast for the number of employees in 2000 is, of course, affected by this error.

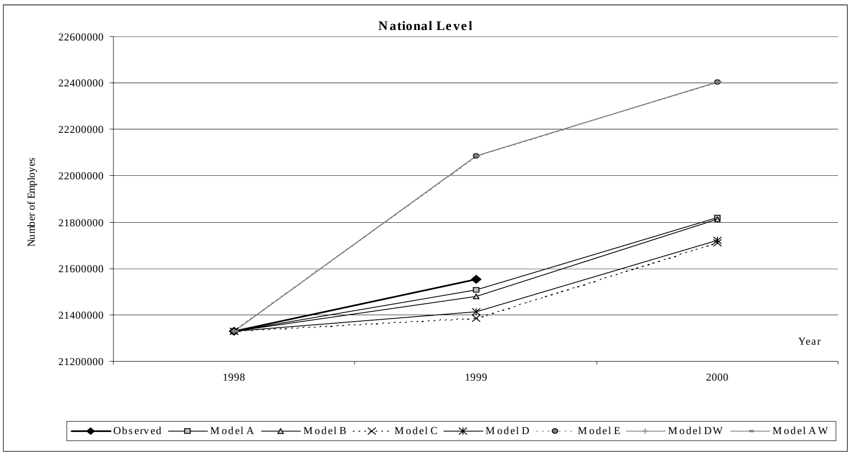

Figure 2. Performance of All Models Trained Until 1998 and Tested on 1999, at a National Level.

In the third phase of the analysis we trained the ANNs on the whole data set (for the years from 1987 until 1999) to predict regional employment in 2000. Figure 3 shows the national forecasts of all models. The models may be grouped into two clusters: the forecasts computed using Models A, B and DW are much higher than the forecasts computed using Models C, E, D and AW. Nevertheless, all models seem to generate rather similar forecast when regional developments are aggregated at national level: the distance between the highest and the lowest forecasts at a national level is of the order of magnitude of only about 130,000 employees over a total of 21 22 million: none of the models proposed seem to generate excessively high or excessively low employment forecasts.

4.3 Forecasts for the Year 2001: Models Adopted and Results

The models proposed in the previous section are designed only to generate one-step-ahead forecasts and cannot therefore be used to generate forecasts for

[8] These figures compare the performance of the models at a national level and could, therefore, hide the models' performance at a regional level.

the year (*t+2*) since they would require as input information for the year (*t+1*). Therefore, to predict employment in 2001 we slightly change the previous approach: we have now to base our analysis on the growth rates between *t* and (*t+2*) instead of on the growth rates between *t* and (*t+1*). All other aspects of the analysis remained unchanged.[9] Table 4 shows the statistical indicators estimated on the ex-post forecasts of regional employment in 2001; the test set is on the year 1999.

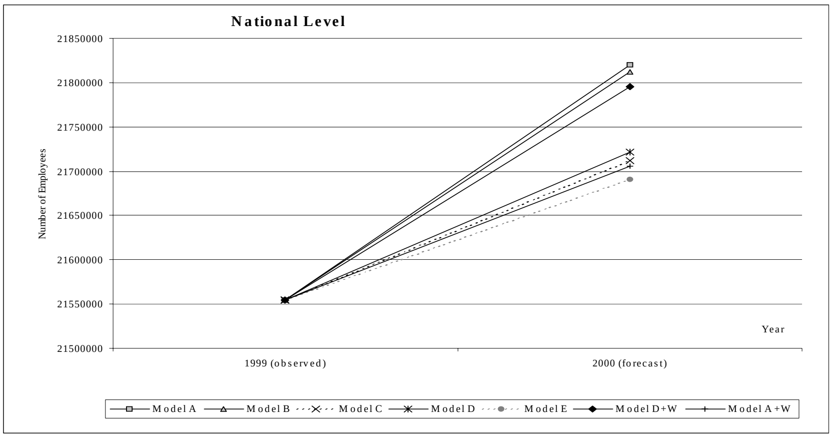

Figure 3. National Forecasts for the Year 2000 of the Models Trained on the Whole Data Set.

Table 4. Comparative Analysis of the Models to Forecasts for 2001 (Test Set: 1997/99)

Training Set	**Model A-2001**	**Model B-2001**	**Model AW-2001**	**Model D-2001**	**Model DW-2001**
MSE	5562937	16535292	6466852	5870054	5507190
MAE	1324	2178	1437	1340	1336
MAPE	2.182	3.394	2.359	2.179	2.183
Test Set	**Model A-2001**	**Model B-2001**	**Model AW-2001**	**Model D-2001**	**Model DW-2001**
MSE	4151746	8398732	3679887	3322544	3356230
MAE	1112	1663	1054	1012	1003
MAPE	1.898	2.598	1.833	1.783	1.757

[9] This is only the fastest way of making such forecasts for 2001. More sophisticated approaches are left for future researchers.

The comparison of Models A-2001 and D-2001 with Models AW-2001 and DW-2001, suggests that, contrary to the experiments described in the previous section, the wage variable seems now to be useful for improving the performance of all models, except Model B-2001. Furthermore, the models using information on the degree of urbanisation (Models D-2001 and DW-2001) seem to perform better than all the other models. This result is reflected in Table 4, which shows that Models D-2001 and DW-2001 perform rather well: these models fit the training data well and appear here to be the best ones for generalising the examples presented.

Figure 4 shows that all models generate similar forecasts of total employment in West Germany, with the only exception of Model B-2001, which, at the aggregate level, seems to greatly overestimate the development of West German employment. This result might be expected given the bad performance of Model B-2001 on both the training and test set. We may anyway be fairly confident about the robustness of the forecasts of the remaining four models (see Table 4).

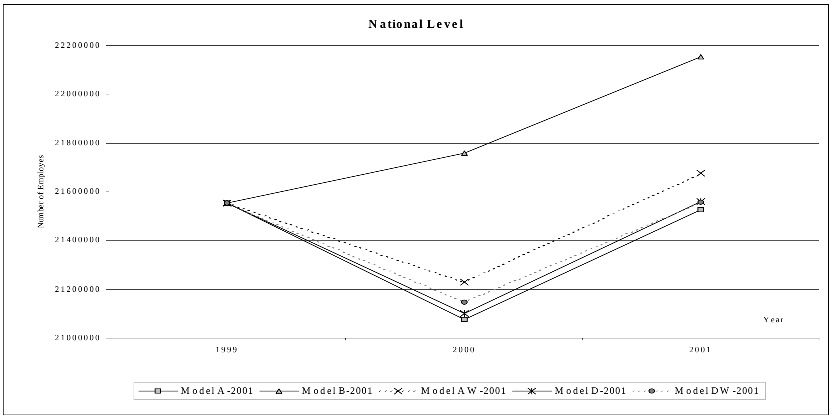

Figure 4. National Forecasts for 2001.

All models discussed above are able to generate forecasts for both 2000 and 2001; the last step in our analysis consists of comparing the forecasts for 2000 computed by the two groups of models presented: the models specifically designed to forecast employment in 2000 shown in the previous section, and the models designed to generate forecasts for 2001. Figure 5 shows the forecasts of the total number of employees aggregated at national level, computed by all models proposed. These forecasts can be clustered into two groups. In the first group we find all the models tuned to generate forecasts with a lag of two years. The only exception is Model B-2001, which shows values that are more similar to the second group. In the second group we find all the remaining models. While Model A-2001 generates the lowest employment forecasts, Model A generates the highest. However, the difference between the result from Model A and that from Model A-2001 is of only 745,000 employees over a total of 21 22 million employees.

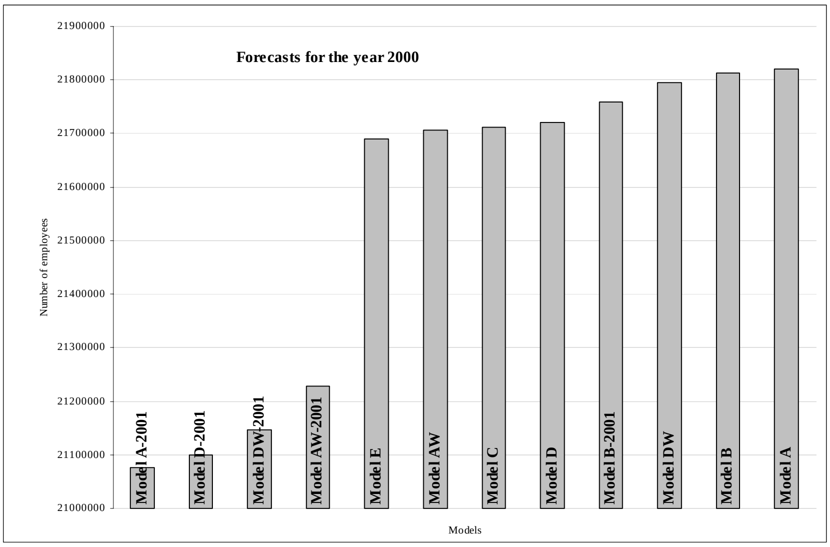

Figure 5. Comparison of the National Forecasts for 2000 of All Models

Although the indicators in Table 4 suggest that different models might lead to good results, we may conclude that the performance of Model B-2001 is rather satisfactory. Model B and Model A can be chosen as the best models to generate forecasts with a time span of one year, while Model DW and Model B can be chosen as the best models to generate forecasts with a time span of two years.

5. COMPARISON WITH PANEL MODELS

To better evaluate the capability of ANNs to generate reliable employment forecasts, we compare them with more conventional models based on panel data econometrics. This comparison is based on the forecasts for 2000 and 2001.[10]

The first conventional model we estimate to generate forecasts with a time span of one year, is a dynamic model with exogenous variables, as suggested by Hausman and Taylor (for more detail on panel data econometrics, see Baltagi, 2001):

[10] Because we used the last year available in our data set (1999) to choose the best ANN architecture, it might be argued that an *ex post* forecast based on the year 1999 might favour the ANN models versus more conventional techniques. Fortunately, the real figures for employment in 2000 and 2001 became available recently, thus making this final comparison possible. All conventional models were estimated using Stata 7.

$$y_{jt} = \beta\, y_{jt-1} + \Sigma_k\, \gamma_k\, X_{kjt} + \varepsilon_{jt} \qquad (2)$$

where y_{jt} is the total number of persons employed in region j in year t, the target variable; X_{kjt} is the share of workers employed in sector k (k = 1, 2, … 9) in region j at time t; and ε_{jt} is the remaining disturbance. Because of the lagged dependent variable y_{jt-1} (total number of workers employed in region j at time $t-1$) the fixed-effect estimator would not be consistent. As suggested by Arellano and Bond (1991), the model is estimated by GMM (Generalised Method of Moments).

An alternative way to define our model is to use the lagged value of sectoral employment instead of the lagged dependent variable:

$$y_{jt} = \alpha_j + \Sigma_k\, \gamma_k\, X_{kjt-1} + \varepsilon_{jt} \qquad (3)$$

where X_{kjt-1} is the total number of persons employed in sector k in region j at time $t-1$ and α_j are regional fixed-effects.

It might be argued that these two estimators, by implicitly assuming the regression coefficients to be time and region invariant, impose too much structure on the data, while, because of structural differences between regions, we may expect the coefficients to vary across regions. For this reason the models in equations (2) and (3) have also been estimated separately for the nine urbanisation groups, thus allowing for heteroskedasticity. This estimation strategy allows – in a crude way – to deal with the problem of the spatial heterogeneity of regions.

To avoid redundant information, we did not add information on average daily wages per region in these models, since wages might be highly dependent on the sectoral composition of employment (Krueger and Summers, 1988). A regression of lagged values of sectoral employment on wages does indeed have an R^2 of 0.99 in our data set.

Finally, we computed forecasts using a naïve no-change model ($y_{jt} = y_{jt-1} + \varepsilon_{jt}$), which can be considered as the simplest and cheapest model available.

Table 5 compares the mean squared error, the mean absolute percentage error, and the mean absolute error of all ANN and conventional models proposed up to now to generate one-step-ahead employment forecasts. The ANN models are shown in the upper panel of Table 5, and the conventional models are shown in the bottom panel. Model AB* is the model in equation (2) estimated for all West German regions, while Model AB** is the model in equation (2) estimated separately for the nine urbanisation groups. Similarly, Model FE* is the model in equation (3) estimated for all West German regions, while Model FE** is the model in equation (3) estimated separately for the nine urbanisation groups. Model NC is the naïve no-change model.

Among the conventional models, those in which the estimation is done separately for urbanisation groups clearly outperform the more restrictive models which impose a common national trend. Nevertheless, although the difference might be considered small, these conventional models also appear to perform slightly worse than the ANN models. Among the ANN models, Model B seems to be the best one, although Model A, which was our second choice, now seems slightly worse than model DW.[11] We may therefore conclude that the ANN models may be considered as a valid and even slightly superior tool for regional employment forecasting. Overall, from the figures in Table 5, Model B has the lowest MSE, MAE and MAPE.

Table 5. Comparison of Forecasts for 2000.

ANN Models	**Model A**	**Model B**	**Model C**	**Model D**	**Model E**	**Model DW**	**Model AW**
MAE	124914	102813	149762	132800	138432	115282	134739
MSE	9554045	7110697	12374773	10640059	10986997	9778299	10780933
MAPE	1.499	1.248	1.788	1.628	1.683	1.331	1.610
Conventional models			**Model AB***	**Model AB****	**Model FE***	**Model FE****	**Model NC**
MAE			700530	123182	161515	144203	172166
MSE			307950472	7611541	10573874	7266404	12617882
MAPE			14.819	1.784	2.152	2.056	2.237

The models computing two-step-ahead forecasts have been computed on a model similar to Equation (3): $y_{jt} = \alpha_j + \Sigma_k \gamma_k X_{kjt-2} + \varepsilon_{jt}$ where X_{kjt-2} has been substituted to X_{kjt-1}. The model has been estimated by means of fixed effects for the whole country (Model FE* in Table 6), and separately for the nine urbanisation groups (Model FE** in Table 6). The third model estimated (Model NC in Table 6) is again a naïve no-change model, in which $y_{jt} = y_{jt-2} + \varepsilon_{jt}$.

Table 6. Comparison of Forecasts for 2001.

ANN Models	**Model A-2001**	**Model B-2001**	**Model AW-2001**	**Model D-2001**	**Model DW-2001**
MAE (%)	239861	132478	207960	232581	233252
MSE	39817433	12925466	36922159	38106665	38341486
MAPE (%)	2.774	1.844	2.322	2.731	2.760
Conventional Models		**FE***	**FE****	**NC**	
MAE (%)		305352	235662	233761	
MSE		41184438	22805205	27216258	
MAPE (%)		3.962	3.259	2.977	

Table 6 compares the mean square error, the mean absolute percentage error and the mean absolute error of all ANN and conventional models proposed up to now to generate forecasts with a time span of two years. Since in 2001 the two regions in which the area of Hannover was subdivided have been aggregated, we computed the results of Table 6 using only 325 regions, disregarding the two regions that have been aggregated. The major problem in this case is that the two regions that have been aggregated belonged to two different urbanisation groups.

[11] To reduce the uncertainty connected with the choice of "the most suitable model", from a forecasting point of view the possibility of combining forecasts generated by different models might be a suitable alternative. Since the purpose of this paper is the comparison of different models and techniques, here we compare each model separately.

Table 6 shows that the fixed-effect models in which the estimation is done separately for each group of regions seems to be only slightly better than the corresponding fixed effect model which is estimated for the whole country. The no-change model now appears better than the models based on panel data. The ANN models still tend to outperform the more conventional models. In this case too, we can conclude that the ANN is a useful tool to generate reliable employment forecasts.

6. CONCLUSION

The artificial neural network (ANN) methodology has been proposed as a tool for computing employment forecasts at regional level. The empirical case study refers to 327 West German regions for which ex-post forecasts are generated with a time span of one and two years.

A comparison with conventional models based on panel data techniques emphasised the ability of ANNs to capture the data structures and to 'extrapolate' useful information within a spatial context. ANN regional employment forecasts seem to be slightly more reliable than regional forecasts generated using panel data techniques.

Since the reliability of our estimations would probably benefit from the inclusion of additional economic background information, future research should try to introduce in such models more economic background variables. Furthermore, to render the model comparison more transparent and more complete, future research should aim at using longer time series and testing the models on subsequent forecasts over a period of more than one year.

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APPENDIX.

Table A1. Summary of the Models Proposed.

Model	*Input Variables*
	One-Step-Ahead Forecasts
Model A	Growth rate of sectoral employment; year: dummies
Model B	Growth rate of sectoral employment; year: qualitative
Model C	Growth rate of sectoral employment; year: dummies; fixed effects
Model D	Growth rate of sectoral employment; year: dummies; urbanization level: qualitative
Model E	Growth rate of sectoral employment; year: dummies; urbanisation level: dummies
Model AW	Growth rate of sectoral employment; year: dummies; growth rate of daily wages
Model DW	Growth rate of sectoral employment; year: dummies; urbanisation level: qualitative; growth rate of daily wages
	Two-Step-Ahead Forecasts
Model A-2001	Growth rate of sectoral employment; year: dummies
Model B-2001	Growth rate of sectoral employment; year: qualitative
Model AW-2001	Growth rate of sectoral employment; year: dummies; growth rate of daily wages
Model D-2001	Growth rate of sectoral employment; year: dummies; urbanization level: qualitative
Model DW-2001	Growth rate of sectoral employment; year: dummies; urbanisation level: qualitative; growth rate of daily wages

Model A is a three-layer ANN with 21 inputs, 10 hidden neurones and 1 output. The activation function is a sigmoid, and the learning process was forced to stop after 500 epochs to avoid overfitting.

Model B is a three-layer ANN with 10 inputs, 5 hidden neurones and 1 output. The activation function is a sigmoid, and the learning process was forced to stop after 800 epochs to avoid overfitting. The learning rate is set at 0.5.

Model C is a three-layer ANN with 22 inputs, 9 hidden neurones and 1 output. The activation function is a sigmoid, and the learning process was forced to stop after 150 epochs to avoid overfitting.

Model D is a three-layer ANN with 22 inputs, 10 hidden neurones and 1 output. The activation function is a sigmoid, and the learning process was forced to stop after 350 epochs to avoid overfitting.

Model E is a three-layer ANN with 30 inputs, 10 hidden neurones and 1 output. The activation function is a sigmoid, and the learning process was forced to stop after 350 epochs to avoid overfitting. The main difference between model D and model E is the way in which the variable ‘degree of urbanisation’ is introduced in the models. While model D treats the variable as qualitative information, model E treats it as a number of dummies variables.

Model AW is a three-layer ANN with 22 inputs, 10 hidden neurones and 1 output. The activation function is a sigmoid, and the learning process was forced to stop after 200 epochs to avoid overfitting.

Model DW is a three-layer ANN with 23 inputs, 9 hidden neurones and 1 output. The activation function is a sigmoid, and the learning process was forced to stop after 200 epochs to avoid overfitting.

Model A-2001 is a three-layer ANN with 20 inputs, 10 hidden neurones and 1 output. The activation function is a sigmoid, and the learning process was forced to stop after 400 epochs to avoid overfitting.

Model B-2001 is a three-layer ANN with 10 inputs, 5 hidden neurones and 1 output. The activation function is a sigmoid, and the learning process was forced to stop after 350 epochs to avoid overfitting.

Model AW-2001 is a three-layer ANN with 21 inputs, 9 hidden neurones and 1 output. The activation function is a sigmoid, and the learning process was forced to stop after 850 epochs to avoid overfitting.

Model D-2001 is a three-layer ANN with 21 inputs, 10 hidden neurones and 1 output. The activation function is a sigmoid, and the learning process was forced to stop after 550 epochs to avoid overfitting.

Model DW-2001 is a three-layer ANN with 22 inputs, 10 hidden neurones and 1 output. The activation function is a sigmoid, and the learning process was forced to stop after 450 epochs to avoid overfitting.

MODELLING CHILD CARE NEEDS: THE CASE OF TOWNSVILLE, AUSTRALIA

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ABSTRACT: This paper focuses on a set of research questions which have been highlighted as salient by the child care industry in Townsville, Australia. A survey among households in Townsville revealed that finding a childcare centre at the right location drives "formal" childcare usage. Non-usage is primarily related to respondents not getting care for the hours they need, and them being unable to find care at short notice. It is shown that a geographical area in Townsville, Murray, would be the ideal location for a new childcare facility. The results of this research should be of interest to practitioners and policy makers in childcare.

1. INTRODUCTION

In the months leading up to the Australian federal election in 2004, the major political parties were battling over who was offering better policies for childcare (Jokovich, 2004). This comes as little surprise, since the perception in communities around Australia is that there is a shortage of childcare places (Lee, et al., 2001).

Research into childcare has focused on affordability (Popple and Martin, 2003; Powlay, 2000), community attitudes towards childcare (Evans and Kelley, 2002), and other determinants of demand such as parent's labor force status (Gray, et al., 2002; Joesch and Hiedemann, 2002). While these studies do suggest some generalizations about childcare: for example, family income doesn't affect the type of childcare chosen by parents for their children (Popple and Martin, 2003), little or no research has systematically explored the issues that are salient for the childcare industry. This paper addresses the following questions which have been highlighted as salient by the child care industry in Townsville, a regional city in Northern Queensland, with a population base forecast to grow faster than Queensland and Australia (Unicare NQ Limited, 2003; Townsville Enterprise Limited, 2002): (i) is there adequate supply of childcare places in Townsville, (ii) what factors determine market preference for formal and informal care, (iii) what are the areas of greatest customer density for childcare, and (iv) where should a new childcare facility be located in order to maximize utilization.

The paper is organized as follows. Section 2 discusses the conceptual frameworks employed to (i) forecast childcare users for the period 2005 and 2006, (ii) assess predictors of formal care, and (iii) model customer density and location choice for new childcare services. Section 3 outlines the methodology of the study, Section 5 presents the results of the study and Section 5 concludes with a set of recommendations for the childcare industry in Townsville.

2. CONCEPTUAL MODELS

2.1 The Prediction Model to Assess Childcare Users in 2005 and 2006

We model population changes to potential childcare consumers based on the following assumptions:

1. $P = P(t)$ denotes the total consumer population for childcare at time "t".
2. Both entry and exit to childcare are proportional to the population size (P) and time interval (δt). That is, entry to childcare = $xP\delta t$ and exit to childcare = $yP\delta t$, where x and y are constants.

Thus, increase in population during the time interval 'δt' is given by:

$$\delta P = xP\delta t - yP\delta t \tag{1}$$

which can be rewritten as:

$$(x-y)\, P\delta t = \theta P\delta t \tag{2}$$

where $\theta = (x-y)$.

The above formulation leads to the first-order differential equation:

$$\delta P / \delta t = \theta P \tag{3}$$

or

$$[(1/P)\,(\delta P / \delta t)] = \theta \tag{4}$$

which can be expressed as:

$$(1/P)\,\delta P = \delta t\,\theta \tag{5}$$

Integrating on both sides of (5) results in:

$$\int (1/P)\,\delta P = \int \theta\,\delta t \text{ or} \tag{6}$$

$$\int (1/P)\,\delta P = \theta t + C \tag{7}$$

where C is a constant.

We can re-express (7) as:

$$\ln P = \theta t + C \tag{8}$$

At 't' = 0, we have $P(0) = e^{\theta t + C}$ which can be rewritten as:

$$P(0) = ke^{\theta t} = k \tag{9}$$

Similarly, for 't' = 1, we have $\ln P(1) = \theta(1) + C$ which can be rewritten as:

$P(1) = e^{\theta 1 + C}$ or alternatively

$$P(0)e^{\theta} = P(1) \tag{10}$$

Note that the above prediction model is a reasonable one to employ when our prediction exercise is for a time interval not exceeding thirty years (Hutchinson, 1978).

2.2 Predictors of Formal versus Informal Care

Here, our objective is to estimate the probability of the two response outcomes: that is, formal care versus informal care, as a function of the following predictor variables: availability of childcare at short notice, getting care for the hours needed, cost of childcare, finding a childcare centre in the right location, and finding good quality childcare. These predictors were chosen based on a literature review on the subject (for example, Gray, et al., 2002; Joesch and

Hiedemann, 2002) and based on the industry's ability to control the variables. In other words, these predictors are manipulable or changeable by the industry.

In line with ABS (1999), formal care is defined as, 'regulated care that takes place away from child's home', and informal care as, 'care extended by family members, friends, paid babysitters, and neighbours'.

We express the relationship between criterion and predictor variables as follows:

$$y_i = \beta' x_i + e \tag{11}$$

where $y = 1$ = Formal care
$y = 0$ = Informal care
x_i = The set of predictors, where i = 1, …, n
β = Parameters
e = Error term

Expressed in probability form (11) becomes:

$$\text{Prob } (y_i = 1) = (\text{Prob } (e_i > - \beta' x_i) = 1 - F(-\beta' x_i) \tag{12}$$

where F = cumulative density function of *e*. We assume that "e_i" is logistic and so can express $F(-\beta' x_i)$ as:

$$F(-\beta' x_i) = \exp(-\beta' x_i) / 1 + \exp(-\beta' x_i) = 1 / [1 + \exp(\beta' x_i)] \tag{13}$$

The likelihood function for the probability model in (13) becomes:

$$L = \Pi_{yi=1} [1 - F(-\beta' x_i)] \,.\, \Pi_{y=0} F(-\beta' x_i) \tag{14}$$

Simplifying (14) using "ln" results in:

$$\Sigma_n \ (j) \ln [1-F(-\beta' x_i)] + (k) \ln [F(-\beta' x_i)] \tag{15}$$

where j = number of cases where y = 1, and k = number of cases where y = 0. Then we find the maximum of "ln L" by differentiating with respect to β_s and setting the resulting derivatives to "0" to solve for β_s.

Note that assuming a binary response: that is, modelling formal and informal care, is in line with the argument that category need should be modelled first before modelling secondary demand (Best, 2005). In other words, parent's needing childcare would choose formal or informal care first before deciding on types of care such as long day care, before-after school care, paid babysitter, friends, etc. Note that information obtained from category need analysis can be used to influence customer behaviour towards formal childcare. For instance, if category choice depends on factors such as 'care at short notice', 'cost of care', etc., then the formal care industry in Townsville can "sell" its product by communicating these benefits to customers.

2.3 Model for Consumer Density Assessment and Location for New Childcare Centre

We employ the kernel density approach to estimate customer densities in Townsville SLAs (Silverman, 1986). Donthu and Rust (1988) have shown the superiority of this method over methods such as histogram for density estimation purposes. For this exercise, we employ as kernel function (K) a standard normal bivariate distribution. In line with common practice, the bandwidth "h" was chosen to minimize the approximate mean integrated square error of the estimated density. The kernel estimate defined in "d" dimensions can be written as:

$$f\,(\mathbf{x}) = (nh^d)^{-1}\,\Sigma^n_i\,K\,((\mathbf{x} - \mathbf{x}_i)\,/\,h) \tag{16}$$

The kernel function has the following properties:

(i) $0 < K(x) < C$;
(ii) $K(x) = K(-x)$;
(iii) $\int K(x)\,dx = 1$;
(iv) $\int K(x)x\,dx = 1$;
(v) $h \rightarrow 0$ as $n \rightarrow \infty$

As regards location choice for new childcare facility, we begin with the density estimate $f(x,y)$, and express the market share of childcare facility(s) at location "j" as:

$$MS_j = \int^{\infty}_{-\infty} \int^{\infty}_{-\infty} f(x,y)\,P_j\,(x,y)\,dx\,dy \tag{17}$$

where $P_j(x,y)$ is similar to Luce's formulation for choice: that is, $U_j\,/\,\Sigma^k_i\,U_k$ (Luce, 1959).

Specifically, in line with gravity models (Leeflang, Wittink, Wedel and Naert, 2000), it is assumed that childcare decisions are made under conditions of uncertainty; and that utility for a customer is based on her expectation of costs and benefits associated with childcare at location "j".

We compute U_j as an exponential function of the distance between childcare facility(s) in one location and other statistical local areas. That is:

$$U_j = \exp\,(-d^2_j) \tag{18}$$

The optimal location (x*, y*) for the new child care facility j is found by maximising market share ("MS_j" in (17)). We employ the Newton search procedure to find the local optima.

3. METHODOLOGY

Both primary and secondary data were employed to address the research questions.

3.1 Secondary data

For forecasting purposes, population data for each of the 25 local statistical areas (SSAs) in Townsville, for the period 1991-2001, were collected. The focus was on the childcare consumer: that is, children in the 0-12 age group. The ABS

2001 Census of Population and Housing provided the required information (see www.abs.gov.au).

Information for market potential calculations was obtained from Census of Childcare Services (2003), and ABS (2003). Briefly, the proportion of childcare users reported in the census, for each of the 0-12 age group, was used as weights for the forecast population. Market potential estimates were derived for each age group for 2005 and 2006.

Details about childcare businesses in each of the 25 SLAs in Townsville were obtained from Queensland Government's web site: www.families.qld.gov.au\childcare\search\text\index.cfm.

Based on the licensed capacity of the childcare centres in each SLA, a demand-supply assessment was carried out and used as input to the location choice exercise.

3.2 Primary Data

In order to explore the likelihood of the marketplace choosing formal rather than informal care, a questionnaire survey of Townsville residents was undertaken. The target population included adults in households with one or more children less than 12 years of age. Since most commonly available sampling frames such as the telephone directory do not reveal whether any given address will yield a household with the desired characteristics, survey takers were employed to identify participants and to drop-off a two-page, self-administered questionnaire at their homes. Two survey takers dropped off 520 questionnaires to 400 households. The sampling approach to drop-off questionnaire method discussed in Lovelock, et al. (1976) was employed. Specifically, households were chosen randomly using the Telstra White Pages directory on CD: 2004 edition, and survey takers were instructed to (i) make one call back to each household where no one was home before substituting another, and (ii) deliver as many questionnaires to each household as there were household members who matched the sampling criteria.

Respondents were requested to state whether they needed childcare over the last 12 months. If care was needed, respondents were asked to state the level of difficulty each of the following have been for them in the last 12 months: finding quality childcare, finding the right person to take care of the child, getting care for the hours needed, finding care for a sick child, finding care during school holidays, cost of childcare, juggling multiple childcare arrangements, finding care for a special needs child, finding a place at the preferred childcare centre, finding a childcare centre in the right location, finding care at short notice, and finding care where children are happy. Likert scales were used in all the rating exercises. Factual information sought from respondents included household characteristics, and age of the respondent.

4. RESULTS AND DISCUSSION

4.1 Childcare Users in 2005 and 2006

Children attend childcare services for a number of reasons. According to Blain (2004), parents place their children in long day care, family day care and before and after school care mainly for work related purposes. In other words, these parents are either working, or looking for work or studying. Parents also arrange childcare for personal reasons such as shopping and entertainment. Table 1 highlights the commonly cited determinants of childcare discussed in the extant literature.

Table 1. Determinants of Demand for Childcare Places.

Child Characteristics	**Family Characteristics**
Age, school attendance	Parent’s labour force status, parent’s income, number and age of other dependents

Data from the Census of Child Care Services (1999 & 2002) suggest that childcare usage in Australia is growing at a rate of 8 percent per annum[12]. In other words, the determinants given in Table 1 are assumed to “cause” or influence childcare usage.

Table 2 provides details related to consumption of childcare services in the state of Queensland (QLD) as at May 2002. Note that children less than five years of age constitute the major users / consumer segment for ‘long day care’, ‘family day care’, ‘in-home care’, and ‘occasional care’. On the other hand, ‘after school care’, and ‘vacation care’ are largely consumed by children in the 6-12 years of age category. In the following pages, we focus on the 0-12 age group and predict changes to this population over time.

The prediction model discussed earlier was fitted to population data for the SLAs in Townsville. In all, 13 prediction equations were developed for each of the 25 SLAs resulting in a total of 325 prediction equations for each of the forecast year 2005 and 2006. Each equation represented an age group within the 0 to 12 years of age category. Table 3 shows the numerical values for the 13 prediction equations employed to forecast population growth for the ‘Douglas’ area. The Data Appendix contains the forecasts for all of the age groups in each of the SLAs.

Appendix Tables A1 and A2 suggest some generalizations about population in the 0-5 and 6-12 age groups in Townsville. For instance, the SLA ‘Townsville City’ has fewer children, whereas the SLA ‘Murray’ has the largest concentration of children in the region. In terms of population growth during 2005 and 2006, the SLA ‘Douglas’ registers the largest growth for children in the

[12] In 1999, there were 577,500 children attending care. The number for 2002 was 732,100. These figures translate into an annual growth rate of 0.079.

0-5 age group, and 'Murray' poses the greatest growth in numbers in the 6-12 age group. In summary, Murray, Douglas, and Cranbrook would have the most concentration of children in the region in 2006.

Table 2. Childcare Services in QLD: Type and Patronage.

		% in the age group	
TYPE OF CARE	**Number**	**≤ 5**	**> 5 and <13**
Private long day care services	65108	91	9
Community long day care services	14573	98	2
Family day care schemes	18762	75	25
In-home care schemes	468	62	38
Outside school hours care	30007	15	85
Vacation care	20514	10	90
Occasional care	1196	99	1
Other	558	80	20

Note: Other includes multifunctional services, mobile libraries, aboriginal playgroups, and multifunctional aboriginal playgroups or MACS. See Census of Childcare Services (2003).

Table 3. Prediction Equations for Douglas: Age Group 0-12.

Age	Base Population (2001)	θ (Growth Parameter)	Population Forecast for 2006
< 1	47	0.33	245
1 - < 2	40	0.22	123
2 - < 3	39	0.12	72
3 - < 4	40	0.17	94
4 - < 5	31	0.10	51
5 - < 6	30	0.26	113
6 - < 7	37	0.18	91
7 - < 8	38	0.15	80
8 - < 9	30	0.04	38
9 - < 10	31	0.08	46
10 - < 11	30	0.08	45
11 - < 12	29	0.06	38
< 13	28	0.05	36

While population projections do reveal the maximum number of childcare users or children, it does not provide us with an estimate of the most probable number of childcare users. In other words, our focus shifts from maximum number of children to maximum number of consuming units or market potential.

In order to derive market potential for childcare industry in Townsville, we weighted the population forecasts by the proportion of children who consumed childcare services in the past. Specifically, childcare consumption data (ABS, 2003) were used as weights to compute market potential for the industry, in each of the SLA. For instance, consider the "3 years of age" segment in the

Townsville region. From Appendix Table A1 we know that the forecast population for this segment for 2005 is 1110. We apply a 0.63 weighting to this number – 63 percent being the childcare usage rate among children in this population, to arrive at a market potential figure of 698. Table 4 lists the market potential, age-wise, for the Townsville region. Appendix Tables A3 and A4 highlight the market potential, age-wise, for each of the SLAs for 2005 and 2006 respectively.

Table 4. Market Potential Computations: Weights and Predictions for 2005 and 2006.

Age	Proportion of Consumers in that Age Group*	Market Potential 2005	Market Potential 2006
0	0.07	88	93
1	0.27	313	322
2	0.41	395	392
3	0.63	698	709
4	0.83	947	964
5	0.28	370	388
6	0.13	156	161
7	0.13	174	184
8	0.13	158	163
9	0.07	92	96
10	0.07	82	85
11	0.07	85	87
12	0.07	91	94

*Source: ABS (2003) Child Care, Australia.

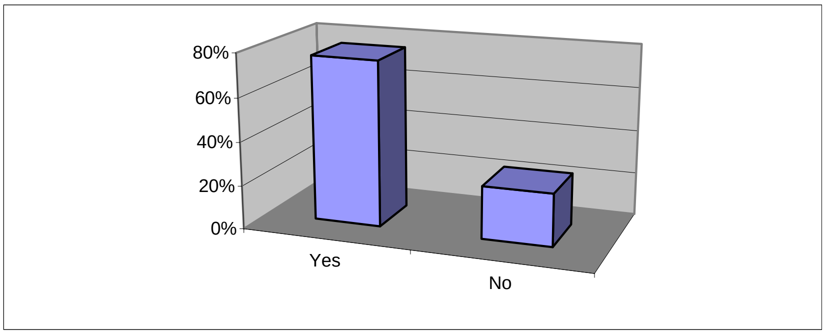
Briefly, as shown in Table 4, the “0-5” age group is likely to consume 77 percent of the childcare services. Within this segment, 34 percent of the services will be demanded by 4 year olds, followed by 3 year olds with a claim for 25 percent of the available services. As regards children in the 6-12 age group, the majority of the demand will emanate from less than 9 year olds.

Given these numbers, how would Townsville’s population care for their children? Is there adequate number of “formal” childcare places in Townsville? Which location offers the optimal “reach” to potential customers? These questions are addressed next.

4.2 Predictors of Formal Care: Results of Questionnaire Survey

The drop-off method of data collection resulted in a 46 percent response rate (n = 240). Of these, 76 percent reported needing some form of childcare in the last 12 months. When queried about the kinds or types of care needed for their children, 44 percent cited full-day care, 14 percent half-day care, 27 percent mentioned before/after school care, and 15 percent stated that they had a need for night or weekend care for their children (Figure 1).

(i) The Question Read, “Over the last 12 months, have you needed childcare for any of your children…”



(ii) Kinds of Care Needed

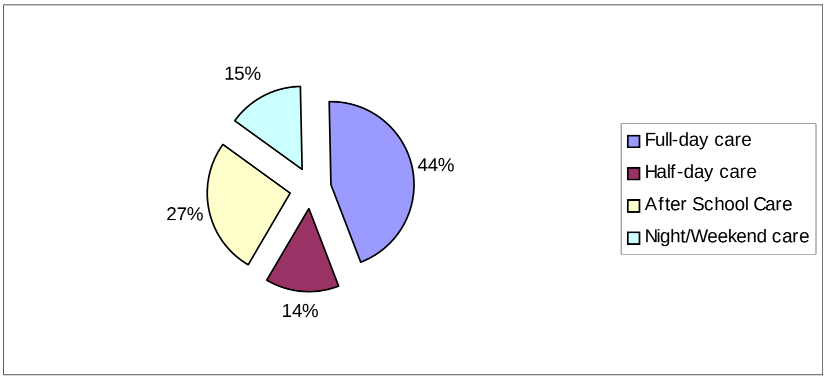
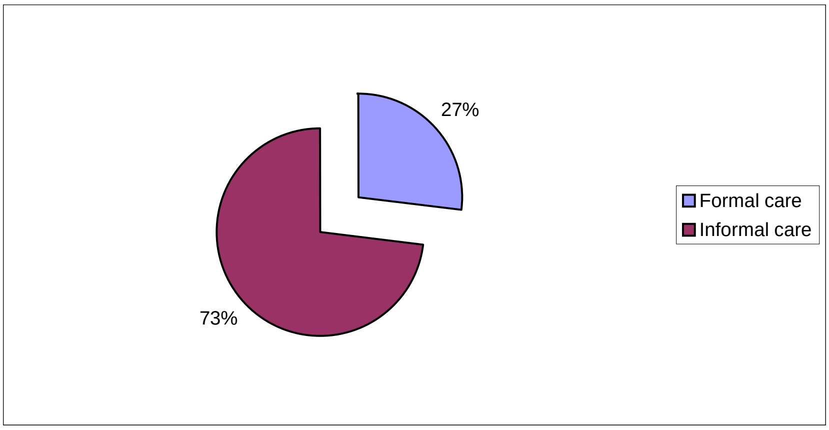


Figure 1. Need for Childcare.

When asked about the mode of care: that is, whether care was provided by relatives, non-relatives, childcare centre, etc., a majority of the respondents (55 percent) stated that relatives cared for their children, 27 percent stated that they had utilised the services of childcare centres, and 18 percent had placed their children in non-relative’s home. In terms of our classification of care as formal or informal, the survey suggests that formal care was utilised by at least 27 percent of the respondents in the region (Figure 2). Note that this figure is similar to formal care usage reported by ABS (2003): that is, 25 percent.

Having established the usage of formal versus informal care in the community, we now turn to understanding the predictors of formal child care in Townsville.

(i) Formal versus Informal Care



(ii) Informal Care: How Provided

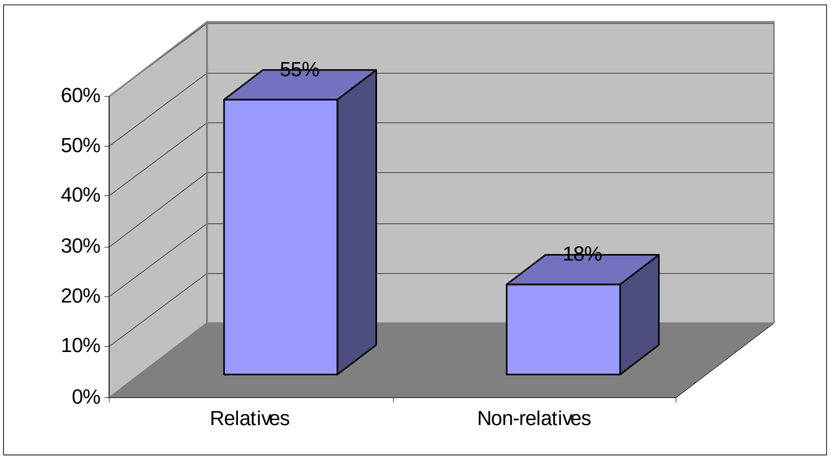


Figure 2. How Care was Provided for Children

As mentioned earlier, our interest is in modelling the choice of formal care. We estimate $y = \beta' x_i + e_i$, and based on that, assess the probability of formal care usage as:

Prob (y = 1= Formal Care) = $1 - F(-\beta' x_i) = \exp(\beta' x_i) / 1 + \exp(\beta' x_i)$.

Table 5 presents the descriptive statistics for all the variables used in the model, and highlights the "partial" effects of each independent or predictor variables on changes in the respondent's probability for patronising formal care.

Table 5. Partial Effects of the Predictor Variables.

Coefficient	Value	Std. Error	T-ratio	Prob $|t|\grave{o}x$	Mean	S.Dev
β_0	.22	.40	.560	.57	1.0000	.00000
β_1 (Quality)	.18E-01	.10	.183	.85	5.0053	2.0855
β_2 (Getting care for hours needed)	-.23	.10	-2.248	.02	4.4118	2.3932
β_3 (Cost)	-.95E-01	.94E-01	-1.013	.31	2.9412	1.6950
β_4 (Location)	.37	.64E-01	5.804	.00	3.6043	2.7305
β_5 (Finding care at short notice)	-.10	.54E-01	-1.893	.05	2.5882	2.2544

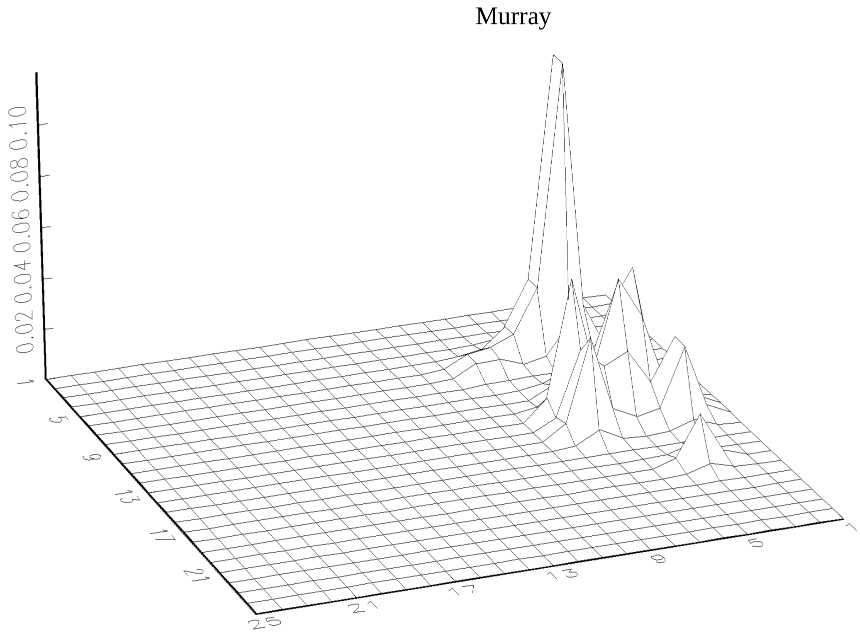
The results highlight that formal childcare is driven by customers finding a childcare centre at the right location. Non-usage is primarily related to respondents not getting care for the hours they need, and them being unable to find care at short notice. Note that cost of care does not appear to be an issue for the respondents.

Based on these findings: that is, $\beta' x_i = .22 + .018x_1 - .23x_2 - .095x_3 + .37x_4 - .10x_5$, we arrive at a probability of 0.44 for formal care when the predictor variables are fixed at their mean values. Since the location variable (x_4) provides the most impact on usage of formal care, any attempt to influence potential customer perceptions and usage behaviour toward formal care should begin with changes to this variable. Next, we examine customer density in the SLAs with the objective to finding the optimal location for a childcare facility in Townsville.

4.3 Customer Density and Optimal Location for Childcare

As at 16 February 2005, there were 42 long day cares, two family day cares, and eight kindergarten in Townsville that had a combined total of more than 2788 licensed places. This translates into approximately 0.76 places per child in the target age group: that is, market potential for children in the 0-12 years of age divided by the number of licensed childcare places. If we restrict our focus to children in the “0-5 age group”, then there are enough long day care places for each child in the Townsville region. As regards “after school care” market, there were 17 businesses competing for 841 potential users in the 6-12 years of age category (Queensland Government, 2005).

While the region has adequate childcare places, this does not mean that each SLA has adequate supply of places. In fact, only 18 of the 25 SLAs have long day care facilities in the region. Three of the 25 SLAs: Pallerenda, Pimilco, and Railway Estate, have no formal care places. Figure 3 shows the kernel density plot of customers in the SLAs. It was constructed using demand-supply estimates of the SLAs. For instance, the SLA “Murray” has a market potential for 596 childcare places in 2005 and 631 places for 2006 (Appendix 2). It has a supply of 194 places. We input these details into the kernel estimate to arrive at a density value of 0.11 (z axis in Figure 3). Figure 3 was constructed as follows. First, we obtained from ABS (2005) a Townsville regional map that contained all of the 25 SLAs. Next, we partitioned the map finely into 400 x, y coordinates or grid. Finally, we superimposed the “z” axis (density estimates) on to the x and y axes, to arrive at Figure 3. Other places that show gaps in excess of 100 childcare places include: Mt. Louisa – Mt St John-Bohle, Railway Estate, and Vincent (Figure 4). Note that these calculations assume that category need for “formal” childcare places exists and/or will be created in these markets. In other words, the formal childcare industry will, through marketing communications, associate its product to the customer need for childcare to ensure that formal care is the preferred mode of childcare in the region.



Notes: The 0-12 age group projections for 2005 are used in all computations.

Oversupply exists as follows: (Douglas has 76 places more than the number of children in the 0-12 age group followed by North Ward - Castle Hill with 55 more places than the total predicted population for 2005/2006.

Note that we assume that there is little or no multiple childcare arrangements in the target markets.

Figure 3. Customer Density Assessment Based on Demand-Supply Gaps: Kernel Density Plot

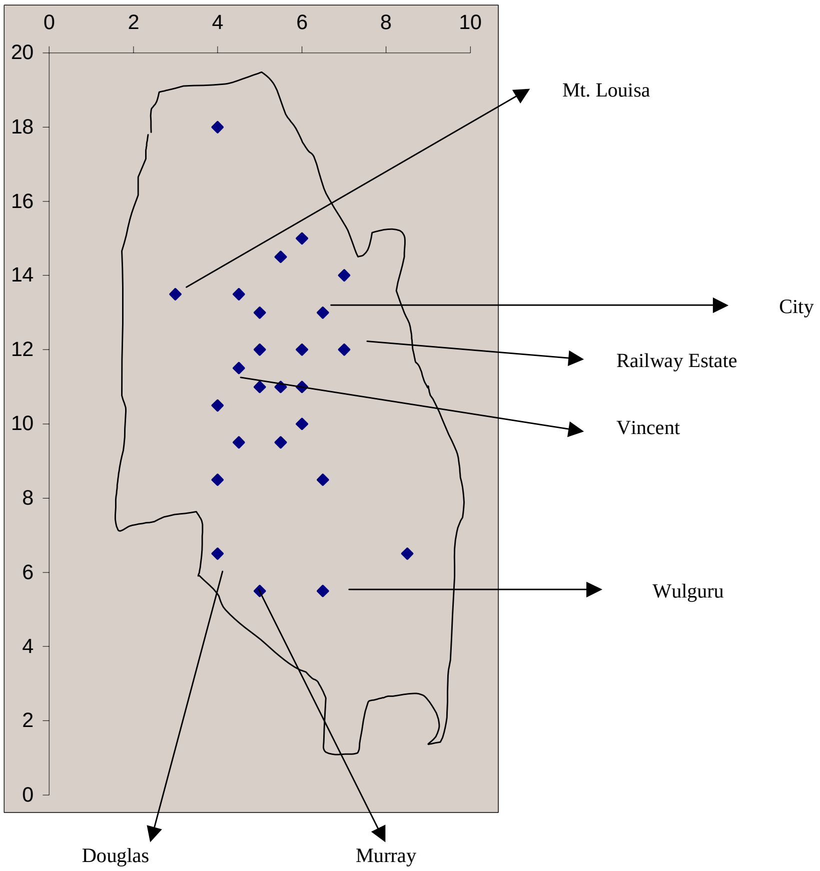


Figure 4. Townsville Region: Location of SLAs with Need for Additional Childcare Places

The geographical area with coordinates x = 5 and y = 5 within "Murray" would be the ideal or best location for a new childcare facility. This location would give the new facility a 14 percent market share for formal care in the region. Table 6 shows that the new facility would also attract customers from Douglas, and Wulguru (Figure 4).

Table 6. Market Share Estimation.

SLA	Estimated Market Share Before the New Entry	Estimated Market Share After the New Entry
Douglas	5%	4%
Murray	18%	8%
Wulguru	16%	13%

5. CONCLUSIONS

This paper analyses the childcare industry in Townsville: the capital of North Queensland region. In line with ABS (1999), the industry was partitioned into two categories: formal care and informal care. Formal care is defined as 'regulated care that takes place away from child's home', and informal care as, 'care extended by family members, friends, paid babysitters, and neighbours'. The research addressed a set of four questions that dealt with demand and supply of childcare. The research questions and the corresponding responses are:

(i) Is there adequate supply of childcare places in Townsville?

As at 16 February 2005, there were 42 long day cares, two family day cares, and eight kindergarten in Townsville that had a combined total of approximately 2788 licensed places. This figure translates into 0.76 places per child in the target age group: that is, children in the 0-12 years of age group. Given that only 27% of children in the target age group utilize formal care, we conclude that Townsville region has adequate childcare places. However, some of the SLAs in the region might benefit from new care centres since these would minimize the distance customers have to travel to use formal care.

(i) What factors determine market preference for formal and informal care?

Finding a childcare centre at the right location drives formal childcare usage. Non-usage is primarily related to respondents not getting care for the hours they need, and them being unable to find care at short notice.

(ii) What are the areas of greatest customer density for childcare?

SLAs with greatest density include: Murray, Mt. Louisa – Mt St John-Bohle, Railway Estate, and Vincent. In other words, these places have the greatest need for formal childcare.

(iii) Where should a new childcare facility be located in order to maximize utilization?

The new facility should be located within the "Murray" area. Market share computations suggest that this location would give the new facility a 14 percent market share. The facility is expected to attract customers from nearby SLAs such as Douglas and Wulguru.

Consider the following hypothetical scenario about a meeting involving regional planners:

"I think there is a need for a childcare centre in the community", quipped a senior manager. "What if we built a facility and nobody came", said another. "Location is the key", replied another. "Let us have it in the newly

planned constructions within the CBD area. That should attract the most customers" was the conclusion of the meeting.

The above scenario appears to be a common tactic among managers for selecting locations or sites for businesses (Krasner, 2005). Specifically, management intuition tends to replace market research in selecting new locations. It is hoped that the market research methods outlined in this paper would aid decision-making in regional planning exercises.

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DATA APPENDIX

Table A1. Population Projections for Townsville SLAs: 2005.

SLA	Age 0	Age 1	Age 2	Age3	Age 4	Age5	Age 6	Age 7	Age 8
Aikenvale	93	51	62	42	49	56	46	59	45
Cranbrook	80	82	98	84	90	119	81	69	111
Currajong	32	21	29	26	29	21	30	16	23
Douglas	176	98	64	79	46	86	76	69	36
Garbutt	30	21	27	24	18	34	42	22	37
Gulliver	23	47	30	43	58	71	35	71	50
Heatley	54	59	79	44	86	73	81	75	93
Hermit Park	53	39	45	38	35	54	38	63	34
Hyde Park-Mysterton	23	39	19	18	22	16	22	38	23
Mt Louisa-Mt St John-Bohle	67	82	57	72	87	86	67	77	75
Mundingburra	34	40	18	37	37	38	23	53	49
Murray	141	152	129	160	202	211	274	215	253
North Ward-Castle Hill	45	40	46	48	46	34	34	70	59
Oonoonba-Idalia-Cluden	31	30	18	33	14	34	47	14	29
Pallarenda-Shelley Beach	5	16	5	12	11	9	21	12	12
Pimlico	46	48	11	36	38	25	13	33	33
Railway Estate	49	39	20	36	25	64	31	45	27
Rosslea	12	20	6	19	15	13	21	67	11
Rowes Bay-Belgian Gardens	34	16	20	19	26	28	17	26	29
South Townsville	24	9	23	26	23	24	31	36	21
Stuart-Roseneath	6	10	11	13	8	14	4	3	3
Townsville City	27	28	6	25	12	24	19	31	8
Vincent	57	52	50	48	56	72	31	55	36
West End	60	40	43	67	48	52	49	47	34
Wulguru	55	80	48	61	59	62	67	71	88
Total	1257	1159	964	1110	1140	1320	1200	1337	1219

Table A1 Continued.

SLA	Age 9	Age 10	Age 11	Age 12	0-5 Total	6-12 Total	Grand Total
Aikenvale	56	33	44	75	353	358	711
Cranbrook	90	95	90	125	553	661	1214
Currajong	24	18	34	51	158	196	354
Douglas	42	41	36	34	549	334	883
Garbutt	52	37	17	43	154	250	404
Gulliver	34	28	35	41	272	294	566
Heatley	112	59	82	56	395	558	953
Hermit Park	55	41	25	29	264	285	549
Hyde Park-Mysterton	37	23	34	26	137	203	340
Mt Louisa-Mt St John-Bohle	33	55	60	54	451	421	872
Mundingburra	50	52	50	53	204	330	534
Murray	222	246	225	270	995	1705	2700
North Ward-Castle Hill	49	61	82	54	259	409	668
Oonoonba-Idalia-Cluden	61	16	16	43	160	226	386
Pallarenda-Shelley Beach	18	35	6	29	58	133	191
Pimlico	31	38	25	50	204	223	427
Railway Estate	37	14	46	25	233	225	458
Rosslea	11	42	25	3	85	180	265
Rowes Bay-Belgian Gardens	21	19	45	24	143	181	324
South Townsville	26	17	17	13	129	161	290
Stuart-Roseneath	11	13	21	19	62	74	136
Townsville City	3	20	25	20	122	126	248
Vincent	66	44	56	41	335	329	664
West End	56	24	21	52	310	283	593
Wulguru	117	104	90	72	365	609	974
Total	1314	1175	1207	1302	6950	8754	15704

Table A2. Population Projections for Townsville SLAs: 2006.

SLA	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8
Aikenvale	97	49	60	39	47	54	43	57	43
Cranbrook	81	82	101	83	91	123	79	66	113
Currajong	32	20	29	25	29	20	29	15	22
Douglas	245	123	72	94	51	113	91	80	38
Garbutt	30	19	26	23	16	33	44	21	37
Gulliver	21	48	28	44	62	77	35	76	52
Heatley	52	56	79	41	88	72	81	77	97
Hermit Park	53	38	45	37	34	56	38	68	34
Hyde Park-Mysterton	21	41	17	17	21	15	21	38	22
Mt Louisa-Mt St John-Bohle	70	84	55	71	92	90	67	78	77
Mundingburra	33	40	16	37	36	38	21	55	49
Murray	149	158	131	164	216	228	301	231	277
North Ward-Castle Hill	43	38	46	48	48	34	33	76	62
Oonoonba-Idalia-Cluden	31	30	17	33	13	36	53	13	29
Pallarenda-Shelley Beach	5	17	5	12	11	8	23	12	11
Pimlico	47	52	10	37	40	25	12	36	35
Railway Estate	51	39	18	36	25	70	30	47	26
Rosslea	11	20	5	19	15	13	22	88	11
Rowes Bay-Belgian Gardens	34	15	19	17	26	28	15	26	28
South Townsville	24	8	23	28	23	26	34	40	22
Stuart-Roseneath	5	12	12	14	8	14	4	2	3
Townsville City	30	32	5	28	13	26	19	36	7
Vincent	55	51	47	46	53	71	27	54	34
West End	62	39	43	73	48	55	52	50	35
Wulguru	52	80	46	59	56	61	63	72	90
Total	1334	1191	955	1125	1162	1386	1237	1414	1254

Table A2 Continued.

SLA	Age 9	Age 10	Age 11	Age 12	0-5 Total	6-12 Total	GrandTotal
Aikenvale	55	31	43	76	346	348	694
Cranbrook	90	95	90	126	561	659	1220
Currajong	24	17	34	56	155	197	352
Douglas	46	45	38	36	698	374	1072
Garbutt	55	37	16	44	147	254	401
Gulliver	35	27	35	41	280	301	581
Heatley	119	59	84	55	388	572	960
Hermit Park	62	42	25	28	263	297	560
Hyde Park-Mysterton	37	23	35	25	132	201	333
Mt Louisa-Mt St John-Bohle	30	53	60	51	462	416	878
Mundingburra	52	51	50	53	200	331	531
Murray	236	272	241	302	1046	1860	2906
North Ward-Castle Hill	49	64	89	53	257	426	683
Oonoonba-Idalia-Cluden	68	15	15	45	160	238	398
Pallarenda-Shelley Beach	18	40	5	33	58	142	200
Pimlico	34	42	25	54	211	238	449
Railway Estate	38	13	46	24	239	224	463
Rosslea	11	48	28	3	83	211	294
Rowes Bay-Belgian Gardens	20	18	48	23	139	178	317
South Townsville	27	17	17	12	132	169	301
Stuart-Roseneath	12	13	24	19	65	77	142
Townsville City	3	21	30	20	134	136	270
Vincent	69	42	58	39	323	323	646
West End	60	24	21	56	320	298	618
Wulguru	124	109	91	70	354	619	973
Total	1374	1218	1248	1344	7153	9089	16242

Table A3. Market Potential for Townsville SLAs:2005.

SLA	Age 0	Age 1	Age 2	Age 3	Age4	Age 5	Age6	Age 7	Age 8
Aitkenvale	6	14	25	26	41	16	6	8	6
Cranbrook	6	22	40	53	75	33	11	9	14
Currajong	2	6	12	16	24	6	4	2	3
Douglas	12	27	26	50	38	24	10	9	5
Garbutt	2	6	11	15	15	10	5	3	5
Gulliver	2	13	12	27	48	20	5	9	7
Heatley	4	16	32	28	71	20	11	10	12
Hermit Park	4	10	18	24	29	15	5	8	4
Hyde Park-Mysterton	2	11	8	11	18	5	3	5	3
Mt Louisa-Mt St John-Bohle	5	22	23	45	72	24	9	10	10
Mundingburra	2	11	8	24	31	11	3	7	6
Murray	10	41	53	101	167	59	36	28	33
North Ward-Castle Hill	3	11	19	30	39	10	4	9	8
Oonoonba-Idalia-Cluden	2	8	7	21	12	10	6	2	4
Pallarenda-Shelley Beach	0	4	2	7	10	2	3	2	2
Pimlico	3	13	5	22	31	7	2	4	4
Railway Estate	3	10	8	22	21	18	4	6	4
Rosslea	1	5	2	12	13	4	3	9	1
Rowes Bay-Belgian Gardens	2	4	8	12	21	8	2	3	4
South Townsville	2	2	9	16	19	7	4	5	3
Stuart-Roseneath	0	3	5	8	7	4	1	0	0
Townsville City	2	8	2	16	10	7	2	4	1
Vincent	4	14	21	30	47	20	4	7	5
West End	4	11	18	42	40	15	6	6	4
Wulguru	4	22	20	39	49	17	9	9	11
Total	87	314	394	697	948	372	158	174	159

Table A3 Continued.

SLA	Age 9	Age 10	Age 11	Age 12	0-5 Total	6-12 Total	GrandTotal
Aitkenvale	4	2	3	5	128	34	162
Cranbrook	6	7	6	9	229	62	291
Currajong	2	1	2	4	66	18	84
Douglas	3	3	3	2	177	35	212
Garbutt	4	3	1	3	59	24	83
Gulliver	2	2	2	3	122	30	152
Heatley	8	4	6	4	171	55	226
Hermit Park	4	3	2	2	100	28	128
Hyde Park-Mysterton	3	2	2	2	55	20	75
Mt Louisa-Mt St John-Bohle	2	4	4	4	191	43	234
Mundingburra	4	4	3	4	87	31	118
Murray	16	17	16	19	431	165	596
North Ward-Castle Hill	3	4	6	4	112	38	150
Oonoonba-Idalia-Cluden	4	1	1	3	60	21	81
Pallarenda-Shelley Beach	1	2	0	2	25	12	37
Pimlico	2	3	2	3	81	20	101
Railway Estate	3	1	3	2	82	23	105
Rosslea	1	3	2	0	37	19	56
Rowes Bay-Belgian Gardens	2	1	3	2	55	17	72
South Townsville	2	1	1	1	55	17	72
Stuart-Roseneath	1	1	1	1	27	5	32
Townsville City	0	1	2	1	45	11	56
Vincent	5	3	4	3	136	31	167
West End	4	2	1	4	130	27	157
Wulguru	8	7	6	5	151	55	206
Total	94	82	82	92	2812	841	3653

Table A4. Market Potential for Townsville SLAs: 2006.

SLA	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8
Aitkenvale	7	13	24	25	39	15	6	7	6
Cranbrook	6	22	41	52	76	34	10	9	15
Currajong	2	5	12	16	24	6	4	2	3
Douglas	17	33	30	59	42	32	12	10	5
Garbutt	2	5	11	15	13	9	6	3	5
Gulliver	1	13	12	28	52	22	5	10	7
Heatley	4	15	32	26	73	20	11	10	13
Hermit Park	4	10	19	23	28	16	5	9	4
Hyde Park-Mysterton	1	11	7	11	18	4	3	5	3
Mt Louisa-Mt St John-Bohle	5	23	23	45	76	25	9	10	10
Mundingburra	2	11	7	23	30	11	3	7	6
Murray	10	43	54	103	179	64	39	30	36
North Ward-Castle Hill	3	10	19	30	40	10	4	10	8
Oonoonba-Idalia-Cluden	2	8	7	21	11	10	7	2	4
Pallarenda-Shelley Beach	0	5	2	8	9	2	3	2	1
Pimlico	3	14	4	23	33	7	2	5	5
Railway Estate	4	11	7	23	20	20	4	6	3
Rosslea	1	5	2	12	12	4	3	11	1
Rowes Bay-Belgian Gardens	2	4	8	11	22	8	2	3	4
South Townsville	2	2	9	17	19	7	4	5	3
Stuart-Roseneath	0	3	5	9	7	4	0	0	0
Townsville City	2	9	2	18	10	7	3	5	1
Vincent	4	14	19	29	44	20	4	7	4
West End	4	11	18	46	40	15	7	6	5
Wulguru	4	22	19	37	47	17	8	9	12
Total	92	322	393	710	964	389	164	183	164

Table A4 Continued.

SLA	Age 9	Age 10	Age 11	Age 12	0-5 Total	6-12 Total	Grand Total
Aitkenvale	4	2	3	5	123	33	156
Cranbrook	6	7	6	9	231	62	293
Currajong	2	1	2	4	65	18	83
Douglas	3	3	3	2	213	38	251
Garbutt	4	3	1	3	55	25	80
Gulliver	2	2	2	3	128	31	159
Heatley	8	4	6	4	170	56	226
Hermit Park	4	3	2	2	100	29	129
Hyde Park-Mysterton	3	2	2	2	52	20	72
Mt Louisa-Mt St John-Bohle	2	4	4	4	197	43	240
Mundingburra	4	4	4	4	84	32	116
Murray	16	19	17	21	453	178	631
North Ward-Castle Hill	3	4	6	4	112	39	151
Oonoonba-Idalia-Cluden	5	1	1	3	59	23	82
Pallarenda-Shelley Beach	1	3	0	2	26	12	38
Pimlico	2	3	2	4	84	23	107
Railway Estate	3	1	3	2	85	22	107
Rosslea	1	3	2	0	36	21	57
Rowes Bay-Belgian Gardens	1	1	3	2	55	16	71
South Townsville	2	1	1	1	56	17	73
Stuart-Roseneath	1	1	2	1	28	5	33
Townsville City	0	1	2	1	48	13	61
Vincent	5	3	4	3	130	30	160
West End	4	2	1	4	134	29	163
Wulguru	9	8	6	5	146	57	203
Total	95	86	85	95	2870	872	3742

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