MONASH

5/99

ISSN 1440-771X
ISBN 0 7326 1060 5

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AUSTRALIA

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Working Paper 5/99
March 1999

DEPARTMENT OF ECONOMETRICS
AND BUSINESS STATISTICS

Inter-Regional Migration in Australia: An Applied Economic Analysis[†].

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Abstract: In analysing the effects of economic policy in a Federal system, such as Australia, it is important to understand the interactions between the States and Territories. In particular, given that there is free movement between labour markets, to analyse economic policy it is important to understand the factors influencing inter-regional migration. In this paper we use data from 1982 to 1996 to estimate a structural econometric model of inter-regional migration. The results are then used to re-specify and calibrate the Computable General Equilibrium model MONASH-MRF. This then provides a more detailed picture of labour market responses when we subsequently simulate the response of net inter-state migration to changes in State Government spending.

J. E. L. Classification: C68, J61, R15.

Keywords: CGE models, Migration, MONASH-MRF.

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[†] This work was supported by an Australian Research Council Small Grant.

1. Introduction.

In analysing the effects of economic policy in a Federal system, such as Australia, it is important to understand the interactions between the States and Territories. In particular, given that there is free movement between labour markets, to analyse economic policy it is important to understand the factors influencing inter-regional migration. MONASH-MRF (MMRF) is a multi-regional, multi-sectoral Computable General Equilibrium (CGE) model of the Australian economy which is used extensively in Australia by State government bureaucracies and the private sector to conduct comparative static simulations and for forecasting. Enhancing the existing structure of MMRF would provide a more detailed picture of regional labour market responses to changes in, for example, regional wage rates and unemployment.

In this paper, we use data from 1982 to 1996 to estimate a structural econometric model of net migration inflows. The precise form of this model will be influenced by our knowledge of the labour market module in MMRF as well as by econometric specification test results. The results are then used to re-specify and calibrate MMRF and to simulate the response of net inter-state migration to changes in State Government spending.

The remainder of this paper is organised as follows. In section 2, we briefly outline the existing structure of MMRF and, more specifically, the labour market module and options for the choice of closure. Section 3 examines the proposed specification of the econometric model for migration. The results from estimation are discussed in section 4, and we look at various interpretations/uses of the results. Section 5 contains details of the re-specification of the labour market module in MMRF in terms of the new equations and closure. In section 6, we conduct a simulation to gauge the response of net inter-state migration to a 5 per cent increase in Victorian Government expenditure and a 5 per cent cut in each of New South Wales and Queensland Government expenditure. Finally, section 7 contains some concluding remarks.

2. MMRF and the Existing Labour Market Module.

MMRF divides Australia into 8 regional economies, each with 13 industrial sectors. The model has 4 types of agent (industries, households, governments and foreigners). The model has a CGE core, which sets up the supply and demand relationships and the market clearing identities. In addition to this core are blocks of equations describing government finances, accumulation relationships and regional labour market settings. Our primary interest is in the labour market module, however further details of the model can be found in Peter *et al.* (1996).

The labour market module consists of equations that determine regional population using natural growth, inter-regional migration and foreign migration and equations that determine various regional labour market settings. In the standard short run closure of MMRF each of the components of population is fixed. Our task is to find regional labour supply for given settings of regional participation rates and ratios of population to population of working age. In addition, fixing regional wage differences results in the demand for labour being fixed and therefore regional unemployment being determined as a residual.

Regional population can be 'freed up' or endogenised by inserting migration equations in MMRF. In order to do this, we need to conduct some econometric analysis to determine the variables upon which we believe inter-regional migration depends and the precise nature of these relationships. This should provide values for the parameters in the new equations in MMRF. The next section outlines an econometric model for migration, which will form the basis of our new equations in MMRF.

3. An Econometric Model for Migration.

In its current form, MMRF contains no theory of population movements - they are either fixed or determined as a residual. Using historical data, we can specify and estimate an econometric model that explains inter-regional migration in terms of both economic and non-economic factors. The construction of such a model should be influenced by previous econometric work.

In Australia, there have been several studies attempting to estimate a formal econometric model of inter-regional migration (see, *inter alia*, Flood *et al.* (1991), Industry Commission (1993), Poot (1995)). More recently, Groenewold (1993, 1997) has estimated a set of equations for net inter-state migration and Williams *et al.* (1997) have estimated a single equation for net in-migration to Queensland. Our approach is similar to that of Groenewold.

That is, we will estimate a set of migration equations for all regions in Australia.

3.1 Model specification.

Our general specification is

$$M_{i,t} = f\left(W_{i,t}, \overline{W}_{i,t}, U_{i,t}, \overline{U}_{i,t}, H_{i,t}, \overline{H}_{i,t}, Z_{i,t}\right) \qquad i = 1, \dots, 8; \quad t = 1, \dots, T \qquad (1)$$

where $M_{i,t}$ is the net in-migration (inflows less outflows) to the *i*th region at time *t*, $W_{i,t}$, $U_{i,t}$ and $H_{i,t}$ represent (for region *i* at time *t*) real wages, unemployment and house prices, respectively. The corresponding variables with bars represent average values for the rest of Australia (i.e. for the other regions excluding region *i*). Finally, $Z_{i,t}$ represents a vector of other variables that may influence net regional migration. Our next task is to examine these variables and how they enter the model in more detail.

Economic theory suggests that regional differences in the cost of living and employment prospects will be the major influences on regional labour market movements. Regional real wages are the usual measure of the spending power of current incomes. We also include housing costs to reflect a stock of wealth, which is hypothesised to impact on spending power. Regional unemployment rates are the usual proxy for regional employment prospects.

In addition to economic factors, some form of trend, climate and distance factors may be important. For the short period of time that we shall be considering, we would expect relative climate factors between regions to remain fairly stable. Cross-section or panel data studies, using gravity or interaction models of migration, often point out that distance (which represents the time and cost of moving) has an inverse relationship to migration levels (see Golledge & Stimson (1987)). However, distances between migrant sources and destinations are fixed and therefore provide us with no further information on overall migration behaviour through time. A time trend (alternatively, a lagged migration variable) is often included as a proxy for other unobserved causes of migration, for example some form of momentum or 'copy-cat' behaviour by migrants or changes in other variables for which we have no data.

Previous studies of migration present us with several options as to the choice of migration variable. We could use either the logarithm of migration $\ln(M_{i,t})$, or a differenced variable $(M_{i,t} - M_{i,t-1})$, or a ratio of migration to population $M_{i,t}/P_{i,t}$, or use the (raw) level of migration $M_{i,t}$. We consider each of these options in turn.

Williams *et al.* (1997) used the logarithm of net migration into Queensland to reduce the impact of heteroscedasticity on their model. Over their sample period, net migration to Queensland was positive. However, when modelling net migration into all regions, we find that for some regions (in particular, Victoria and New South Wales) net migration is negative over the sample period. Thus logarithms are not defined.

A time differenced migration variable would explain some form of adjustment effect in migration. A differenced variable of the form $(M_{i,t} - M_{i,t-1})$ is equivalent to having the current migration level $M_{i,t}$ as the dependent variable and including the lagged migration level as an independent variable, with a coefficient of unity. If we believe $M_{i,t-1}$ influences $M_{i,t}$, it would be prudent to estimate such a coefficient, rather than restricting its value to unity. Also, the (assumed) value of unity is likely to exaggerate the actual effect of past migratory behaviour on current migration levels.

The usual reason for modelling a ratio of migration to population is to take account of the 'size effect' (see Groenewold (1993)). This effect is defined as the increase in migration that results purely from an increase in the population. That is, as the population increases, there are more people at risk of moving between the regions. This, of itself, is enough to increase the number of migrants, even if the proportion of migrants in the population remains unchanged. However, as Groenewold (1993) shows, in accounting for the size effect in this manner we impose parameter restrictions that are complex and data dependent.[1] The size effect can be accounted for equally well by modelling the level of migration with population $P_{i,t}$ used as an explanatory variable. This would ensure that the parameter restrictions are less complex and able to be imposed at all points in the sample.[2]

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[1] The parameter restrictions will depend on regional population and so change at each point in the sample. Thus we will have a separate restriction for each parameter at each point in time and no degrees of freedom with which to estimate. In order to maintain sufficient degrees of freedom, Groenewold imposes the restrictions at sample means for regional population. However, this will result in the restrictions that cannot hold for all points in the sample.

[2] Groenewold also justifies the use of a ratio in preference to a level (or flow) on the grounds that it "is more

We have opted to use the level of migration in terms of a net inflow into a region from all other regions. We are able to allow for some adjustment process by using lagged migration as an explanatory variable, with a coefficient that is not restricted to unity. If any evidence of heteroscedasticity is found we may reduce the inefficiency of estimates by adopting robust standard errors for any statistical inference. The size effect can be incorporated into our model by including population as an explanatory variable.

In terms of our explanatory variables, for each region *i* at time *t*, we have three 'own state' variables designed to capture movements resulting from changes in specific regional economic characteristics: wages, unemployment and house prices. Regional wage effects ($W_{i,t}$) are captured by real average weekly earnings (nominal average weekly earnings of all workers in the state, deflated by the state's CPI). Unemployment ($U_{i,t}$) is represented by the regional unemployment rate, and house prices ($H_{i,t}$) are indicated by the region's capital city housing CPI.

To allow for the characteristics of alternative destinations for potential migrants, we need to include corresponding economic variables for the other states. One option is to include variables for each of the states in every equation. This would allow for a 'bilateral' comparison of variables between the source and destination regions. However, our data do not reveal the source of migrants and thus it becomes difficult to untangle the specific effects of variables for different states. As we include explanatory variables for every state in each equation, multicollinearity becomes more likely to adversely affect our results. Thus parsimony is lost and (potentially) little explanation of the causes of migration is gained.

Alternatively, we could combine the variables for all states into an 'Australia-wide' equivalent. This would mean comparing the characteristics for own state and Australia in the decision to migrate, as was done by Groenewold (1993) and Williams *et al.* (1997). However, we believe that the characteristics involved in the decision to migrate may be based on some concept of source-destination comparison. Since we do not know the source of the migrants, some notion of an equivalent 'rest of Australia' variable would seem

likely to avoid non-stationarity problems". While the use of a ratio to take account of the size effect or to reduce the extent of heteroscedasticity may be justified, the use of a ratio instead of a level will not necessarily induce stationarity if the level of migration is found to be non-stationary.

reasonable.

Each of the 'rest of Australia' variables has been constructed as a weighted average of the corresponding 'own state' variables, excluding the given region of interest. Thus, real average weekly earnings for the rest of Australia (excluding region *i*) is constructed as

$$\overline{W}_{i,t} = \sum_{j \neq i}\left(\left(E_{j,t} \Big/ \sum_{k \neq i} E_{k,t}\right) W_{j,t}\right) \tag{2}$$

where $E_{j,t}$ are employment weights for region *j* at time *t*. Similarly, unemployment for the rest of Australia is

$$\overline{U}_{i,t} = \sum_{j \neq i}\left(\left(L_{j,t} \Big/ \sum_{k \neq i} L_{k,t}\right) U_{j,t}\right) \tag{3}$$

and the housing CPI is

$$\overline{H}_{i,t} = \sum_{j \neq i}\left(\left(C_{j,t} \Big/ \sum_{k \neq i} C_{k,t}\right) H_{j,t}\right) \tag{4}$$

where $L_{j,t}$ is the regional labour force and $C_{j,t}$ is the housing CPI combining weight for region *j* at time *t*. Obviously, these 'rest of Australia' variables will change with the equation in which they appear. For example, in the equation for region 1 we would have

$$\overline{W}_{1,t} = \sum_{j=2}^{8}\left(\left(E_{j,t} \Big/ \sum_{k=2}^{8} E_{k,t}\right) W_{j,t}\right) \qquad (5),$$

which excludes wages in region 1 from the calculation. In the corresponding equation for region 8 we would have

$$\overline{W}_{8,t} = \sum_{j=1}^{7}\left(\left(E_{j,t} \Big/ \sum_{k=1}^{7} E_{k,t}\right) W_{j,t}\right) \qquad (6),$$

which excludes wages in region 8 from the calculation.

In our general model, $Z_{i,t}$ includes other variables that may influence net regional migration. Such variables often include lagged migration, time trends, election dummies and some form of state specific tax variables. The inclusion of a linear time trend captures the long term drift from 'rust belt' to 'sun-belt' regions that has been observed over recent years. This phenomenon is typically associated with growing numbers of retirees moving to Queensland. Lagged migration (as discussed above) takes account of 'copy-cat' behaviour, or its reverse. Williams *et al* (1997) used a tax variable to account for the common perception of Queensland as being a lower taxed state, relative to the rest of the country. However, her tax variable appears to be similar to a time trend.

Groenewold also tried to include a tax variable in his model. He constructed a 'net fiscal benefit' variable using annual data and then interpolated it to get quarterly data. He found the tax variable not significant enough to warrant its inclusion (this may have been a result of the interpolation procedure). Since we are currently unable to get data on tax variables for all states on a quarterly basis, we did not include a tax variable. However, Williams *et al*'s finding suggests that the use of a trend variable may proxy tax differences.

Finally, we note that Williams *et al.* (1997) suggested that elections may be a significant factor in migration decisions. Such election variables need to account for the occurrence of an election and whether the ruling party changed as a result of the election. Moreover, it was recognised that the effect on net in-migration would be "unpredictable *a priori* in both magnitude and direction" (Williams *et al.* (1997, p. 10)). At the level of analysis conducted in this paper, it is necessary to define both State/Territory and Federal election variables.

3.2 The Functional Form.

Having decided upon the variables to include in our general model, we must now turn our attention to the specific functional form that we will use.

Our model specification is:

$$M_{i,t} = \alpha_i + \sum_j \rho_{ij} M_{i,t-j} + \gamma_i \text{trend} + \beta_i \left(W_{i,t} - \overline{W}_{i,t}\right) + \delta_i \left(U_{i,t} - \overline{U}_{i,t}\right) + \eta_i \left(H_{i,t} - \overline{H}_{i,t}\right) + \varepsilon_{i,t} \tag{7}$$

$$i = 1, \ldots, 8; \quad t = 2, \ldots, T$$

We allow ρ_j to vary across equations. This assumes that current and lagged migrations are related by different coefficients, according to the region of interest. At a later stage, we can test whether all regions have the same value for ρ_j. Relativity is important to this model. We expect that if, for example, wages in all regions increase by the same *amount*, net migration will remain unchanged. For this reason, we believe an 'own state' - to - 'rest of Australia' comparison is what is important to (potential) migrants. We have allowed for multiple lags of M_{it}, as adjustment or copy-cat behaviour may occur over several time periods.

Since the dependent variable (net in-migration) adds to zero across all regions, the system has a singular covariance matrix for the error terms $\varepsilon_{i,t}$. The usual solution to this singularity problem is to drop an equation and estimate the remaining equations as a system. As a result of the adding up condition, we would also expect to see some relationship amongst the coefficients of the model whereby we could generate those in the deleted equation using the coefficients in the estimated system. However, since the variables on the right hand side vary by equation, the adding up restriction on the coefficients is neither simple nor data (time)-independent.

$$\sum_i \rho_{i,j} = 0 \quad \forall j, \qquad \sum_i \alpha_i = 0, \qquad \sum_i \gamma_i = 0, \qquad i = 1, \ldots, 8. \tag{8}$$

Although the system of equations (7) is singular, it is not invariant. The system, and therefore the estimates, will change according to the equation that is deleted. Ordinarily, this would be regarded as problematic. However, as explained in section 5 below, we do not require these coefficients directly.

As long as the same equation is dropped in the estimation stage as is dropped in the calibration/simulation of MMRF it should not matter. Moreover, since our primary interest is in simulating migration responses to various shocks to the economy in MMRF, the recovery of the coefficients of the deleted equation is not necessary - we can generate migration responses for that region by subtracting those of all of the other regions from zero. The adding up restriction on migration can then be used to calculate net migration into the region for which the equation has been dropped. So, although invariance would be convenient, the lack of invariance does not halt our progress.

3.3 The Data Sources.

Following Groenewold (1993), we used quarterly ABS data on net in-migration by State from the DX database.

- Insert Figure 1 Here -

We also used the DX database for the remainder of the variables. Real wages were defined as average weekly earnings (all employees) deflated by the State CPI. Unemployment rate was the State unemployment rate. The series for house prices were defined as the state's capital city housing CPI (rebased to 1996), multiplied by the median house price in 1996 in the Capital city. In this way, we were able to convert the Housing CPI into a series of price levels. To use a series of median house prices would have ignored the rental section of the market. To use the housing CPI as is would have ignored the fact that each series measures percentage changes from a different level (albeit in the same base period). So although the housing CPI moves similarly for say Melbourne and Sydney, actual house prices are quite different for those two cities.

4. Econometric Results.

Estimating our model (7) using quarterly data over the period 1983:1 to 1996:4 has given quite interesting results. Although we use quarterly data, there were no consistent seasonal effects found to be significant. We found that the inclusion of four lags of the dependent variable was optimal, even though some of the intervening lags may not have been significant. Overall, we rejected the use of wages in the model (results available on request), leaving us with house prices and unemployment as economic variables to explain inter-regional migration.

It was discovered that Tasmania, Northern Territory and Australian Capital Territory were fundamentally different to the other states of Australia, possibly because of their small size relative to the rest of the states. Table 1 shows some descriptive statistics for net in-migration over our sample and gives us some idea of why the three small states differ from the rest of the states. The net in-migration for the smaller states is quite small relative to the other states, and has a standard deviation 2-3 times the size of its mean (represented by the coefficient of variation, V). Although SA and WA are also quite volatile, it appears from our results that we can explain this volatility in terms of our economic variables.

- Insert Table 1 Here -

We could find no evidence that our economic variables had any direct impact on net migration into those smaller regions. It is possible that people move to those regions for different reasons. As a result, we decided to regard those three regions as one alternative: SMALL. That is, one could choose to move to NSW, VIC, QLD, SA, WA or SMALL. The variables in our model specification (*i.e.* the 'ROA' variables) remain unchanged. However, taking account of the adding up constraint now means that we drop the equation for SMALL and estimate for the remaining 5 regions.

If we had data on other possible causes of migration, we could then attempt to model migration in each of the regions of SMALL. However, we are primarily interested in the effects of the economic variables on net in-migration for all eight regions. Since there appeared to be no direct effects of these variables in the regions of SMALL, we can gain no further information by attempting to model migration in these regions separately. All we can say at this point is that the direct effects of the economic variables are zero for these regions.

- Insert Table 2 Here -

Table 2 presents the results from estimation. Generally, the results seem reasonable for most of the states. Results for the aggregated region SMALL (comprising TAS, NT and ACT) are not presented. Although it is customary to calculate the coefficients of the deleted equation, in this case it is not possible to get calculated coefficients that are time independent.

For each of the five states, the economic variables perform quite well. We would expect to see that as unemployment in a region rises relative to the rest of Australia, the probability of finding a job in that region (relative to ROA) would decline. As a result, net migration into that region would fall. Similarly, as house prices rise in a region relative to the rest of the country, we would expect net in-migration to that region to fall. Each of the economic variables have correct signs and are significant.

Experimentation with various lags of net in-migration yielded interesting results. We found that four lags of the dependent variable was the optimal choice, even if for some states the intervening ones were not necessarily significant. We rejected the assumption of a common set of lag coefficients for the five estimating equations. Including lagged net in-migration allows for some momentum or copycat behaviour by migrants. We would therefore, typically, expect to see positive coefficients on lags of migration. A negative sign on lagged migration may be regarded as an adjustment to bring population back into line.

Although the time trends are statistically significant for NSW, VIC, QLD, and SA, they are of little practical significance. For example, the time trend in Queensland only accounts for 33 (net) people entering the state per quarter. This is small in comparison to the mean net in-migration for Queensland over the sample, which was approximately 8,000 people. For NSW the highly statistically significant time trend accounts for 126 (net) people entering the state each quarter. This is an interesting result given that for NSW mean net in-migration over the sample was -4300 (approx). Looking at Figure 1, there does not appear to be any obvious upward trend for NSW. We can therefore conclude that in the absence of the effects of our economic variables, net migration into NSW would have been positive (however small) over the sample!

Although we performed no formal tests for stationarity of our variables (and hence the residuals), we regard the DW statistics as indicative of the stationarity or otherwise of the residuals. That is we interpret them in the same manner as a cointegrating regression DW statistic (CRDW). The residuals appear to be stationary, as the DW statistics are typically close to two in absolute value. The R-squared values for each equation are not really applicable in the usual manner, as we are estimating a system of equations. A system measure of goodness of fit would be more appropriate. However, if we use these figures as an indicator of how well the model is performing then it would seem that the model is satisfactory.

5. Respecification of the MMRF Labour Market Module.

The previous version of the Labour Market Module had three options for inter-regional migration: let it be exogenously set at values determined by ABS forecasts, allow it to be determined as a residual component of population change or use a mixture of both. Although we are not able to have fully functioning equations for inter-regional migration for all states, our current work represents an improvement in that we are able to use equations for five of the states. The other three are determined as an ad hoc split up of the residual, as outlined below.

In terms of implementing our econometric results in MMRF, our first task is to specify the levels form of the equations to be used. Our original model (7) has subsequently been modified to include lags of net in-migration and to exclude the wage variables. Thus our model has become:

$$\begin{aligned} M_{i,t} &= \alpha_i + \rho_{i1} M_{i,t-1} + \rho_{i2} M_{i,t-2} + \rho_{i3} M_{i,t-3} + \rho_{i4} M_{i,t-4} \\ &\quad + \gamma_i trend + \delta_i \left(U_{i,t} - \overline{U}_{i,t}\right) + \eta_i \left(H_{i,t} - \overline{H}_{i,t}\right) + \varepsilon_{i,t} \end{aligned} \tag{9}$$

$$i = 1, \ldots, 8; \quad t = 5, \ldots, T.$$

For the comparative static analysis that we shall undertake, we do not have a time dimension to our equations. Therefore, the time trend and lags of the dependent variables are not applicable. The CGE model is calibrated as a deterministic model, allowing for no random error term. Thus our model would be:

$$\mathrm{M_i} = \alpha_i + \delta_i \left(\mathrm{U_i} - \overline{\mathrm{U}}_i\right) + \eta_i \left(\mathrm{H_i} - \overline{\mathrm{H}}_i\right) \qquad \mathrm{i} = 1, \ldots, 8 \tag{10}$$

with

$$\begin{aligned} \overline{\mathrm{U}}_i &= \sum_{r \neq i} \left(\frac{\mathrm{L_r}}{\overline{\mathrm{L}}_i}\right) \mathrm{U_r}, \qquad \overline{\mathrm{L}}_i = \sum_{r \neq i} \mathrm{L_r}, \\ \overline{\mathrm{H}}_i &= \sum_{r \neq i} \left(\frac{\mathrm{C_r}}{\overline{\mathrm{C}}_i}\right) \mathrm{H_r}, \qquad \overline{\mathrm{C}}_i = \sum_{r \neq i} \mathrm{C_r} \end{aligned} \tag{11}$$

where all variables are defined as before. Our econometric model (9) is based on quarterly data, however the nominal time frame in MMRF is one year. In order to make the parameters compatible between the two models, we must multiply those from the econometric model multiply by $1 \Big/ \left[1-\sum_{j=1}^{4}\rho_{ij}\right]$ to take account of lagged effects and then by 4 to get corresponding figures for α_i, δ_i and η_i in (10).

In MMRF, migration enters as a change variable so we need to difference (9) to get

$$\Delta M_i = \delta_i\left(\Delta U_i - \Delta\overline{U}_i\right) + \eta_i\left(\Delta H_i - \Delta\overline{H}_i\right), \qquad i = 1,\dots,8, \tag{12}$$

where

$$\Delta\overline{U}_i = \sum_{r \neq i}\frac{L_r}{\overline{L}_i}\Delta U_r, \qquad \Delta\overline{H}_i = \sum_{r\neq i}\frac{C_r}{\overline{C}_i}\Delta H_r, \tag{13}$$

$$\Delta M_i = \delta_i\left(\Delta U_i - \Delta\overline{U}_i\right) + \eta_i\left(H_i\frac{\Delta H_i}{H_i} - \overline{H}_i\frac{\Delta\overline{H}_i}{\overline{H}_i}\right), \qquad i = 1,\dots,8, \tag{14}$$

$$100 * \Delta H_i / H_i = h_i, \qquad 100 * \Delta\overline{H}_i / \overline{H}_i = \overline{h}_i, \tag{15}$$

$$\Delta M_i = \delta_i\left(\Delta U_i - \Delta\overline{U}_i\right) + \frac{\eta_i}{100}\left(H_i h_i - \overline{H}_i\overline{h}_i\right), \qquad i = 1,\dots,8, \tag{16}$$

$$100 * \frac{\Delta\overline{H}_i}{\overline{H}_i} = \sum_{r\neq i}\left(\frac{C_r}{\overline{C}_i} * \frac{H_r}{\overline{H}_i} * \frac{\Delta H_r}{H_r} * 100\right), \tag{17}$$

$$\overline{h}_i = \sum_{r\neq i}\left(\frac{C_r}{\overline{C}_i} * \frac{H_r}{\overline{H}_i} * h_r\right). \tag{18}$$

So our modelled equations become

$$\Delta M_i = \delta_i\left(\Delta U_i - \Delta\overline{U}_i\right) + \frac{\eta_i}{100}\left(H_i h_i - \overline{H}_i\overline{h}_i\right) + \mathrm{f}_i, \qquad i = 1,\dots,8, \tag{19}$$

$$\Delta\overline{U}_i = \sum_{r\neq i}\frac{L_r}{\overline{L}_i}\Delta U_r, \tag{20}$$

$$\overline{\mathrm{h}}_\mathrm{i} = \sum_{\mathrm{r}\neq\mathrm{i}}\left(\frac{\mathrm{C_r}}{\overline{\mathrm{C}}_\mathrm{i}} * \frac{\mathrm{H_r}}{\overline{\mathrm{H}}_\mathrm{i}} * \mathrm{h_r}\right) \tag{21}$$

with formulae

$$\overline{L}_i = \sum_{r \neq i} L_r, \tag{22}$$

$$\overline{H}_i = \sum_{r \neq i} \left(\frac{C_r}{\overline{C}_i} \right) H_r, \tag{23}$$

$$\overline{C}_i = \sum_{r \neq i} C_r. \tag{24}$$

Our migration equations have now incorporated a shift variable f_i that can be used as a switch to turn the migration equations on or off as we please. The use of switches will be discussed in more detail later. Our estimated econometric model (9) considered migration for only five states as being determined by economic variables. However, the above specification includes equations for all eight regions, and thus we need to be able to 'switch off' the equations for TAS, NT and ACT and determine migration into these regions in some other manner. Given that net in-migration adds to zero across all regions, if we know what migration is for each of our five large states, then we can easily derive the total for SMALL. Our task is then to distribute this net migration between the component regions of SMALL. One naïve method of distributing the total for SMALL amongst its components would be to allocate one-third to each of the three regions. However, a more realistic split would be based on regional populations. We would distribute total migration for SMALL into each of its component regions, according to their share of population in SMALL:

$$\Delta M_i = \left(\frac{P_i}{P_{SMALL}} \right) * \Delta M_{SMALL} \qquad \text{i} \in \text{SMALL}. \tag{25}$$

In MMRF, to implement this distribution of net migration across the regions of SMALL, we require two further equations:

$$\Delta M_{BIG} = \sum_{i \in BIG} \Delta M_i, \tag{26}$$

$$\Delta M_{ALL} = \Delta M_{BIG} + \Delta M_{SMALL}. \tag{27}$$

Having linearised the system, our next task is to close the system. Specifying the closure amounts to making a decision as to the exogeneity or endogeneity of each of the variables in the new equations. However, we must bear in mind that, for the system of equations to be identified, the number of endogenous variables must be equal to the number of equations.

Our new section of the MMRF labour market module includes 29 equations and 51 variables, as shown in Table 3.

- Insert Table 3 Here -

Assuming that the old version of MMRF had the correct number of exogenous and endogenous variables, we need to partition the variables occurring in our extra equations such that 29 are endogenous and 22 exogenous to *this* system of equations. Of course, it is possible that a variable is endogenous in MMRF, but exogenous to the migration sub-module. However, any variable whose value is determined within this system will be endogenous and the rest exogenous to this part of MMRF. Our choice of closure is given in Table 4.

- Insert Table 4 Here -

Since the sum of net inter-regional migration across all regions is zero (by definition), ΔM_{ALL} will be exogenously set at zero. ΔM_{BIG} and ΔM_{SMALL} are determined by equations 26 and 27, respectively, and are thus endogenous. $\Delta\overline{U}_i$ and $\overline{h}_i$ are calculated from equations 20 and 21, respectively, and are also endogenous for all regions in the model. Although actually endogenous to the model, ΔU_i and h_i are exogenous to this system of equations, as they are determined elsewhere in MMRF.

In order for migration (ΔM_i) to be explicitly determined by economic factors in our model, it must be endogenous. Migration for the regions in BIG is determined by (19), for $i = 1, \ldots, 5$. However, as explained earlier, migration for the regions of SMALL is determined as a residual by (25), (26) and (27). For this to be the case, the equations (19) for $i = 6, 7, 8$ must be 'switched off'.

The exact choice of closure will be influenced by many factors, including whether or not we want inter-regional migration to be determined by the economic variables, or calculated as a residual component of population change, or set exogenously at levels determined by ABS forecasts. This is where the shifters (or 'switch' variables) f_i in the migration equations play their part.

The f_i are the 'switches' that are used to turn the migration equations on or off. Put simply, to turn on or activate a migration equation, we need to exogenise the corresponding f variable, given that the corresponding migration variable is endogenous. In fact, when we allow migration to be determined by other variables in the model, we allow only (at this stage) five migration equations to be turned on, with migration to the remaining three regions being determined as a proportion of the residual (stems from $\sum_i M_{it} = 0$). Thus we have three of the migration equations turned off. This is achieved by having f_i ($i = 1, \ldots, 5$) exogenous and f_i ($i = 6, 7, 8$) endogenous. Hence, the role of f_i is to determine whether or not net inter-regional migration is directly affected by other variables in MMRF.

Should we wish to use the new TABLO code to compare simulations with or without the new migration equations, we can simply swap ΔM_{it} ($i = 1, \ldots, 5$) with f_i ($i = 1, \ldots, 5$). I.e. exogenise ΔM_{it} ($i = 1, \ldots, 5$) and endogenise f_i ($i = 1, \ldots, 5$). In doing so, we have the same number of equations and endogenous variables, ensuring that MMRF is still closed.

The TABLO code for the new equations is given in appendix 1. In addition to the equations, we have also included the relevant declarations, read statements, formulas and updates required to make the code operational. In terms of the closure choice, we have labelled our new closure as the migration closure, and when we turn off the migration equations we refer to this as the standard short run closure.

6. Policy Simulation: Changes in State Government Spending.

To gauge the effectiveness of our new equations for regional migration, we carried out an illustrative policy simulation. The idea was to compare the results from a standard short-run closure and the new migration closure. The simulation should include realistic shocks that are designed to disturb unemployment rates and house prices. We chose to manipulate State government expenditure for the three largest states - New South Wales, Victoria and Queensland. For Victoria we added 5 per cent to government expenditure and for each of the other two states we cut government spending by 5 per cent.

- Insert Table 5 Here -

The results show that the main impact of the migration closure of MMRF is, as expected, on the regional labour market and regional population variables. In particular, allowing inter-regional migration to occur moderates the impact of the policy change on regional unemployment and magnifies the impact on regional employment. The pattern and actual numbers of migrants induced by the policy shock is broadly in line with expectations. However, we should note that it could be that turning on the new migration equations (which allow inter-regional migration to be affected by house prices and unemployment) makes little *practical* difference to the results from the simulation. Further experience of using MMRF with the new closure will help understand whether differences such as those observed here are significant in practice.

7. Concluding Remarks.

In this paper we have addressed the potentially important issue of inter-regional migration in Australia. Utilising both econometric and computable general equilibrium modelling methodologies we specified an appropriate economic model, estimated it using historical data and the implemented the empirical results within the CGE model. The result model was used to simulate the impacts of a change in regional economic policy. Our results indicate that there may be quite large differences between the results of the policy simulations using the model with and without the inter-regional modification.

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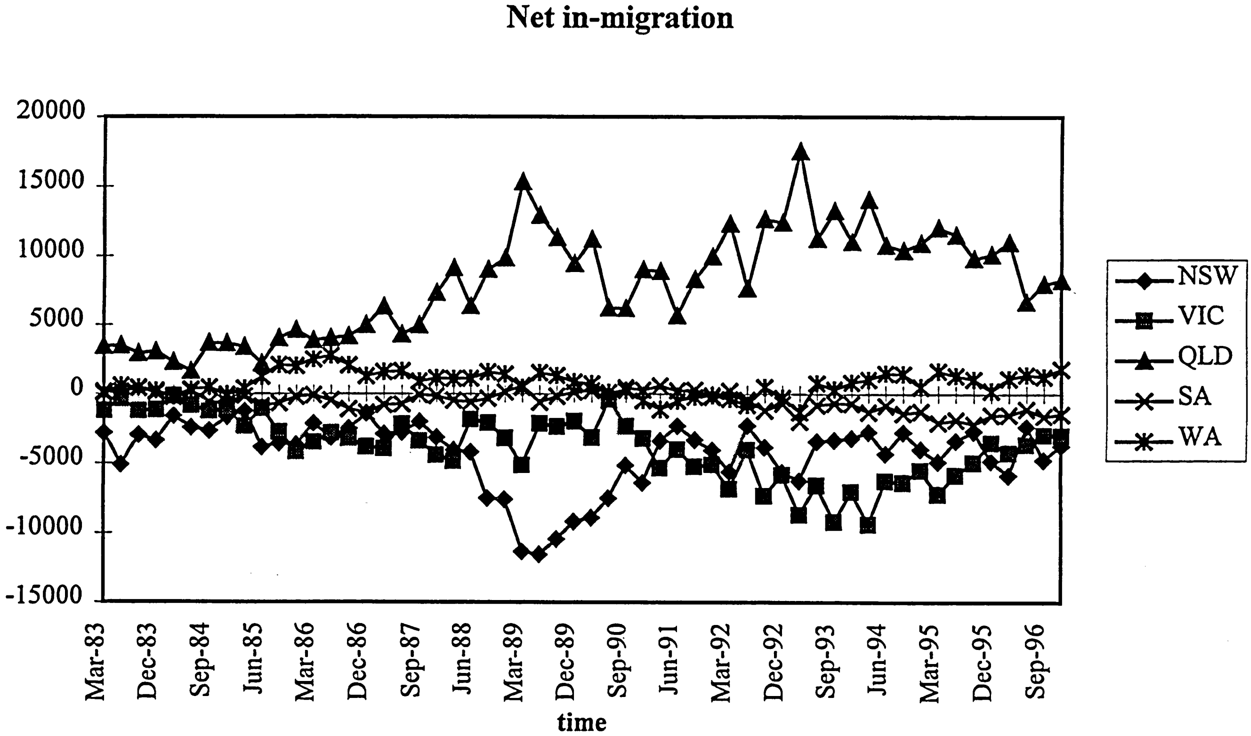
Appendix 1: Figures and Tables of Results.

Figure 1: Australian Regional Net In-Migration.



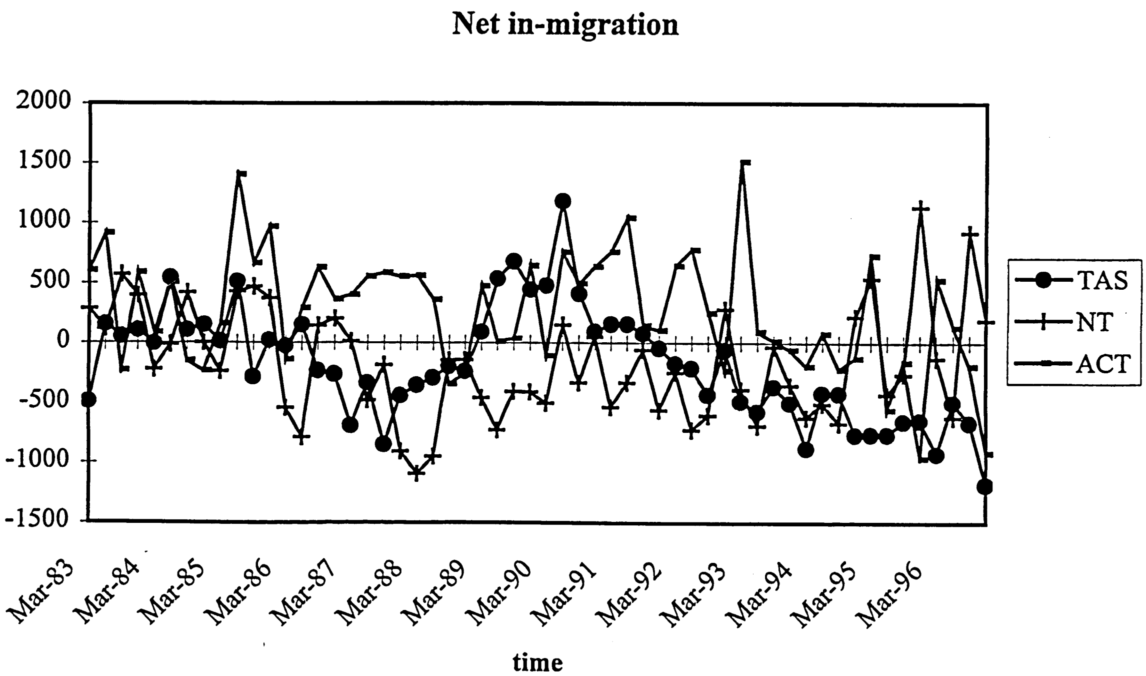


Table 1: Descriptive Statistics for Net In-Migration.

	Mean	Standard Deviation	Coefficient of Variation *
NSW	-4302.1	2423.2	0.56
VIC	-3845.2	2277.1	0.59
QLD	8002.2	3805.5	0.48
SA	-554.0	713.8	1.29
WA	778.1	879.0	1.13
TAS	-177.9	463.3	2.60
NT	-168.2	471.2	2.80
ACT	267.0	499.8	1.87

* V = SD/Mean

Table 2: Parameter Estimates for the Econometric Model of Migration.

	NSW	VIC	QLD	SA	WA
Constant	3098.61 (3.8570)	-3225.16 (-7.3728)	2607.04 (3.5960)	-980.048 (-3.0776)	-126.546 (-0.1280)
M_{t-1}	0.227706 (2.5771)	0.163683 (2.3103)	0.315798 (4.3467)	0.255247 (2.2880)	0.437285 (4.4569)
M_{t-2}	0.267265 (3.0112)	0.023670 (0.3347)	0.141990 (1.8733)	0.219082 (1.9363)	0.148916 (1.3725)
M_{t-3}	-0.039288 (-0.4333)	-0.032227 (-0.4660)	0.018801 (0.2370)	-0.119323 (-1.1035)	0.333630 (3.0664)
M_{t-4}	0.037366 (0.4585)	0.324701 (5.0277)	0.077678 (1.0989)	0.141060 (1.4321)	-0.139661 (-1.3904)
Trend	126.608 (3.4820)	-59.5616 (-3.3077)	33.7877 (1.6004)	-54.5813 (-4.3930)	-20.0742 (-0.6945)
Unemployment (OS - ROA)	-1301.51 (-4.8946)	-703.305 (-6.4808)	-678.754 (-4.1099)	-149.248 (-1.6002)	-244.980 (-2.9427)
Housing (OS - ROA)	-0.204123 (-4.9857)	-0.190833 (-6.6579)	-0.104734 (-3.0799)	-0.050408 (-3.9785)	-0.024615 (-0.4962)
R-squared	0.674973	0.824580	0.715531	0.709555	0.582398
DW	1.76740	2.01286	1.79853	2.15706	1.91618
System Log-likelihood = -2221.58 Note: t-statistics in parentheses.					

Table 3: Equation Count and Variable Count for New Section.

Equation	Count	Variable	Count
ΔM_i	8	ΔM_i	8
$\Delta \overline{U}_i$	8	ΔU_i	8
$\overline{h}_i$	8	$\Delta \overline{U}_i$	8
ΔM_{BIG}	1	h_i	8
ΔM_{ALL}	1	$\overline{h}_i$	8
ΔM_i (SMALL split)	3	f_i	8
		ΔM_{ALL}	1
		ΔM_{BIG}	1
		ΔM_{SMALL}	1
Total:	29		51

Table 4: Migration Closure.

Variable	Migration Closure	
	Exogenous	Endogenous
ΔM_i	0 *(5)*	8 *(3)*
ΔU_i	8	
$\Delta \overline{U}_i$		8
h_i	8	
$\overline{h}_i$		8
f_i	5 *(8)*	3 *(0)*
ΔM_{ALL}	1	
ΔM_{BIG}		1
ΔM_{SMALL}		1
Total	22	29

Figures in italics represent variable swaps to turn off the new migration sub-module.

Table 5: Simulation Results (NSW, VIC, QLD).

	NSW		VIC		QLD	
Variable	Std	Mig	Std	Mig	Std	Mig
Govt. spending	-5.00	-5.00	5.00	5.00	-5.00	-5.00
Migration ('000)	0.000	-3696	0.000	2479	0.000	-2418
Population	0.000	-0.094	0.000	0.084	0.000	-0.122
Unemp rate (% pt)	0.657	0.576	-0.828	-0.760	0.684	0.583
Unemp rate o/s	-0.168	-0.127	0.432	0.409	-0.011	0.010
Unemp rate diff	*0.825*	*0.703*	*-1.260*	*-1.169*	*0.695*	*0.573*
House price	-0.975	-1.000	0.780	0.776	-0.983	-0.998
House price o/s	0.042	0.030	-0.782	-0.804	-0.290	-0.308
House price diff	*-1.017*	*-1.030*	*1.562*	*1.580*	*-0.693*	*-0.690*
GSP	-0.422	-0.427	0.530	0.536	-0.428	-0.439
Employment	-0.717	-0.723	0.922	0.930	-0.756	-0.767

Appendix 2: Documentation of the new section in the LMM in the TABLO language.

```
! LABOUR MARKET & REGIONAL MIGRATION MODULE !
! Regional migration: Added by J. Fry and M. Peter, June 1998 !

SET BIG_REG # Big regions # (NSW,VIC,QLD,SA,WA) ;
SUBSET BIG_REG is subset of REGDEST ;
SET SMALL_REG = REGDEST - BIG_REG ;

VARIABLE
   (change)
delf_rm       # Shifter in equation E_RM_Addup #;
   (change)(all,q,REGDEST)
del_rm(q)     # Ordinary change in inter-regional migration #;
   (change) (all,q,REGDEST)
del_unr(q)    # Percentage-point changes in regional unemploy rate #;
   (all,q,REGDEST)
employ(q)  # regional employment: persons #;
   (change)
del_rm_b# Total net migration in BIG regions #;
   (change)
del_rm_s# Total net migration in SMALL regions #;
   (change) (all,q,REGDEST)
del_unr_Q1(q) # Av. %-point changes in unemp. rate outside the region #;
   (all,q,REGDEST)
p3o_Q1(q) # Average house price outside the region #;
!   (all,q,REGDEST)
rw_Q1(q) # Average real wage outside the region #; !
   (change) (all,q,REGDEST)
del_fmig(q) # Shifter in regional migration equation #;

COEFFICIENT
C_POP_QS # Total net migration in SMALL regions # ;
   (all,q,REGDEST)
C_POP(q)      # regional population #;
   (all,q,REGDEST)
MIG_PAR_U(q) # Unemployment parameter # ;
   (all,q,REGDEST)
MIG_PAR_HP(q) # House Price parameter # ;
!   (all,q,REGDEST)
MIG_PAR_W(q) # Real Wage parameter # ; !
   (all,q,REGDEST)
C_L_Q1(q) # Labour Force outside the region # ;
!   (all,q,REGDEST)
C_E_Q1(q) # Employment outside the region # ; !
   (all,q,REGDEST)
C_P3O(q) # House prices # ;
   (all,q,REGDEST)
```

```
C_P3O_Q1(q) # House prices outside the region # ;
   (all,q,REGDEST)
PVAL3O_Q1(q) # Total purchase value of housing outside the region # ;
!   (all,q,REGDEST)
C_RW(q) # Real Wage # ;
   (all,q,REGDEST)
C_RW_Q1(q) # Real Wage outside the region # ; !

READ
MIG_PAR_U from file PDATA Header "MPRU" ;
MIG_PAR_HP from file PDATA Header "MPHP" ;
!MIG_PAR_W from file PDATA Header "MPRW" ; !

FORMULA

   (Initial) (all,q,REGDEST)
C_P3O(q) = 1.0 ;
   (Initial) (all,q,REGDEST)
C_P3O_Q1(q) = 1.0 ;
!   (Initial) (all,q,REGDEST)
C_RW(q) = 1.0 ;
   (Initial) (all,q,REGDEST)
C_RW_Q1(q) = 1.0 ; !
C_POP_QS = Sum(q,SMALL_REG, C_POP(q));

   (all,q,REGDEST)
C_L_Q1(q) = Sum(r,REGDEST:r ne q, C_LABSUP(r));
   (all,q,REGDEST)
PVAL3O_Q1(q) = Sum(r,REGDEST:r ne q, PVAL3O("HOUSING",r));
!   (all,q,REGDEST)
C_E_Q1(q) = Sum(r,REGDEST:r ne q, C_EMPLOY(r)); !

UPDATE
   (all,q,REGDEST)
C_P3O(q) = p3o("HOUSING",q) ;
   (all,q,REGDEST)
C_P3O_Q1(q) = p3o_Q1(q) ;
!   (all,q,REGDEST)
C_RW(q) = realwage_w(q) ;
   (all,q,REGDEST)
C_RW_Q1(q) = rw_Q1(q) ; !

EQUATION
E_regmig # Regional Migration #
   (all,q,REGDEST)
del_rm(q) = MIG_PAR_U(q)*(del_unr(q) - del_unr_Q1(q))
        + (MIG_PAR_HP(q)/100.0)
        *(C_P3O(q)*p3o("HOUSING",q) - C_P3O_Q1(q)*p3o_Q1(q))
        + del_fmig(q);

! Add the following two lines into the above equation
```

```
    E_regmig to incorporate a real wage effect
      + (MIG_PAR_W(q)/100.0)
      *(C_RW(q)*realwage_w(q) - C_RW_Q1(q)*rw_Q1(q))!

E_del_unr_Q1 # unemployment rate outside the region #
   (all,q,REGDEST)
del_unr_Q1(q) = (1/C_L_Q1(q))
           * Sum(r,REGDEST:r ne q, C_LABSUP(r)*del_unr(r));

E_p3o_Q1 # house prices outside the region #
   (all,q,REGDEST)
p3o_Q1(q) = (1/PVAL3O_Q1(q))
           * Sum(r,REGDEST:r ne q, PVAL3O("HOUSING",r)*p3o("HOUSING",r));

!E_rw_Q1 # wage rate outside the region #
   (all,q,REGDEST)
rw_Q1(q) = (1/C_E_Q1(q))
           * Sum(r,REGDEST:r ne q, C_EMPLOY(r)*realwage_w(r)); !

E_del_rm_b # total net migration in BIG regions #
del_rm_b = Sum(q,BIG_REG,del_rm(q)) ;

!E_RM_addup # Adding-up condition on reg. mig. #
delf_rm = sum(q,REGDEST,del_rm(q)); !
! Adding up constraint - replaces equation E_RM_addup above !
E_del_rm_s # Adding-up condition on reg. mig. #
delf_rm = del_rm_b + del_rm_s ;

E_small_regmig # net migration in each of the SMALL regions #
   (all,q,SMALL_REG)
C_POP(q) * del_rm_s = C_POP_QS * del_rm(q) ;
```