A Migration Based Theory of the Exchange Rate and the New Zealand's Experience[1]

Debasis Bandyopadhyay
Department of Economics
University of Auckland, Auckland
New Zealand

Andrew Binning
Norges Bank, Oslo
Norway

January 2016

Abstract

Conventional exchange rate theory has proven unreliable in its attempts to explain the real exchange rate. In the March 2003 Reserve Bank Monetary Policy Statement two graphs appeared, one of total net migration and the other the nominal TWI exchange rate. Closer inspection revealed they were correlated. This paper aims to answer the question: can migration be used to predict the exchange rate? The hypothesis tested in this paper is that the heterogeneity in the market shares of aggregate demand and labour supply between the migrants and the native born population constitute important determinants of the real exchange rate. In particular, the model provides an analytically tractable equation consistent with a general equilibrium theory of the exchange rate determination as a function of migration. It turns out that migration data is able to partially explain the movements in the real exchange rate. The correctly specified general equilibrium performs well in and out of sample and gives valuable insight into the determination of the real exchange rate for New Zealand.

Key Words: International Migration, Real Exchange Rate, Net Capital Inflow, Open Economy Macro
JEL Codes: C53, F22, F37, F41

---

[1] This paper originates from the B.Com (Hons) dissertation which Andrew Binning wrote under the supervision of Debasis Bandyopadhyay at the University of Auckland.

1. Introduction

The exchange rate has long been one of the hardest variables to predict and explain in Economics. Traditional models using traditional fundamentals have failed to provide consistently reliable estimates and beat the random walk, a benchmark for forecasting performance. This paper takes a new and unconventional approach using international labour movements or migration to explain the real exchange rate. In particular, the purpose of this paper will be to answer the question: can migration data be used to explain the real exchange rate in the New Zealand economy?

Fluctuations in the exchange rate have very important Macroeconomic policy implications for a small open economy such as New Zealand. For example the exchange rate can determine the price of imports and hence may affect inflation and have effects on employment. So it is important for policy makers to understand the dynamics characteristic of floating exchange rates and the mechanics behind them. The problem arises through the poor performance of traditional models and fundamentals in determining the real exchange rate.

Traditional exchange rate models determine the exchange rate through the international interaction and arbitrage between the goods, financial and money markets. Some of these models include staples such as Purchasing Power Parity, Uncovered Interest Parity and the Monetary Model. Traditional fundamentals used in these models include relative interest rates, price, inflation, output and money supply differentials as well as forward and expected exchange rates [2](Engel and West 2003).[3]

Meese and Rogoff (1983) test the out of sample forecasting performance of some of these traditional models using data from the 1970's. They find the random walk hypothesis out performs all models they test over short and medium horizons. Engel and West (2003) find the exchange rate is a better predictor of the fundamentals than the fundamentals are of the exchange rate.[4]

To date migration and labour mobility have not been considered as fundamental determinants of the exchange rate. In the March 2003 Reserve Bank Monetary Policy Statement, two graphs appeared. They have been included as figures 1 and 2 in the Appendix.

---

[2] All differentials are bilateral and between respective countries.
[3] For a good summary of past work see Engel and West (2003).
[4] The term "fundamentals" refers to the traditional fundamental variables the exchange rate is believed to be determined by.

The graph on the left is the Nominal Trade Weighted Index exchange rate and is a measure of the New Zealand dollar's value in terms of trading partners' currency where the weights correspond to the proportion of trade New Zealand shares with the respective countries. It can be thought of as an over all measure of the relative value of the New Zealand dollar. The graph on the right is of annual total net migration. It is the net of total long term and permanent arrivals and departures. It is interesting to note that the peaks and troughs in both series appear to coincide. There is a trough around the year 1992, a peak in about 1996 and another trough in 2000 before both series trend up again.

The correlation present in the graphs shown raise some interesting questions. Upon seeing such a relationship the first question that must be posed is whether the observation is spurious or whether there is a relationship between migration and the exchange rate. Can economic theory explain the observed correlation? Can econometric tools determine whether this is a spurious relationship? In order to address the first question a review of the literature must be undertaken. The second question will be answered in a following section using diagnostic econometric tools.

The literature relating international labour mobility to the real exchange rate through the labour market is in its infancy. Hercowitz and Yashiv (2002) and Agiomirgianakis and Zervoyianni (2001) are two recent papers that have related the real exchange rate to the labour market through international labour mobility. Agiomirgianakis and Zervoyianni (2001) consider labour mobility to be endogenous to their model, determined by the real wage differential between countries. They use a general equilibrium model to show that an asymmetric shock to the goods and or bonds markets is transmitted to the real exchange rate. Increasing labour mobility can reduce the resulting volatility in the real exchange rate by ensuring that real wages equalise faster.

Hercowitz and Yashiv (2002) take an alternative approach and treat migration as exogenous to their model. They model Israel's immigration experience in the 1990's where the collapse of the former USSR and the tightening of U.S. and European immigration policy[5] saw a large influx of immigrants. A general equilibrium model is set up with a heterogenous population consisting of immigrants and the native born. Immigrants have differential entry into the goods and labour markets compared to the native born population. Their disproportionate share of aggregate demand and delayed entry in the labour market

[5] Hercowitz and Yashiv (2002) consider the causes of the immigration like the break up of the former USSR and foreign immigration policy to be exogenous to their model, which means immigration, can also be taken as exogenous to the model.

cause the real exchange rate to initially appreciate and then depreciate after they have been resident for some time.

As suggested the approaches taken to modelling migration and the real exchange rate to date have only considered labour mobility as a sensitivity to the real wage differential as in Agiomirgianakis and Zervoyianni (2001) or have only used immigration as a determinant of the real exchange rate as in Hercowitz and Yashiv (2002). As yet emigration has not been used explicitly in these models to explain the real exchange rate, nor has any study of this nature been conducted for the New Zealand economy. Therefore this paper will investigate the use of migration broken into its separate components, immigration and emigration as determinants of the real exchange rate for the New Zealand economy.

The purpose of this paper will be to answer the question: can migration data be used to explain the real exchange rate in the New Zealand economy? What causes the movements in the exchange rate is unclear. Can the relationship observed in the Reserve Bank Monetary Policy statement be used to explain some of the variation in the exchange rate? To answer this question diagnostic econometric tools like Granger causality tests will be used to ascertain the direction of causality[6], where the functional form is unknown. When these have been performed immigration and emigration can be included in a general equilibrium model and calibrated to the New Zealand economy. Once the model is calibrated hypothesis tests can be performed to evaluate the performance of the model. Policy experiments can be undertaken using the model regarding the recent change to immigration policy in New Zealand. Only migration's effects will be considered on the exchange rate, the exchange rates effects on migration will not be covered directly in this paper.

Following this introduction, section two contains a literature review. Section three describes the data used in this project, data construction and data sources. Section four reports the plausible relationships between the exchange rate and other relevant variables, using diagnostic econometric tools. Section five develops a general equilibrium model from the literature. Section six explains how this general equilibrium model is calibrated to the New Zealand economy. Section seven presents results of testing this model and related policy issues.

[6] The use of the term causality refers to Granger Causality.

2. Literature Survey

This section takes a deeper look at some methods used to explain the exchange rate and their performance. A brief discussion is given on Granger causality in non-stationary variables, a methodology to be used in the following section. Engel and West (2003) use the methodology to establish direction of causality between the fundamentals and the exchange rate. In addition the literature relating migration to the real exchange rate is discussed especially with regard to Hercowitz and Yashiv (2002).

Granger causality is an econometric tool designed to test for the statistical direction of causality between time series variables. Granger causality is based on the bivariate VAR. In systems with stationary time series data, x Granger causes y if y is regressed on the lags of x and y and at least one of the coefficients on the lagged x is significant (Granger 1969). The Granger causality method has also been adapted to non-stationary data through the bivariate Error Correction model. Chaudhuri (1997) describes the methodology. Error Correction Models require all variables in the system to be non-stationary and integrated of the same order. The variables must also be cointegrated. If the variables are cointegrated causality is at least implied in one direction if not in both directions (Engle and Granger 1987). Granger causality is determined by the significance of the coefficient on the cointegrating vector in the ECM, if the coefficient on the cointegrating vector is significant then the independent variable Granger causes the dependent variable (Engle and Granger 1987).

Engel and West (2003) use Granger causality tests to establish the direction of causality between the fundamentals and the exchange rate. They find in many cases that the exchange rate Granger causes the fundamentals, but only one case where the fundamentals Granger cause the exchange rate. Thirty different cointegrating equations are tested for six countries using five fundamentals. The Johansen test is used to test for cointegration. Five out of the thirty proposed relationships are found to be cointegrated at the 5% level using the trace statistic and none are found using the maximum eigenvalue test, so it is assumed there is no cointegration between the variables. All nonstationary variables are entered in differences in bivariate VARs to establish Granger causality. Engel and West (2003) is notable for the absence of cointegration. Cointegration implies a long run equilibrium relationship exists between the variables and it is generally agreed that the presence of cointegration is required between nonstationary variables for there to be Granger causality (Chaudhuri 1997). New Zealand was not part of the sample and migration was not included.

In addition to the diagnostic econometric tests a general equilibrium model will be set up to model the effects of migration on the real exchange rate and develop a better understanding of the relationship. The model to be used in this paper is based on Hercowitz and Yashiv (2002) with the addition of emigration, technology and aggregate demand shocks. It is chosen because only immigrations effects are considered on the real exchange rate and a simple modification will allow emigration to be included. As noted a general equilibrium model is set up with a Cobb Douglas production function in the standard form, except for the inclusion of imported capital as a factor of production. The population is heterogeneous and consists of native born and immigrants, where immigrants have differential entry into the goods and labour markets compared to the native born population. Immigrants have lower employment and participation in the labour market shortly after arrival. Employment rates increase with the time they have been resident in the host country, eventually converging to the native-born rate. Immigrants' activity in the goods market in terms of their consumption exceeds that of the native born at some stage during their settling phase in the host country. This is due to set up costs like the purchase of a house or business. Aggregate supply is determined by recent immigrants' employment rate and aggregate demand is determined by immigrants' over representation in the goods market, while both are determined by the real exchange rate. In equilibrium aggregate demand equals aggregate supply, so the system is solved for the real exchange rate. The differential between immigrants' contribution to production through labour and their consumption determines the real exchange rate. Hercowitz and Yashiv (2002) find when immigrants arrive in Israel they consume more than they contribute to production through labour, resulting in an increase in aggregate demand and a real appreciation of the exchange rate. After they have been resident for some time, their employment levels increase, contributing more to production relative to their consumption, leading to excess aggregate supply and a real depreciation of the exchange rate.

Similarly there are other microeconomic facts New Zealand shares with Israel, the country Hercowitz and Yashiv (2002) build their model round, that have influenced the decision to use this model. There is evidence of immigrants having an entry differential in the New Zealand labour market. Winkelmann and Winkelmann (1998) carry out a longitudinal study of immigrants' labour market outcomes over a 15 year period using census data and find an entry differential exists in the labour market. Recent immigrants have lower labour market participation and employment rates compared to the native born. They find that immigrants' labour market participation eventually converges to that of the native born after residing in the host country for some time.

3. Data

This section discusses the data used for the statistical diagnostics in section four and the general equilibrium model in section five. The data used in this paper is as follows: the diagnostic statistical analysis will use Total permanent and long term arrivals and departures, US permanent and long term arrivals and departures and both the NZ/US nominal and real exchange rates for the 1985:2 to 2002:4 period. The general equilibrium model will be calibrated using only Total permanent and long term arrivals and departures and the NZ/US real exchange rate[7], in addition to the native born population, the domestic capital stock and gross fixed capital formation for the 1986:2 to 2002:4 period, where all data is quarterly. "Total" refers to migrants going to/coming from all locations, "US" refers to migrants going to/coming from USA and "long term and permanent" refers to migrants that plan to stay or leave for more than one year. The data relationships are chosen because they exhibit the highest correlation (see Appendix for figures 3 and 4). Other bilateral migration and their respective exchange rates show some correlation but are not as substantial.

The relationship chosen is an important one since the NZ/US exchange rate has the biggest impact on New Zealand. The NZ/US exchange rate has the largest weighting in the Trade Weighted Index at 35% (RBNZ 2002), where trade with the US only makes up 14.2% of all exports and 16.0% of all imports (StatsNZ 2000). The TWI has an 80% correlation with the NZ/US exchange rate over the sample period.[8]

The permanent and long term migration data is acquired from the Infos database and seasonally adjusted by adding the three consecutive preceding quarters. The resulting variables are divided by four for the general equilibrium model which requires quarterly data. Hercowitz and Yashiv (2002) use data for the immigrant population of working age. This paper uses data for total migration flows since the working age constitute the large majority. [9]

The real exchange rate index is constructed using data for the NZ/US nominal exchange rate and CPI data for USA and New Zealand. The real exchange rate as measured in this paper is the price of a foreign basket of good in terms of a domestic basket of goods. The nominal exchange rate is defined as the amount of domestic currency required to buy one unit of foreign currency. Nominal exchange rate data and price indices are from the Reserve Bank of New Zealand.

---

[7] It is easier to calibrate the model using Total migration than US/NZ bilateral migration.
[8] The author performed a simple correlation analysis with the TWI and the US/NZ exchange rate.
[9] The author of this paper estimates that approximately 78% of immigrants and 81% of emigrants between 1987 and 2002 were of working age in New Zealand.

The native-born population of working age is calculated using data from the 1986, 1996 and 2001 censuses for the population between the ages of 15 and 64. The quarterly population growth rate is calculated to fit the native-born population to the census data by using an appropriate growth trend. For the purposes of the study it is assumed that there were no immigrants residing in New Zealand in the first quarter of 1985. The first cohort arrives in the second quarter of 1985. It is possible to get census data for 1986 on the number of people born overseas, however data is unavailable for how long they have been resident in New Zealand.

Annual domestic capital stock data is taken from Statistics New Zealand and transformed into quarterly data through an interpolation process.[10] Gross fixed capital formation data and the quarterly real GDP figures are taken from the International Financial Statistics database. The GDP deflator and employment data are taken from the New Zealand time series and Infos databases respectively.

4. Diagnostic Statistical Tests

This section investigates the relationship between the exchange rate (real and nominal) and migration. Granger causality tests are performed to establish the nature of the relationship and direction of causality using a similar methodology outlined by Chaudhuri (1997) and based on Engle and Granger (1987). When the direction of causality has been confirmed, the type of relationship that exists can be determined and incorporated in an appropriate general equilibrium model and calibrated to the New Zealand economy. It will be shown in this section that migration Granger causes the exchange rate.

The variables to be used in the diagnostic econometric tests include Total arrivals, Total departures, US arrivals, US departures and both the nominal and real NZ/US exchange rates for the 1985:2 to 2002:4 period. The decision is made to enter the variables in logs. Total arrivals, Total departures, US arrivals and US departures all have a growth trend.[11] Economic theory dictates variables with a growth trend should be entered in logs. The level of net migration could be negative so the log of departures is subtracted from the log of arrivals generating a variable with a similar shape to net migration in levels and can be interpreted as an index of the relative growth in migration. Traditional models of the real and

---

[10] Thanks to Mark Smith RBNZ for interpolating the capital stock data for this paper.
[11] They could be growing at the same rate as the population.

nominal exchange rate have entered both variables in logs due to nonlinearities in the models functional form; this convention is continued.

The Philips-Perron unit root test is used to test all variables for stationarity[12], the results are reported in the Appendix E.1. All variables are found to be non-stationary at the 5% level so an Error Correction Model is used. In order to use an Error Correction Model the non-stationary variables in the system must be cointegrated.[13] The following cointegrating specifications are devised under the assumption that migration grows with time.

Equal weighting restriction applied to Arrivals and Departures

(1) $s_{Rt} = \alpha_1 + \beta_1 Totnet_t + \gamma_1 t + (\varepsilon_{1*})_t$

(2) $s_t = \alpha_2 + \beta_2 Totnet_t + \gamma_2 t + (\varepsilon_{2*})_t$

(3) $s_{Rt} = \alpha_3 + \beta_3 USnet_t + \gamma_3 t + (\varepsilon_{3*})_t$

(4) $s_t = \alpha_4 + \beta_4 USnet_t + \gamma_4 t + (\varepsilon_{4*})_t$

Arrivals and Departures together without restrictions

(5) $s_{Rt} = \alpha_5 + \beta_{51} \ln(Tot\ Arr)_t + \beta_{52} \ln(Tot\ Dep)_t + \gamma_5 t + (\varepsilon_{5*})_t$

(6) $s_t = \alpha_6 + \beta_{61} \ln(Tot\ Arr)_t + \beta_{62} \ln(Tot\ Dep)_t + \gamma_6 t + (\varepsilon_{6*})_t$

(7) $s_{Rt} = \alpha_7 + \beta_{71} \ln(US\ Arr)_t + \beta_{72} \ln(US\ Dep)_t + \gamma_7 t + (\varepsilon_{7*})_t$

(8) $s_t = \alpha_8 + \beta_{81} \ln(US\ Arr)_t + \beta_{82} \ln(US\ Dep)_t + \gamma_8 t + (\varepsilon_{8*})_t$

[12] Only the Philips Perron unit root test is used to test for stationarity because cointegration is only found using this test when residual based cointegration tests are performed.
[13] Alternatively if the non-stationary variables are not cointegrated, they could be differenced and included in a VAR, and the resulting system could provide useful insight into the short run dynamics of the variables. Only the cointegrated variables and relationships will be covered in this paper because cointegration is a powerful result and implies that a long run equilibrium relationship exists between the variables and causality in at least one direction.

Arrivals and Departures individually

(9) $s_{Rt} = \alpha_9 + \beta_9 \ln(US\ Arr)_t + \gamma_9 t + (\varepsilon_{9*})_t$

(10) $s_t = \alpha_{10} + \beta_{10} \ln(US\ Arr)_t + \gamma_{10} t + (\varepsilon_{10*})_t$

(11) $s_{Rt} = \alpha_{11} + \beta_{11} \ln(Tot\ Arr)_t + \gamma_{11} t + (\varepsilon_{11*})_t$

(12) $s_t = \alpha_{12} + \beta_{12} \ln(Tot\ Arr)_t + \gamma_{12} t + (\varepsilon_{12*})_t$

(13) $s_{Rt} = \alpha_{13} + \beta_{13} \ln(US\ Arr)_t + \gamma_{13} t + (\varepsilon_{13*})_t$

(14) $s_t = \alpha_{14} + \beta_{14} \ln(US\ Arr)_t + \gamma_{14} t + (\varepsilon_{14*})_t$

(15) $s_{Rt} = \alpha_{15} + \beta_{15} \ln(US\ Dep)_t + \gamma_{15} t + (\varepsilon_{15*})_t$

(16) $s_t = \alpha_{16} + \beta_{16} \ln(US\ Dep)_t + \gamma_{16} t + (\varepsilon_{16*})_t$

where:

$s_t = \ln S_t$, the log of the nominal exchange rate, where the exchange rate is the price of one unit of foreign currency in terms of domestic currency.

$s_{Rt} = \ln S_{Rt}$, the log of the real exchange rate

$Totnet = \ln(Tot\ Arr) - \ln(Tot\ Dep)$

$USnet = \ln(US\ Arr) - \ln(US\ Dep)$

Tot Arr = Total Permanent and Long Term Arrivals

Tot Dep =Total Permanent and Long Term Departures

US Arr = US Permanent and Long Term Arrivals

US Dep =US Permanent and Long Term Departures

In total sixteen cointegrating equations are tested using residual based cointegration tests. The residuals are collected from each of the cointegrating equations and tested for stationarity using the Philips-Perron unit root test and critical values supplied in Philips and Ouliaris (1990).

Out of the sixteen cointegrating equations tested, eight are found to be cointegrated at the 15% level or lower (see Appendix E2). The 15% level is used because of the low power of unit root tests under small sample sizes (Blough 1992). The coefficients in the cointegrating vector are obtained using Dynamic OLS with one lead and lag and the cointegrating vectors are generated using the coefficients estimated under DOLS[14].

Estimated Cointegrating Equations

(1*) $s_{Rt} = 0.1350 - 0.3623 Totnet_t + 0.0067t$

(0.0336) (0.0612) (0.0009)

(2*) $s_t = 0.3876 - 0.2918 Totnet_t + 0.0050t$

(0.0259) (0.0498) (0.0007)

(5*) $s_{Rt} = 9.1015 - 0.9283 \ln(Tot\ Arr)_t + 0.0885 \ln(Tot\ Dep)_t + 0.0128t$

(1.6686) (0.1188) (0.0691) (0.0014)

(9*) $s_{Rt} = 10.6532 - 1.3636 \ln(US\ Arr)_t + 0.0104t$

(1.2950) (0.1700) (0.0011)

(11*) $s_{Rt} = 10.2614 - 0.9472 \ln(Tot\ Arr)_t + 0.0130t$

(1.1654) (0.1100) (0.0011)

(13*) $s_{Rt} = -9.2738 + 1.270 \ln(US\ Dep)_t - 0.0058t$

(0.9351) (0.1242) (0.0010)

(15*) $s_{Rt} = -2.6865 + 0.2688 \ln(Tot\ Dep)_t + 0.0035t$

(1.1153) (0.1029) (0.0010)

(16*) $s_t = -1.9200 + 0.2202 \ln(Tot\ Dep)_t + 0.0025t$

(0.9190) (0.0848) (0.0008)

---

[14] Stock and Watson (1993) explain the methodology.

The coefficients on arrivals and net migration are negatively signed, implying that an increase in arrivals will result in an appreciation of the exchange rate (nominal and real). The coefficients on departures are positively signed implying that an increase in departures will cause a depreciation of the exchange rate (nominal and real).

All the cointegrating vectors are included in Error Correction Models. The optimal lag length is chosen by minimising the Schwarz Information Criterion. The estimated equations are reported in Appendix E3. The bivariate ECMs can be interpreted as Granger Causality tests[15] where the independent variable Granger Causes the dependent variable if the coefficient on the cointegrating vector is significantly different from zero (Chaudhuri 1997). If the coefficient on the cointegrating vector is insignificant but the coefficients on one or more lags of the independent variable are significant then the dependent variable is weakly exogenous. If the coefficients on both the cointegrating vector and the lags of the independent variable are insignificant then it is said that the dependent variable is strongly exogenous. Granger causality Results are reported below.

Table 1: Granger Causality Results

	Dependent Variables							
Independent Variables	s_t	s_{Rt}	Tot net	US net	ln(TotDep)	ln(TotArr)	ln(USDep)	ln(USArr)
s_t								
s_{Rt}								
Tot net	**	***						
US net								
ln(TotDep)	*	**						
ln(TotArr)		***						
ln(USDep)		***						
ln(USArr)		***						

* refers to the Independent variable Granger causing the Dependent variable at the 10% level.

** refers to the Independent variable Granger causing the Dependent variable at the 5% level.

***refers to the Independent variable Granger causing the Dependent variable at the 1%level.

[15] See Chaudhuri (1997) for a full description of the methodology.

Table 2: Level of Exogeneity

	Independent Variables							
Dependent Variables	s_t	s_{Rt}	Tot net	US net	ln(TotDep)	ln(TotArr)	ln(USDep)	ln(USArr)
s_t								
s_{Rt}								
Tot net	Strongly	Strongly						
US net								
ln(TotDep)	Strongly	Strongly						
ln(TotArr)		Strongly						
ln(USDep)		Strongly						
ln(USArr)		Strongly						

The table reads as follows: the Dependent variable Tot net is strongly exogenous to the Independent variable s, etc.

All migration variables included in the bivariate ECMs are strongly exogenous and Granger cause the exchange rate. The exchange rate (both nominal and real) does not have an affect on migration but migration has a long run affect on the exchange rate.

An ECM is set up where Total departures and arrivals are entered separately, without the equal weighting restriction imposed by net migration. Using the same approach as the bivariate Granger causality test, the ECM can be interpreted. From equation (5**) in Appendix E.3, Total arrivals and Total departures are strongly exogenous to the real exchange rate. Total arrivals and Total departures Granger cause the real exchange rate.

Cointegration between migration and the exchange rate is the most important finding from this section. It implies a long run equilibrium relationship exists between the variables and causality in at least one direction. This suggests the relationship observed in the Reserve Bank Monetary Policy Statement is not spurious. Sixteen cointegrating specifications are tested, eight are found to be cointegrated at the 15% level or lower. Six of the cointegrating relations found involve the real exchange rate. Where cointegration is found using the nominal exchange rate, it is also found using the real exchange rate under the same specification at a higher significance level. When Granger causality tests are performed migration is found to Granger cause the real exchange rate and to be strongly exogenous. This is an important result suggesting the exchange rate does not have an effect on migration.

However it is difficult to interpret the econometric equations so a theoretical model is developed to understand the relationship in a general equilibrium framework.

5. A Theoretical Model

This section develops the general equilibrium model that will be used in this paper and calibrated for the New Zealand economy. The model borrows the foundation from Hercowitz and Yashiv (2002). It builds on that foundation a necessary structure to examine the special role of emigration and technology as well as immigration in the exchange rate determination. It will be interpreted using similar reasoning outlined in Hercowitz and Yashiv (2002) except where the model deviates by the inclusion of emigration, technology and aggregate demand shocks. It is a general equilibrium model in the standard form except for one feature. The model uses heterogeneous capital stocks. It allows indigenously produced capital to be different from foreign capital in form and content. For example the operating instructions for imported machinery could be written in a foreign language making substitution more difficult.

At each date *t*, let Y_t, A_t, L_t, K_t and Km_t denote, respectively, domestically produced output, total factor productivity, which is an index of technology, labour, indigenous capital and imported capital. There are no exports in the model and Km_t represents total imports.

The Cobb Douglas production function is given by:

$$Y_t = A_t L_t^{\alpha} Km_t^{\beta} K_t^{1-\alpha-\beta} \qquad (1)$$

Labour, imported capital and domestic capital are all imperfect substitutes in the production of domestic output. Two scenarios are reported in Hercowitz and Yashiv (2002). The first is where the capital stock is homogeneous and consists of only imported capital, implied by the restriction $1-\alpha-\beta=0$, and the second is where the capital stock is heterogeneous, both imported and domestic capital are factors of production implied by the restriction $1-\alpha-\beta<0$.

Hercowitz and Yashiv (2002) refer to K_t as an additional input used in production when there is a heterogeneous capital stock and imperfect capital substitution $(1-\alpha-\beta<1)$. In this paper K_t is interpreted as indigenous capital that may also include human capital.

Hercowitz and Yashiv (2002) specify that K_t grows at the same rate as the native born population (implying the economy is in the steady state) but this restriction may be relaxed conditional on K_t being uncorrelated with migration flows.

The following section describes the profit maximisation exercise of the representative firm in this economy. Let P_t, P_t^*, S_t, W_t and r_t denote, respectively, the domestic price level the foreign price level, the nominal exchange rate, the nominal wage and the real interest rate.

The representative firm's profit Π_t at each date *t* is given by:

$$\begin{aligned}\Pi_t &= P_t Y_t - S_t P_t^* Km_t - W_t L_t - r_t P_t K_t \\ &= P_t A_t L_t^\alpha Km_t^\beta K_t^{1-\alpha-\beta} - S_t P_t^* Km_t - W_t L_t - r_t P_t K_t\end{aligned} \tag{2}$$

The first order conditions of profit maximisation are described below.

$$\frac{\partial \Pi_t}{\partial Km_t} = \beta P_t A_t L_t^\alpha \; Km_t^{\beta-1} K_t^{1-\alpha-\beta} - SP_t^* = 0 \tag{3.a}$$

The nominal factor price of imported capital is the price of imported capital in foreign currency converted into domestic currency. Let S_{Rt} denote the real exchange rate at time *t*. By dividing both sides of (3a) by the domestic price level, the factor price of imported capital is given by,

$$\beta A_t L_t^\alpha Km_t^{\beta-1} K_t^{1-\alpha-\beta} = \frac{S_t P_t^*}{P_t} = S_{Rt} \tag{3.b}$$

By (3.b) the optimal level of imported capital is such that the real exchange rate equals the marginal product of imported capital.

Under the small open economy assumption the real interest rate is constant and equal to the world real interest rate, the firm takes as given to determine its desired capital stock such that

$$\begin{aligned}&\frac{\partial \Pi_t}{\partial K_t} = (1-\alpha-\beta) A_t L_t^\alpha Km_t^{\beta-1} K_t^{-(\alpha+\beta)} - r_t = 0 \\ &(1-\alpha-\beta) A_t L_t^\alpha Km_t^{\beta-1} K_t^{-(\alpha+\beta)} = r_t\end{aligned} \quad , \tag{3.c}$$

Or, equivalently, marginal product of indigenous capital equals the world's interest rate. The choice of labour is determined by:

$$\frac{\partial \Pi_t}{\partial L_t} = \alpha P_t A_t L_t^{\alpha-1} Km_t^{\beta} K_t^{1-\alpha-\beta} - W_t = 0$$
$$\alpha L_t^{\alpha-1} A_t Km_t^{\beta} K_t^{1-\alpha-\beta} = \frac{W_t}{P_t} = w_t \qquad (4)$$

Note that the optimal level of employment gives the standard result that the real wage equals marginal product of labour, which, however, depends on the level of imported capital and hence on the real exchange rate.

The above link between the labour productivity and the exchange rate contributes to the determination of the real exchange rate as a function of labour.

The population of working age is heterogeneous and composed of two components, native-born population of working age P_t^N and immigrant population of working age P_t^I where ΔP_{t-q}^I denotes the flow of immigrants for the period *t*-*q* and the stock of immigrants at time *t* can be written as:

$$P_t^I = \sum_{q=0}^{t} \Delta P_{t-q}^I \ ,$$

where *t* is the number of quarters since the first immigrant cohort arrived and *q* is the number of quarters a particular cohort has been resident.

This paper deviates from Hercowitz and Yashiv (2002) with the inclusion of the term ΔP_t^E, which represents the flow of emigrants for the current time period. It is assumed that all emigration is from the native born population for simplicity.[16] The time order is critical for the inclusion of emigration in the model, all emigration occurs at the end of the period so that P_t^{N*}, the native born population at the end of period *t* is given by:

$$P_t^{N*} = P_t^N - \Delta P_t^E \quad \text{where } P_t^{N*} \le P_t^N \text{ and } P_t^N = (1+n)(P_{t-1}^N - \Delta P_{t-1}^E) = (1+n)P_{t-1}^{N*}$$

[16] There is evidence for this in the data; most of the variation in New Zealand's emigration is driven by the native born population (Population and Development, 2003)

where n is the growth rate of the native born population due to natural increase and is assumed to be constant.

The population grows over period t due to natural increase then the emigrants leave at the end of the period to give the current period's native born population. In addition the assumption is made that emigration has a one off effect on the population so is only included directly in the model once.

Labour supply, like the population is made up of two components, native-born labour supply and immigrant labour supply. L_t^N and L_t^I are the time t native born and the immigrant labour supplies respectively. λ denotes the elasticity of labour supply with respect to real wages. Let θ_l^E denote the labour market participation factors for impending emigrants, defined as the percentage of employed emigrants out of all impending emigrants of working age. Similarly let $\theta_{l_q}^I$ denote the labour participation factor for immigrants that have been living in the host country for q quarters, defined as the percentage of employed immigrants that arrived q quarters ago out of all immigrants of working age that arrived q quarters ago. The native born population is assumed to have a participation factor of one. Immigrants that have just arrived are assumed to have lower participation factors or employment rates than the native born population.[17] This is due to settling factors like learning the native language (for those that don't already speak it), cultural adjustment and the search time required to find a job. Immigrants that have been in the host country for some time have higher participation factors or employment rates. Their participation factors eventually converge to the native-born rate of one from below.[18] Labour supply as a function of date t real wages w_t, the native born population P_t^N, the flows of immigrants ΔP_{t-q}^I and emigrants ΔP_t^E and there respective participation factors θ_l^E and $\theta_{l_q}^I$, $q = 0,.,t.$ is given by,

[17] This is based on empirical evidence from Israel (Hercowitz and Yashiv (2002)) and from New Zealand (Winkelmann and Winkelmann (1998)).

[18] It is assumed in this paper that the labour participation factors for the quarters since arrival remain constant over time for simplicity. There is evidence of this in the 1996 and 2001 census data.

$$L_t^N = w_t^{\lambda}(P_t^N - \theta_l^E \Delta P_t^E) \qquad (5)$$

$$L_t^I = w_t^{\lambda} \sum_{q=0}^{t} \theta_{l_q}^I \Delta P_{t-q}^I \qquad (6)$$

$$L_t = L_t^N + L_t^I$$

Total labour supply is the sum of the immigrant labour supply and the native born labour supply. The equilibrium labour force is solved for, by setting the labour supply equal to labour demand (MPL).

$$L_t = w_t^{\lambda}(P_t^N - \theta_l^E \Delta P_t^E + \sum_{q=0}^{t} \theta_{l_q}^I \Delta P_{t-q}^I)$$

$$w_t = \left(\frac{L_t}{P_t^N - \theta_l^E \Delta P_t^E + \sum_{q=0}^{t} \theta_{l_q}^I \Delta P_{t-q}^I} \right)^{\frac{1}{\lambda}}$$

$$\alpha A_t L_t^{\alpha-1} Km_t^{\beta} K_t^{1-\alpha-\beta} = \left(\frac{L_t}{P_t^N - \theta_l^E \Delta P_t^E + \sum_{q=0}^{t} \theta_{l_q}^I \Delta P_{t-q}^I} \right)^{\frac{1}{\lambda}}$$

The equilibrium levels of labour and imported capital have been solved for and are given by

$$L_t = Z_{1t} K_t^{\frac{\lambda(1-\alpha-\beta)}{\lambda(1-\alpha-\beta)+1-\beta}} \left(P_t^N - \theta_l^E \Delta P_t^E + \sum_{q=0}^{t} \theta_{l_q}^I \Delta P_{t-q}^I \right)^{\frac{1-\beta}{\lambda(1-\alpha-\beta)+1-\beta}} S_{Rt}^{\frac{-\lambda\beta}{\lambda(1-\alpha-\beta)+1-\beta}}, \qquad (7)$$

$$Km_t = Z_{2t} K_t^{\frac{(1-\alpha-\beta)(1+\lambda)}{\lambda(1-\alpha-\beta)+1-\beta}} \left(P_t^N - \theta_l^E \Delta P_t^E + \sum_{q=0}^{t} \theta_{l_q}^I \Delta P_{t-q}^I \right)^{\frac{\alpha}{\lambda(1-\alpha-\beta)+1-\beta}} S_{Rt}^{-\frac{\lambda(1-\alpha-\beta)+1-\beta+\lambda\alpha\beta}{(1-\beta)[\lambda(1-\alpha-\beta)+1-\beta]}}, \qquad (8)$$

where Z_{1t} and Z_{2t} are functions of α, β, λ, A_t. The equilibrium functions for imported capital and labour are substituted back into the production function (equation (1)) to give aggregate supply. The date *t* aggregate supply as a function of date *t* domestic capital K_t, the date *t* real exchange rate S_{Rt}, labour in terms of the native born population P_t^N, the flows of immigrants ΔP_{t-q}^I and emigrants ΔP_t^E, the labour market participation factors, θ_l^E and $\theta_{l_q}^I$, *q=0, 1,.,t,* is given by,

$$Y_t^S = Z_{3t} K_t^{\frac{(1-\alpha-\beta)(1+\lambda)}{\lambda(1-\alpha-\beta)+1-\beta}} \left(P_t^N - \Delta P_t^E \theta_{l_t}^E + \sum_{q=0}^{t} \theta_{l_q}^I \Delta P_{t-q}^I \right)^{\frac{\alpha}{\lambda(1-\alpha-\beta)+1-\beta}} S_{Rt}^{\left(\frac{-\beta(1+\lambda)}{\lambda(1-\alpha-\beta)+1-\beta}\right)}, \quad (9)$$

where Z_{3t} is a an increasing function of Z_{1t}, Z_{2t}, α and β.

The domestic price level enters the aggregate supply function through the real exchange rate. Following the idea of the Mundell-Fleming model, aggregate demand is a function of the real exchange rate. The domestic price level enters the aggregate demand function through the real exchange rate, in a way similar to the standard textbook model, (see, e.g., page 315, Mankiw's Macroeconomics, 5th edition, 2002). Aggregate demand is also a function of the total population and the composition of the population. The model's assumption is that demand for goods and services by a person depend on how long that person has been residing in the host country and if he or she is planning to emigrate to another country in the near future. In particular, both recent immigrants and those who are planning to emigrate tend to demand different proportions of goods and services than the natives. Let θ_y^E denote the emigrant's share of aggregate demand for goods and services and let $\theta_{y_q}^I$ denote the share of aggregate demand of the immigrants who have been living in the country for *q* periods. Those shares can also be interpreted as the goods market participation factors with the participation factor for the native population being equal to one. With the above specification of heterogeneous demand share, the date *t* aggregate demand as a function of date *t* real exchange rate, S_{Rt}, the stock of population P_t^N, flows of emigrants ΔP_t^E and immigrants ΔP_{t-q}^I and the goods market participation factors, θ_y^E and $\theta_{y_q}^I$, *q=0, 1,.,t.* is given by,

$$Y_t^D = S_{Rt}^{\varepsilon} \xi_t \left(P_t^N - \theta_y^E \Delta P_t^E + \sum_{q=0}^{t} \theta_{y_q}^I \Delta P_{t-q}^I \right) \quad , \varepsilon > 0 \qquad (10)$$

where ε is the relative price elasticity of demand or the price elasticity of substitution between imported and domestically produced goods and ξ_t measures aggregate demand shocks. The equation allows for a dynamic effect on aggregate demand due to migration contrary to the textbook Mundell-Fleming model where the level of population is constant.

Goods market equilibrium implies that $Y_t^S = Y_t^D$. Setting these equations equal to each other and solving for the real exchange rate gives:

$$S_{Rt} = Z_{4t} K_t^{\frac{(1-\alpha-\beta)(1+\lambda)}{\mu}} (P_t^N - \theta_y^E \Delta P_t^E + \sum_{q=0}^{t} \theta_{y_q}^I \Delta P_{t-q}^I)^{\frac{-[\lambda(1-\alpha-\beta)+(1-\beta)]}{\mu}} (P_t^N - \theta_l^E \Delta P_t^E + \sum_{q=0}^{t} \theta_{l_q}^I \Delta P_{t-q}^E)^{\frac{\alpha}{\mu}} \qquad (11)$$

where:

$$\mu \equiv \beta(1+\lambda) + \varepsilon\lambda(1-\alpha-\beta) + \varepsilon(1-\beta) > 0$$

Z_{4t} is a variable and an increasing function of Z_{3t}, and a decreasing function of ξ_t and depends non-trivially on parameters α, β, λ and ε.

Equation (11) can be written as:

$$S_{Rt} = Z_{4t}\left(\frac{K_t}{P_t^N}\right)^{\frac{(1-\alpha-\beta)(1+\lambda)}{\mu}} \left(1 - \frac{\theta_y^E \Delta P_t^E}{P_t^N} + \sum_{q=0}^{t} \frac{\theta_{y_q}^I \Delta P_{t-q}^I}{P_t^N}\right)^{\frac{-[\lambda(1-\alpha-\beta)+(1-\beta)]}{\mu}} \left(1 - \frac{\theta_l^E \Delta P_t^E}{P_t^N} + \sum_{q=0}^{t} \frac{\theta_{y_q}^I \Delta P_{t-q}^I}{P_t^N}\right)^{\frac{\alpha}{\mu}}$$

and can be written in log form, with the approximation

$$\ln\left(1 + \sum_{q=0}^{t} \frac{\theta_{y_q}^I \Delta P_{t-q}^I}{P_t^N} - \frac{\theta_y^E \Delta P_t^E}{P_t^N}\right) \approx \sum_{q=0}^{t} \frac{\theta_{y_q}^I \Delta P_{t-q}^I}{P_t^N} - \frac{\theta_y^E \Delta P_t^E}{P_t^N} \text{ when } \sum_{q=0}^{t} \frac{\theta_{y_q}^I \Delta P_{t-q}^I}{P_t^N} - \frac{\theta_y^E \Delta P_t^E}{P_t^N} \text{ is}$$

sufficiently small enough[19].

[19] 0.2 or less.

$$\ln S_{Rt} \approx \ln Z_{4t} - (\omega_1 - \omega_2)\ln P_t^N + (\omega_1 - \omega_2)\ln K_t - \sum_{q=0}^{t}[(\omega_1\theta_{y_q}^I - \omega_2\theta_{l_q}^I)\frac{\Delta P_{t-q}^I}{P_t^N}] + (\omega_1\theta_y^E - \omega_2\theta_l^E)\frac{\Delta P_t^E}{P_t^N} \qquad (12)$$

where:

$$\omega_1 = \frac{\lambda(1-\alpha-\beta)+(1-\beta)}{\mu} = \frac{(\lambda+1)(1-\alpha-\beta)+\alpha}{\mu} > 0$$

$$\omega_2 = \frac{\alpha}{\mu} > 0$$

which implies:

$$\omega_1 = \frac{(\lambda+1)(1-\alpha-\beta)}{\mu} + \omega_2$$

If $\varepsilon = 0$ then $\omega_1 = \frac{(\lambda+1)(1-\alpha-\beta)+\alpha}{(1+\lambda)\beta} = \frac{s_d^k}{s_f^k} + \phi\frac{s_d^l}{s_f^k}$ where $\phi = \frac{1}{(1+\lambda)}$ and $0 < \phi < 1$

$$\omega_2 = \frac{\alpha}{(1+\lambda)\beta} = \phi\frac{s_d^l}{s_f^k}$$

s_d^k = domestic capitals share of income

s_f^k = imported (foreign) capitals share of income

s_d^l = labour's share of income.

ϕ is a decreasing function of the elasticity of the labour supply with respect to real wages. If $\varepsilon = 0$ (i.e. domestically produced output is neither a complement nor a substitute for imported goods and services), ω_2 can be interpreted as the ratio of labour's share of income to imported capital's share of income, multiplied by ϕ. ω_1 is an increasing function of ω_2 and can be interpreted as the ratio of domestic capital's share of income to imported capital's share of income plus ω_2.

Hercowitz and Yashiv (2002) outline two possible scenarios in their production function. A homogenous capital stock, where imported capital is the only capital input used in the production of domestic output and heterogeneous capital stocks where both imported and indigenous capital are inputs. The homogeneous capital scenario implies that $\omega_1 - \omega_2 = 0$ which means the relative goods market to labour market participation differential for the different immigrant and current emigrant cohorts determines the real exchange rate. From equation (12), if immigrants have a disproportionately high share of aggregate demand and a lower employment rate than the native born, they will be consuming more than they are contributing to production through labour resulting in an increase in aggregate demand and a real appreciation of the exchange rate. If immigrants have a higher employment rate compared to their share of aggregate demand, they will be contributing more to production through labour than they are consuming, aggregate supply will increase and a real depreciation of the exchange rate will occur.

The heterogeneous capital scenario, where both indigenous and imported capital are inputs in production, implies that $\omega_1 > \omega_2$. The real exchange rate is determined by the relative goods market to labour market participation differential as established under the homogeneous capital scenario. In addition the difference between ω_1 and ω_2, determines the real exchange rate. This is due to the substitution effect between imported and indigenous capital, increasing indigenous capitals share of income results in an increase in the factor price of imported capital, which is a real depreciation of the exchange rate. From equation (12), if $\omega_1 > \omega_2$, then an increase in immigration will lead to a real appreciation of the exchange rate, assuming goods market participation exceeds labour market participation. If labour market participation is greater than goods market participation, then the relative difference between ω_1 and ω_2, and the participation factors $\theta^I_{l_q}$, $\theta^I_{y_q}$, θ^I_l and θ^E_y will determine whether there is a real appreciation or depreciation when immigration increases. Growth in the native-born population and the domestic capital stock (If the economy is not in the steady state) could also affect the real exchange rate.

The model will be calibrated to the New Zealand economy by matching the models prediction of the real exchange rate, GDP and employment, equations (11), (9) and (7) respectively to their corresponding data. The variables determined exogenously to the model and hence require data include the domestic capital stock K_t, the stock of the native-born population P^N_t and the flow of immigrants and emigrants, ΔP^E_t and ΔP^I_{t-q} respectively. The parameters α labour's share of income, β imported capital's share of income; $\theta^I_{l_q}$ immigrant labour participation and θ^E_l emigrant labour participation are estimated to match the national accounts and census data. The parameters ε the relative price elasticity of demand, λ the elasticity of labour supply, θ_y^E emigrant's goods market participation and $\theta_{y_q}^I$ immigrant's goods market participation remain free and will be estimated to match the model to the data. The model imposes restrictions on the parameters λ, ε, θ_y^E and $\theta_{y_q}^I$, they must all be strictly positive.

6. Calibration

This section describes how the parameters α, β, θ_l^E and $\theta_{l_q}^I$ are estimated to match their direct counterparts in the data. The remaining parameters λ, ε, θ_y^E and $\theta_{y_q}^I$ are estimated by using equations (7), (9) and (11) to fit the models prediction of the real exchange rate, GDP and employment to their time series counterpart.

The heterogeneous capital restriction is applied when fitting this model[20] suggesting domestic capital is an input in production. The parameter α, labour's share of income, is 0.55 in New Zealand. The parameter β, share of imported capital, is determined as follows:

(13) $$\beta = \frac{S_t P_t^* Km_t}{P_t Y_t} = \frac{S_{Rt}\ Km_t}{Y_t}$$ and

(14) $$\alpha = \frac{w_t L_t}{Y_t}.$$

Net investment income from abroad is used as a proxy for $S_{Rt} Km_t$ to determine $\beta = 0.05$.

To estimate the remaining parameters, the model is calibrated to the New Zealand economy for the 67 time periods between 1986:2 and 2002:4. The number *q* of quarters after which the behaviour of the immigrants and the native born population becomes indistinguishable is determined by econometric tests. It turns out that the value of $q = 4$ for New Zealand immigrants as opposed to 9 that Hercowitz and Yashiv (2002) report for Israel. In other words, immigrants participate in the labour and goods markets exactly like the native born population with a four quarter lag. The labour market participation rates for an immigrant increase gradually over time. The profile of participation rates reported by

[20] The homogeneous restriction could not be applied.

Hercowitz and Yashiv (2002) is used to fit data available for New Zealand immigrants (see Appendix figures 21 and 22). The participation rates for q = 4 and q = 2 are calibrated, respectively, to fit the actual participation rate of the immigrants, who arrived one year ago and those who arrived less than a year ago. The participation rate for immigrants who arrived less than a year ago is assumed to be the median participation rate for all immigrants who arrived within the year and is therefore assigned to the median quarter which happens to be q = 2. The participation factor for the emigrants is chosen to be 95% for all impending emigrants. Presumably, they may not be working fulltime while they are preparing to go overseas. The results reported in this paper are not sensitive to the specific estimates of the labour market participation rates reported above.

Given four lags as discussed above there will be eight parameters to calibrate as follows: $\lambda, \varepsilon, \theta_y^E, \theta_{y_0}^I, \theta_{y_1}^I, \theta_{y_2}^I, \theta_{y_3}^I$ and $\theta_{y_4}^I$. There are three equations to match to the data and the sample contains 67 observations. This means there are 201 variables and eight unknowns, leaving 193 degrees of freedom. Parameter values for $\lambda, \varepsilon, \theta_y^E$ and $\theta_{y_q}^I$ are chosen by comparing a series of the model's simulations and the time series data to reduce the absolute value of the errors for the following three equations.

(15) $S_{Rt}^{Model} - S_{Rt}^{Data} = u_{1t}$

(16) $Y_t^{Model} - Y_t^{Data} = u_{2t}$

(17) $L_t^{Model} - L_t^{Data} = u_{3t}$

where equations (15),(16) and (17) represent the difference between the models prediction of the real exchange rate, GDP and the employed, and their corresponding data equivalents. Following Hercowitz and Yashiv (2002) it is assumed that technology is time invariant and there are no exogenous aggregate demand shocks, without loss of generality.

6.1 Case 1: Baseline Calibration

The estimated parameters of the model based on the Statistics New Zealand data[21] are reported below.

---

[21]Capital data converted from annual to quarterly series by Mark Smith, the RBNZ

Real exchange elasticity of aggregate demand and real wage elasticity of labour supply:

Parameter	$\varepsilon = \frac{\partial \ln Y^d}{\partial \ln S_R}$	$\lambda = \frac{\partial \ln L^s}{\partial \ln w}$
Estimate	0.028	1.220

Goods Market Participation Factors

Parameter	$\theta^I_{y_0}$	$\theta^I_{y_1}$	$\theta^I_{y_2}$	$\theta^I_{y_3}$	$\theta^I_{y_4}$	θ^E_y
Estimate	0.605	1.212	1.011	0.822	7.641	10.000

Labour Market Participation Factors

Parameter	$\theta^I_{l_0}$	$\theta^I_{l_1}$	$\theta^I_{l_2}$	$\theta^I_{l_3}$	$\theta^I_{l_4}$	θ^E_l
Estimate	0.548	0.708	0.774	0.824	0.867	0.95

The calibrated values for the goods market participation parameters reported under Case's 1 and 2 can be interpreted as follows: The goods market participation rate of the immigrants increase with the time they have been present in the host country eventually overtaking the native born rate (with the purchase of a house or investment in a business) before converging to one. It is assumed they become indistinguishable from the native born population when they have lived in the host county for more than four quarters.

The estimated goods market participation factors for Case 1 are displayed in figure 5 (see Appendix). It can clearly be seen that immigrants' goods market participation factors start below those of the native born. There is a slight increase preceding a negligible decline. By the time the immigrants have been resident for four quarters their participation factors have escalated to over seven times those of the native born before converging to one.

All goods market participation factors exceed their respective labour market factors except for the immigrants that arrived three quarters ago. Their labour market participation rate is slightly larger than their goods market participation. The differential is not large enough by itself to cause a real depreciation of the exchange rate when immigration increases because $\omega_1 \theta^I_{y_3} > \omega_2 \theta^I_{l_3}$ (with respect to equation (12)). However the resulting real appreciation is likely to be smaller than if their goods market participation rate exceeded their labour market participation. The higher goods market participation in the remaining quarters suggest that immigrants are consuming more than they are contributing to production through labour. The fourth lag has the largest differential for the immigrants, and is comparable to the emigrant's respective differential. Immigrants purchasing a house, business or other large ticket item, can explain the large differential. A goods market participation factor of one is representative of native born participation in the economy, so it is conceivable when buying a house or business, participation in the economy could be seven times that of the average native born. Similarly the emigrants' large goods to labour market participation differential can be explained by the sale of personal possessions before departure, interpreted as a negative contribution to aggregate demand. This reasoning becomes clearer when the emigrants current goods market participation of ten, entering negatively into aggregate demand, is compared to their previous quarters participation of one, entering positively into aggregate demand. The participation factor of ten implies that one person emigrating is equivalent to losing the consumption share of ten native born for the period they depart. In the quarter preceding their departure their share of aggregate demand is the same as the native born. If an emigrant were to sell all there possessions including their house before they departed the amount sold could be ten times more than the average native born consumes in one quarter.

The estimated relative price elasticity of demand ε, is quite low at 0.028. This suggests that imports and domestically produced output are weak substitutes and sufficiently different for the relative price to have only a limited affect on their demand. The estimated elasticity of labour supply λ is 1.22 indicating workers have a more than proportionate response to wages, and is comparable to the estimate of 1 Hercowitz and Yashiv (2002) supply for Israel.

Table 3: Simple Correlations Case 1

Models Prediction	Correlation with time series counterpart
Real Exchange Rate	-0.15
GDP	0.97
Employed	0.91

The models prediction of the real exchange rate, GDP and the employed are presented with their data equivalents in figures 6, 7 and 8 respectively. Table 3 displays the corresponding simple correlations between the models prediction and the data. The model is able to fit the real exchange rate reasonably well from about 1993 onwards. However preceding this period the model under values the real exchange rate which is apparent in the poor correlation result.

From figure 7, the model's prediction closely replicates GDP although it is unable to explain the dip in the early 1990's. This result is reinforced by the high correlation between the models prediction of GDP and the data. The model is able to simulate the variation in the employed from about 1991 onwards. However before 1991 the model underestimates the employed. This can be explained by the absence of exogenous causes of unemployment and some of the assumptions used to construct the model.[22] Despite this the simple correlation shows the predicted employed is strongly correlated with the data. To improve the fit of the models predicted real exchange rate, the domestic capital stock will be re-estimated in the following section, by including an additional parameter for depreciation.

6.3 Case 2: Capital Altered for Different Depreciation Rate

This section includes the depreciation rate of indigenous capital δ, as a parameter and estimates it in addition to the previously listed parameters to fit the model. The model now has nine parameters with 201 variables leaving 192 degrees of freedom.
The standard capital accumulation equation,

$$K_t = (1-\delta)K_{t-1} + I_{t-1}$$

is substituted for the domestic capital stock in equations (7),(9) and (11). Where δ and I_{t-1} denote the domestic capital depreciation rate and time *t*-1 investment, respectively. Using quarterly gross fixed capital formation as a measure of investment and taking a Statistics New Zealand capital stock data point from the middle of the sample as the base period, the free parameters are chosen to fit the models prediction of the real exchange rate, GDP and employment to their data equivalents.

The parameter estimates are reported below and interpreted.

Elasticities and Domestic Capital Depreciation Rate

Parameter	$\varepsilon = \frac{\partial \ln Y^d}{\partial \ln S_R}$	$\lambda = \frac{\partial \ln L^s}{\partial \ln w}$	δ
Estimate	0.023	1.160	0.00923

---

[22] The assumption that there were foreign-born residents in New Zealand in 1985:1 may have resulted in the under estimation of the total Labour force.

Goods Market Participation Factors

Parameter	$\theta^I_{y_0}$	$\theta^I_{y_1}$	$\theta^I_{y_2}$	$\theta^I_{y_3}$	$\theta^I_{y_4}$	θ^E_y
Estimate	0.604	1.212	1.001	0.871	7.092	7.197

Labour Market Participation Factors

Parameter	$\theta^I_{l_0}$	$\theta^I_{l_1}$	$\theta^I_{l_2}$	$\theta^I_{l_3}$	$\theta^I_{l_4}$	θ^E_l
Estimate	0.548	0.708	0.774	0.824	0.867	0.95

The estimated domestic capital depreciation rate δ can be compared to the Statistics New Zealand rate. A depreciation rate of 3.7% per annum or 0.92% quarterly is estimated to fit the model compared to the 5% per annum or 1.2% quarterly that Statistics New Zealand use.[23] The lower depreciation estimate could be explained by the absence of human capital from the Statistics New Zealand capital stock. Human capital may be required to fit the model and could depreciate less rapidly than physical capital.

The estimated goods market participation factors using the calibrated domestic capital stock resemble to those estimated in the baseline case. Figure 9 presents the goods market participation profile estimated in Case 2, and has an almost identical shape to Case 1.

The goods to labour market participation differentials share a similar trend to those in Case 1. All the goods market participation factors are larger than their corresponding labour market participation factors for the immigrants except the third lag, where the labour participation rate is slightly larger. This is not large enough by itself to cause a real depreciation when immigration increases. The fourth lag of immigration has the largest goods to labour market participation differential and is comparable to the emigrants. The goods market participation factors that are larger than their respective labour market participation factors can be interpreted as recent immigrants consuming more than they are contributing to production through labour in the New Zealand economy.

The goods market participation rate for the emigrants changes the most between Cases. It is still significantly larger than the native born rate of one, but has decreased from ten in the baseline case down to seven. This suggests that when a member of the native born population emigrates they have the same effect on aggregate demand as losing the consumption share of seven native born and can be explained by the same reasons outlined in Case 1.

---

[23] This is estimated using the gross fixed capital formation data and the Statistics NZ capital stock data.

The estimates for the relative price elasticity of demand and the elasticity of labour supply do not change significantly from Case 1. The estimate for λ is 1.160, which is closer to the estimate that Hercowitz and Yashiv (2002) give for Israel.

Table 4: Simple Correlations Case 2

Models Prediction	Correlation with time series counterpart
Real Exchange Rate	0.68
GDP	0.97
Employed	0.91

The model's prediction of the real exchange rate, GDP and the labour force under Case 2 are presented with their data counterparts in figures 10, 11 and 12 respectively. Table 4 displays the simple correlations between the models prediction and the data. The model predicts the real exchange rate better under Case 2 than it could under Case1, which is supported by the increased correlation between model and data. Comparing figure 10 with figure 6, it is apparent that Case 2 can replicate the peak in the real exchange rate in the early 1990's, which it is unable to in the baseline case. The portion of the real exchange rate the model could fit in Case1 is easily replicated under Case 2 although it is still unable to explain the initial peak in the mid 1980's and a subsequent peak in the 1990's. The models predicted employment under Case 2 is comparable to Case 1, the correlation between the model and the data remains unchanged between cases, and it suffers from the same problems explaining the mid 1980's. The predicted GDP in Case 2 fits as well as the baseline case, with the simple correlation remaining unchanged. Adding an extra parameter for domestic capital depreciation has improved the fit of the model, the correlation between the models prediction of the real exchange rate has increased, but there is still room for improvement. The conclusion reached is the source of the poor fit in Case 1 is not just the quality of the capital stock data but some other assumptions of the model. In particular the assumption that the level of technology is time invariant and there are no exogenous demand shocks may not be true. In the next section these assumptions will be relaxed.

6.2a Case 2a: Shocks to Technology and Aggregate Demand

In this section shocks to technology and aggregate demand are considered to account for some of the variation in the data not explained by the model. First analytical expressions of the technology and demand shocks are derived in terms of the variables Z_{1t}, Z_{2t}, Z_{3t} and Z_{4t} of equations (7)-(9) and (11). The calculations and equations for this exercise are reported in the Appendix.

Aggregate demand shocks, required to estimate technology in the foreign exchange market, are determined by setting the models prediction of aggregate demand equal to GDP data. The aggregate demand shocks are solved for by using equation (A.14) from the Technical Note on TFP included in the Appendix. The level of technology required to fit the model's prediction of the real exchange rate, GDP and the employed exactly is determined by setting the models prediction of the real exchange rate, GDP and employed equal to their corresponding data equivalents. Technology is then solved by using equations (A.15), (A.16) and (A.17) the Technical Note on TFP included in the Appendix to determine technology in the goods, the labour and the foreign exchange markets respectively.

The technology estimates presented in figure 13, are determined in the goods, the labour and the foreign exchange markets. The technology estimates from the three markets are relatively consistent and share a similar trend. Technology is decreasing in the 1980's, before stabilising in the 1990's and fluctuating round a mean value. The technology estimated using aggregate supply is closer to the technology estimated using the real exchange rate. The technology estimated in the labour market has more of a descending trend over the time period calibrated. This may be due to labour demand shocks, independent of technology and the other markets.

The real exchange rate could be estimated using the technology estimates generated in the foreign exchange market resulting in a 100% fit of the model. However this would be of limited interest. A better measure of the models performance would be to use the technology generated in the labour or the goods market along with the aggregate demand shocks to estimate Z_{4t} and hence the real exchange rate. This would show whether the model is internally consistent. Both technology estimates are used to estimate the real exchange rate. The technology from the goods market provides a better fit than the technology from the labour market, which is not surprising given figure 13. So only this estimate is reported along with the estimate of the employed using technology from the goods market. There are 201 variables and 9 parameters, the inclusion of technology and aggregate demand shocks adds 67×2 parameters to the model, so there are now 145 parameters leaving 58 degrees of freedom.

Table 5: Simple Correlations Case 2a.

Models Prediction	Correlation with time series counterpart
Real Exchange Rate	0.89
Employed	0.95

Figures 14 and 15 present the models prediction of the real exchange rate and the labour force respectively when technology from the goods market and the aggregate demand shocks are included. Table 5 displays the corresponding simple correlations. The model with technology and aggregate demand shocks is able to replicate more variation in the real exchange rate, than with technology and aggregate demand shocks omitted, the correlation increases from 0.68 to 0.89. However it is still unable to replicate the mid 1980's. The models estimate of employment using technology generated in the goods market is also an improvement over the model with technology and aggregate demand shocks held constant. It can capture more curvature in the data in the early 1990's than it could without technology and the correlation improves. On the whole the inclusion of technology and aggregate demand shocks have improved the models fit. Now the model has been fitted, hypothesis tests will be undertaken to evaluate the models performance, these will be covered in the next section.

7. Testing and Policy Implications

This section looks at three different issues with regard to testing the calibrated model's performance. The first issue tested is the hypothesis that migration data is a good predictor of the real exchange rate. This is evaluated by measuring the out of sample forecasting performance of the general equilibrium model. The second issue involves the hypothesis that the general equilibrium model explains the real exchange rate better than the diagnostic econometrics, a cointegrating style restriction is applied to the general equilibrium model and some comparisons are made. The final issue covered is a policy experiment with regard to the recent change in immigration policy.

7.1 Out of Sample Forecast

In this section the hypothesis that migration is a good predictor of the real exchange rate will be tested. The model used will include a parameter for domestic capital depreciation as established in Case 2 and hold technology and aggregate demand shocks constant. The hypothesis is tested by measuring the out of sample forecasting performance of the model. To test the out of sample forecasting performance, the model is calibrated for only the first half of the sample using the method described previously. The models prediction of the real exchange rate is compared to the real exchange rate data for the 1994:4 to 2002:4 period. The parameter estimates are reported below.

Elasticities and the Domestic Capital Depreciation Rate

Parameter	ε	λ	δ
Estimate	0.026	1.984	0.00923

Goods Market Participation Factors

Parameter	$\theta^I_{y_0}$	$\theta^I_{y_1}$	$\theta^I_{y_2}$	$\theta^I_{y_3}$	$\theta^I_{y_4}$	θ^E_y
Estimate	0.598	1.219	0.948	0.973	3.625	4.277

Labour Market Participation Factors

Parameter	$\theta^I_{l_0}$	$\theta^I_{l_1}$	$\theta^I_{l_2}$	$\theta^I_{l_3}$	$\theta^I_{l_4}$	θ^E_l
Estimate	0.548	0.708	0.774	0.824	0.867	0.95

Figure 16 presents the calibrated and forecasted sections of the general equilibrium model. It is evident that the model is able to replicate the direction of the movements in the real exchange rate over the second half of the sample although it under estimates the magnitude of the trough in1997. The models forecast of the real exchange rate has a 96% correlation with the data. It is able to forecast the peak and the decline in the real exchange rate around 2001 and performs well over the time period.

7.2 Model's Performance

In this section the underlying assumptions of the general equilibrium model will be tested against a comparable equation taken from the Diagnostic Statistics section. Equation (5*) is selected because it is the cointegrating equation most closely resembling equation (12) from the general equilibrium model. Equation (12) is modified by imposing a cointegration style restriction. Cointegration requires that contemporaneous variables integrated of the same order be regressed upon one another to produce a stationary residual. Placing a cointegration style restriction on equation (12) implies only using the current period's immigration and emigration in the model with the parameter estimates generated from Case 2. In addition the steady state restriction must be imposed on the general equilibrium model so that K_t grows at the same rate as P_t^N and equation (12) collapses to something comparable to equation (5*),

$$\ln S_{Rt} \approx \ln\left(Z_{4t}\left(\frac{K_t}{P_t^N}\right)^{\omega_1-\omega_2}\right) - [\omega_1\theta_{y_0}^I - \omega_2\theta_{l_0}^I]\frac{\Delta P_t^I}{P_t^N} + [\omega_1\theta_y^E - \omega_2\theta_l^E]\frac{\Delta P_t^E}{P_t^N}$$

$$\ln S_{Rt} \approx c - [\omega_1\theta_{y_0}^I - \omega_2\theta_{l_0}^I]\frac{\Delta P_t^I}{P_t^N} + [\omega_1\theta_y^E - \omega_2\theta_l^E]\frac{\Delta P_t^E}{P_t^N}$$

where $\ln\left(Z_{4t}\left(\frac{K_t}{P_t^N}\right)^{\omega_1-\omega_2}\right) = c$

Where equation (5*) can be written using the same notation as (12),

$$\ln S_{Rt} \approx \alpha + \beta_1 \ln(4\times\Delta P_t^I) + \beta_2 \ln(4\times\Delta P_t^E) + \beta_3 t$$

$$\ln S_{Rt} \approx [\alpha + (\ln 4)(\beta_1 + \beta_2)] + \beta_1 \ln(\Delta P_t^I) + \beta_2 \ln(\Delta P_t^E) + \beta_3 t$$

$$\ln S_{Rt} \approx \gamma + \beta_1 \ln(\Delta P_t^I) + \beta_2 \ln(\Delta P_t^E) + \beta_3 t$$

where $\gamma = [\alpha + (\ln 4)(\beta_1 + \beta_2)]$

The performance of equation (5*) with in sample is compared to equation (12) with the cointegration style restriction imposed. Plotting both equations using the same data and establishing the base year for the real exchange rate as 1986:2, yields the following results.

When the restriction is applied to the calibrated model it is able to replicate less variation in the real exchange rate compared to the cointegrating equation. However it is evident that a pronounced lag exists in the cointegrating equation. All peaks seem to occur several quarters ahead of their corresponding peaks in the data.

Two possible conclusions can be drawn from this result. The first is the performance of the general equilibrium model using the calibrated parameters and with the cointegration style restrictions imposed, deteriorates. It is unable to explain the amount of variation in the real exchange rate that equation (5*), the cointegrated equation is able to. Alternatively when the cointegrated equation is compared to the calibrated model from Case 2a, a different conclusion can be drawn. The correctly specified calibrated model with technology from the goods market, aggregate demand shocks and arbitrary restrictions removed, is able to replicate more variation in the real exchange rate than equation (5*).

This paper reaches the latter conclusion, suggesting the arbitrary imposition of a cointegration style restriction results in the misspecification of the model. This in turn generates an omitted variable bias. The true specification of the model suggests that contemporaneous emigration, immigration, domestic capital stock, the native born population, goods and labour market participation rates and lagged immigration constitute important determinants of the real exchange rate.

7.3 Policy Experiment: New Zealand's Change in Immigration Policy

This section investigates the effects of an unanticipated shock that changes the flows of migration. This exogenous change to migration could be thought of as an unanticipated change to immigration policy, which ties in with the recent change to immigration policy in New Zealand (New Zealand Immigration Service, 2003). This section takes a look at a hypothetical outcome possible under the new immigration policy using the model calibrated in Case 2.

The policy change is designed to give government more control over the number of immigrants granted residency. Despite this change, the residency quota will be fixed at the 2002/2003 level of 45,000 per year (RBNZ MPS September 2003). So it seems unlikely there will be a sharp decline in immigration in the immediate future. However there is the possibility that immigration could gradually decline as the policy change makes it easier for immigrants with in New Zealand to seek residence, leaving fewer places for immigrants yet to arrive (RBNZ MPS September 2003). The Reserve Bank (MPS September 2003) believes cautiously that immigration has peaked and comments that departures to emigrant's main destination, Australia have decreased since the tightening of social welfare applicability in 2001.

In order to carry out such a policy experiment, the capital scenario must be chosen, the model updated to the current period and some suitable assumptions made. The parameter estimates used for the forecast are those from Case 2. They have been chosen because this scenario is able to replicate the data the closest.[24] The model has been updated to the September quarter of 2003.[25] The capital stock has been extended to the current period by finding the growth rate in the preceding periods and continuing the trend. The population has been extended by using the same growth rate of the last 16 years and adding in the migration flows that have occurred since December 2002. Estimating future migration flows will provide the greatest challenge.

---

[24] The model from Case 2a adjusted for technology comes closer to replicating the data but due to the difficulty in estimating technology shocks the core model from Case 2 will suffice.
[25] Given that the model previous section was calibrated up until the December quarter 2002.

As suggested, government has set the immigrant intake for the 2004 year at 45,000, the same level from the preceding year. Annual permanent and long-term arrivals for the 2003 year were approximately 95,000. This is higher than the residency intake. Clearly not all people classified as total permanent and long-term arrivals are immigrants; therefore it is unclear how the change to immigration policy will affect migration. As noted, the Reserve Bank believes there will be a slight decline in arrivals over the next year.

The forecasts made using the aforementioned expectations are that immigration will gradually decline, while emigration will gradually increase. The method determining the exact numbers can be seen in with figure 22 the migration forecast in the Appendix.

Under the strict assumptions outlined and using the rough migration estimates generated in the Appendix the model predicts there will be a gradual real appreciation of the exchange rate until the first quarter of 2004, it then stabilises and gradually depreciates around the second quarter of 2004, this can be seen in figure 19. It is important to note this is only one possible outcome of the new immigration policy, there are infinitely many possible outcomes dependent upon the assumptions made. In spite of this the result is still of interest. The lagged effect of immigration is evident in the forecast. Immigration is assumed to start declining in the third quarter of 2003, but the depreciation of the real exchange rate is somewhat delayed and does not kick in until the second quarter of 2004.

8. Conclusion

The contribution this paper makes can be summarised as follows. It confirms the findings of Hercowitz and Yashiv (2002) but for New Zealand. Migration data can be used to explain the real exchange rate at least partially. Consequently, Figures 1 and 2 from the March 2003 Reserve Bank Monetary Policy Statement that suggest a possible relationship between net migration and the exchange rate turn out not to be spurious. Granger causality tests confirm the direction of causality from migration to the real exchange rate. To understand this econometrically tested relationship a general equilibrium framework similar to Hercowitz and Yashiv (2002) is used with the allowance made for emigration, a different profile of participation rates for the migrants as well as technology and aggregate demand shocks. The real exchange rate is linked to migration through the interaction of the goods and labour markets in a small open economy. Key differences in behaviour between the native born and migrants cause real effects in those markets.

The paper also reports cointegration, which suggests a long run equilibrium relationship, between the real exchange rate and migration. This finding is quite significant and surprising given that Engel and West (2003) are unable to find cointegration between a list of economic fundamentals (not migration) and the exchange rate.

Besides the general theoretical and econometric findings reported above, the paper contributes in various other ways aiding future research in this area. (i) A general equilibrium model from the literature is modified with the inclusion of technology, aggregate demand shocks and emigration not only to characterise but also to prove analytical expressions relating the real exchange rate to migration. (ii) The theoretical model has been calibrated to benchmark it with a few key aspects of the New Zealand economy. (iii) The predictions of the calibrated model have been tested. In particular, the prediction of the model calibrated to fit data for the first half of the sample is compared to the remaining half of the sample. The model seems to predict the out of sample movements in the real exchange rate reasonable well over the 1995:1 to 2002:4 period with a 96% correlation between forecast and data. (iv) This paper reports a potentially useful discovery that may help to guide empirical research in the future. The calibrated model's performance deteriorates when it is restricted it in accordance with the cointegrating equation. This finding implies that an arbitrary imposition of cointegrating restrictions may cause misspecification of the model, which generates an omitted variable bias. Consequently, an empirical researcher would do better to exploit a richer general equilibrium model, especially when it is available, than relying on cointegrating restrictions alone.

The paper also reports results from a policy experiment regarding the likely effects of an unanticipated change to immigration policy in New Zealand. A hypothetical situation is modelled where it is assumed the new policy causes a slight decline in the flow of immigration and an increase in the flow emigration. Under the assumptions imposed in the calibrated model, the real exchange rate continues to appreciate two quarters after the decline in immigration before it stabilises and then depreciates. The lagged effects of immigrants become evident in the results. The above method of forecasting is possible due to the finding that the participation rates between the 1996 and 2001 for the migrants have remained reasonably stable. However it is unclear whether immigrants' goods market participation factors follow a similar trend.

Like the prediction of the inflation rate based on the quantity theory of money which requires a stable velocity of money, the prediction of the real exchange rate based on the model provided here requires a stable distinct profile of participation rates of migrants. Future research in this area could investigate the stability of immigrants and emigrants' goods market participation rates. For example it is possible that a change to the ethnic composition of migrants may result in changes to the average participation rates. The model presented, here, could be extended to accommodate such changes, however it is beyond the scope of this paper. The model does not include a policy variable that explicitly enables the study of an anticipated change in immigration. Further developments of the model could include such a variable.

References

AGIOMIRGIANAKIS, G. AND A. ZERVOYIANNI, “Economic growth, international labour mobility, and unanticipated non-monetary shocks”, *Journal of Policy Modeling,* Vol.23, No.1, (2001), 1-16

BLOUGH, S “The Relationship Between Power and Level for Generic Unit Root Tests in Finite Samples”, *Journal of Applied Econometrics*, Vol.7, No.3 (1992) 295-308

CHAUDHURI, K. “Cointegration, error correction and Granger causality: an application with Latin American stock markets”, *Applied Economics Letters*, 4, (1997), 469-471

ENGEL, C. AND K. WEST “Exchange rate and Fundamentals”, *Finance and Macroeconomics,* The Federal Reserve Bank of San Francisco (2003) <http://www.frbsf.org>

ENGLE, R AND C GRANGER, “Co-integration and error-correction: representation, estimation and testing”, *Econometrica* Vol.55, No.2 (1987), 251-276.

GRANGER, C. “Investigating causal relationships by Econometric models and cross-spectral methods”, *Econometrica* Vol.37, No.3 (1969), 424-438

HERCOWITZ, Z AND E. YASHIV “A Macroeconomic Experiment in Mass Immigration”, *IZA discussion paper,* No.475 (2002)

MANKIW, G, “Macroeconomics” 5th edition New York: Worth (2002)

MEESE, R. AND K. ROGOFF “The out of sample failure of Empirical Exchange rate models: Sampling error or misspecification?” *Exchange rates and international Macroeconomics* University of Chicago Press (1983),67-105

NEW ZEALAND IMMIGRATION SERVICE, “New Skills category to drive immigration programme” *Media Statement* 1 July (2003) <http://www.immigration.govt.nz>

NEW ZEALAND IMMIGRATION SERVICE, “Skilled Immigration Policy Announcement” (2003) <http://www.immigration.govt.nz/>

PHILLIPS, P.C.P AND OULIARIS, "Asymptotic Properties of Residual Based Tests for Cointegration", *Econometrica*, Vol.58, No.1 (1990), 165-93.

POPULATION AND SUSTAINABLE DEVELOPMENT 2003, Government report (2003)

RESERVE BANK, “Reserve Bank of New Zealand reweights TWI” (2002) <http://www.rbnz.govt.nz/news/2002/0128594.html>

RESERVE BANK, Monetary Policy Statement March (2003) <http://www.rbnz.govt.nz>

RESERVE BANK, Monetary Policy Statement September (2003) <http://www.rbnz.govt.nz>

STATISTICS NEW ZEALAND, “Quick facts, Exports and Imports” (2000) <http://www.stats.govt.nz >

STOCK, J AND M WATSON, “A simple estimator of cointegrating vectors in higher order integrated systems”, *Econometrica*, Vol.61, No.4 (1993), 783-820.

WINKELMANN, L. AND R. WINKELMANN “The Labour Market Outcomes of New Zealand’s Old and New Immigrants”, *Department of Labour Discussion paper 9806* (1998).