RESERVE BANK
OF NEW ZEALAND

DP2007/12

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September 2007

JEL classification: E50, J61, R21, R23

www.rbnz.govt.nz/research/discusspapers/

Discussion Paper Series

ISSN 1177-7567

DP2007/12

Housing Markets and Migration in New Zealand, 1962-2006*

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Abstract

This paper uses a structural vector autoregression model to analyse the relationship between migration flows, housing construction and house prices in New Zealand. It shows that a net immigration flow equal to one percent of the population is associated with an approximately 10 percent increase in house prices. This size of this relationship, which has existed since the 1960s, is an order of magnitude larger than would be expected from the average change in the population and house prices in the long term. One explanation is that migration flows occur at times when locals are changing their demand for housing because of revised expectations about future income growth. A second explanation is that migrant flows have a destabilising effect on agents expectations about the fundamental value of houses. While the paper cannot satisfactorily distinguish between these two options, the results suggest that monetary policy can still be used to dampen the house price changes that occur at times when migration flows are unusually large.

* The views expressed in this paper are those of the author(s) and do not necessarily reflect the views of the Reserve Bank of New Zealand. The authors thank Phil Briggs, the Reserve Bank Knowledge Centre staff (especially Kieran McCloat, Judith Maxim, and Liz Castle) and staff at Statistics New Zealand, particularly John Gudgeon, for help assembling the data used in this paper. We also thank Andrew Aitken, Aaron Drew, David Hargreaves, Ozer Karagedikli, Dave Maré, and Christie Smith for helpful comments and suggestions.

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ISSN 1177-7567

1 Introduction

For most of the last half century, there has been a close relationship between international migrant flows and the New Zealand housing market. During this period, waves of net immigration have been associated with increasing real house prices and rising construction activity; conversely, waves of net emigration have been associated with declining real house prices and falling construction activity. A classic cycle occurred in the 1970s. In the two years to 1974, 124,000 immigrants arrived in New Zealand and real house prices increased by 40 percent. The Kirk government passed legislation restricting British migration in response, but their measure was badly timed for within two years the influx had turned into a large outflow. In the five years to March 1981 350,000 people left New Zealand, real house prices declined by 30 percent, and the government passed legislation to support the housing market.[1]

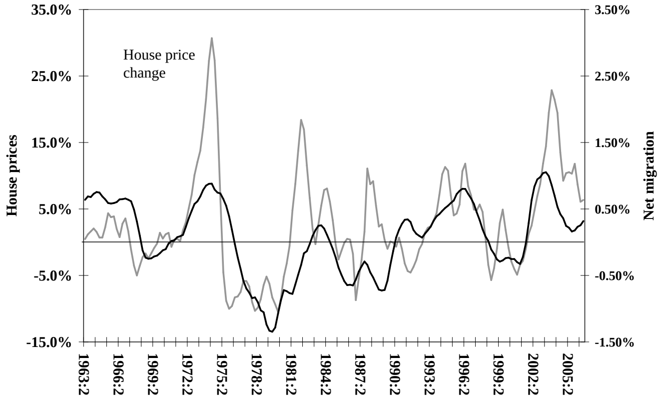
It is not surprising that there is a positive relationship between migration and housing activity, since incoming migrants need houses and out-going migrants vacate them. What is surprising is the strength of the relationship in New Zealand. Figure 1 shows how migration and house price changes varied over the period 1962-2006. The simple correlation coefficient between annual net migration flows and annual house price changes is 0.55, with a slope of 7.8, meaning that a net migration flow equal to one percent of the population is typically associated with a 7.8 percent change in real house prices. More sophisticated estimates presented below show that migration flows are associated with an even larger effect on house prices after three years.

There are at least two reasons for thinking these estimates are large. First, real house prices have only increased by 2.5 percent per year since 1962, while the population has increased by 1.1 percent per year. Thus a 1 percent increase in population has only been associated with a 1.4 percent increase in house prices in the long run, not 7.8 percent.[2] Second, evidence from migration to the United States suggests the effect of migration flows on house prices is also in the order of 1-2 percent.

[1] Net immigration was 45,000 in the two years to March 1974; net emigration was 145,000 in the five years to March 1981.

[2] If a 1 percent increase in population were associated with a 7.8 percent increase in real house prices, house prices would have increased by a factor of 44, not 3, between 1962 and 2006.

Figure 1
Annual change in house prices and annual migrant flows



The best United States evidence comes from episodes where migrants went to a city for reasons unrelated to the strength of the host city economy. One of the best known of these is the 1980 Mariel boat lift, when 125,000 people decamped from Cuba and went to Miami. The Miami population increased by approximately seven percent overnight. Saiz (2003a, 2006) examined how house prices and rents changed in response to this influx, and showed that after three years rents and house prices only increased by eight percent more than they did in similar cities around the country. He concluded that "an immigration inflow amounting to 1 percent of the city's population is associated with increases in housing values and rents of about 1 percent." (Saiz 2003a p20).

It is possible that Miami's experience is not typical. However, Saiz (2003b) estimated a similar sized effect when he conducted a broader examination of the effect of inward foreign migration on United States cities in the 1970s, 1980s, and 1990s. To identify migrations that were exogenous to the state of a city's economy, he used the fact that foreign migrants of a particular nationality tend to migrate to locations where people of that nationality already live, rather than to random locations. Thus an increase in migration from a particular foreign country generates a migration impulse that has little to do with the current state of the destination city's economy. He found the overall effect of an immigration inflow of 1 percent of the initial population raises rents and prices by 0.8-1.6 percent. This effect is also substantially smaller than the crude estimate of 7.8 percent for New Zealand noted above.

There are three main explanations why migration flows might be associated with a much larger effect on house prices in the short and medium terms than in the long term. First, there may be a genuine housing shortage in the short term as the construction sector takes time to build suitable accommodation. This is more likely to be the case if migrants are wealthier than the host population, because then they purchase high quality properties that are in inelastic supply or take a long time to build.[3] Second, the statistical relationship might be biased because of an omitted factor that is simultaneously affecting both house prices and migration. An obvious choice is income expectations: when incomes are expected to increase, it is plausible that house prices will increase and net immigration will be high. If so, the slope coefficient in the simple regression between house prices and immigration will not be causal. Rather, net migration will be a type of indicator variable, signalling when times are good or bad, and thus whether house prices can be expected to rise or fall. Third, migration inflows might have a destabilising effect on agents' expectations about the fundamental value of houses. A temporary increase in house prices stemming from an inflow of migrants may cause local buyers and sellers to have overly optimistic beliefs about the appropriate value of houses, for instance, leading to a prolonged period of high prices.

This paper uses a structural vector autoregression model to examine the relationship between foreign migration flows and the housing market in New Zealand. The model includes a measure of housing construction to incorporate possible delays between the arrival or departure of migrants and an appropriate adjustment to the size of the housing stock, and a measure of economic activity to allow for possible simultaneity between migration flows, house price changes, and income expectations. Separate models are used for the 1962-1982 and 1991-2006 periods to incorporate differences in monetary policy arrangements in these two periods. In general, the models have attractive properties. Nonetheless, the estimated relationship between migration flows and house price movements remains extremely large, larger in fact than the 7.8 percent estimated from the simple correlation, and much larger than

[3] Migrants to the United States are typically poorer than the host population, and are probably renting or purchasing lower quality housing. This is not the case in New Zealand. It is noteworthy that house prices in Vancouver and Toronto (but not other Canadian cities) increased rapidly after large scale migration from Hong Kong occurred (see Ley and Tutchener, 2001).

the long run relationship between population growth and real house price increase.

The paper begins by outlining a simple economic framework that describes the relationship between population size, house prices and construction. In section 3 the structural vector autoregression models are described, and the results are presented. The results are discussed in section 4 and conclusions are offered. Lastly, an alternative specification of the vector autoregression is presented in appendix A, while appendix B provides many additional details about the construction and housing markets in New Zealand.

2 A conceptual framework

The most perplexing question that arises in this paper is why the relationship between migration flows and house price changes is so large. The following framework is designed to explore three possible reasons why migration flows might be associated with large changes in house prices. The main focus of the framework is the way that housing markets adjust when houses differ in terms of their quality. The framework is more elaborate than the empirical models estimated in section 3, as we do not have the appropriate data to estimate models that have different housing quality levels. Nonetheless, in appendix B, we show that there have been changes in the quality of the housing stock since 1990 that are consistent with the adjustment mechanisms implicit in this framework.

The framework assumes that households demand a single house in which to live, and that the quality of this house can be represented by an ordinal vector θ. At least one dimension of this vector reflects house size or some other aspect of housing quality that can be altered through construction.[4]

Let

[4] In practice, there are at least two important dimensions to housing quality: size and location. The focus of this framework is house size, which can be modified through construction. Demand shocks should not have a long term effect on this component of house quality as ultimately the price of a building will reflect construction costs. If location is incorporated into the framework, demand factors will have permanent effects on property prices, as the supply of land is inelastic.

$N_t(\theta)$	$=$	the quantity of housing of quality θ;
$P_t(\theta)$	$=$	the real price schedule of housing units of quality θ at time t (real prices are defined by deflating by the price of consumption goods, P_t^c);
$P_{t+1}^e(\theta)$	$=$	the real price schedule of housing units of quality θ expected to prevail at time $t+1$;
Y_t^i	$=$	the real income of person i at time t;
$\mathbf{Y_t^i}$	$=$	$\{Y_t^i, Y_{t+1}^{e,i}, Y_{t+2}^{e,i}, \ldots\}$ = the expected real income stream of person i at time t;
$\mathbf{Y_t^e}$	$=$	$\{\mathbf{Y_t^1}, \mathbf{Y_t^2}, \ldots, \mathbf{Y_t^{M_t}}\}$ = expected real income distribution of the M_t households at time t;
W_t^i	$=$	the real wealth of person i at time t;
$\mathbf{W_t^i}$	$=$	$\{W_t^i, W_{t+1}^{e,i}, W_{t+2}^{e,i}, \ldots\}$ = the expected real wealth stream of person i at time t;
$\mathbf{W_t^e}$	$=$	$\{\mathbf{W_t^1}, \mathbf{W_t^2}, \ldots, \mathbf{W_t^{M_t}}\}$ = expected real wealth distribution of the M_t households at time t; and
r_t	$=$	real interest rate at time t.

Housing demand

For the purposes of tractability, we shall assume that households' demand for housing depends on interest rates and the current and expected future prices of housing rather than rents.[5] Consider a world without search costs where information about current house prices is freely available. Given income, wealth, interest rates, and the current and expected future price schedule, a household will consider all of the possible quality-price combinations $(\theta, P(\theta))$ and demand a property of quality $\theta = \theta^*(\mathbf{Y_t^i}, \mathbf{W_t^i}, r_t, P_t(\theta), P_{t+1}^e(\theta))$ that

[5] In general, an individual's demand for housing is responsive to either the rental cost of housing $R_t(\theta)$ or the price of housing $P_t(\theta)$. The assumption that we can ignore rents will not be problematic if speculative demand by property investors means that the expected return to rental property is equal to the nominal interest rate plus a constant risk premium, for then the rent schedule will be determined by interest rates and prices as follows:

$$\frac{R_t(\theta) + P_{t+1}^e(\theta)}{P_t(\theta)} = 1 + r_t + risk\ premium$$

maximises its utility.[6] It is assumed that as a household's income or wealth increases, or as interest rates decline, they will demand a better quality house for a given set of prices, that is $\theta^*(.)$ is a non-decreasing function of income and wealth and a non-increasing function of interest rates. Let $I(\theta, \theta_1)$ be an indicator function with value 1 at $\theta = \theta_1$ and value 0 elsewhere. Then the total demand for property is the sum of all individual demands,

$$D(\theta|\mathbf{Y_t}, \mathbf{W_t}, r_t, P_t(\theta), P^e_{t+1}(\theta)) = \sum_{i=1}^{M_t} I(\theta, \theta^*(\mathbf{Y^i_t}, \mathbf{W^i_t}, r_t, P_t(\theta), P^e_{t+1}(\theta))) \quad (1)$$

Housing supply

The stock of housing $N_t(\theta)$ will change through housing investment. In the following framework, people adjust the quality profile of the housing stock by building or altering houses whenever it is profitable to do so. Because there is limited capacity in the construction industry, the cost of construction is an increasing function of the amount of construction work put in place. Consequently, new construction will be expensive when the demand to build is high relative to construction capacity, endogenously reducing the number of projects that are profitable at any particular time.

Suppose it takes $\gamma(\theta_1, \theta_2)$ building resources to convert a house from quality θ_1 to θ_2, $\theta_2 > \theta_1$. If $\theta_1 = 0$, the house is new. If a set of J_t conversions, $\Gamma_t = \{(\theta^1_1, \theta^1_2), (\theta^2_1, \theta^2_2), \ldots, (\theta^{J_t}_1, \theta^{J_t}_2)\}$ are made at time t, the total quantity of building put in place at time t is

$$Q^B_t = \sum_{j=1}^{j=J_t} \gamma(\theta^j_1, \theta^j_2) \quad (2)$$

Suppose the marginal per unit cost of supplying construction services can be described by a cost function P^B_t that depends on the aggregate building

[6] Given the assumption that each household only chooses one house, the demand curve for a house of quality θ' will be the vertical line $Q = 0$ for prices above some critical value P' and the vertical line $Q = 1$ for prices below this level. P' will depend on all other prices and may conceivably be zero. It is possible that a household may be indifferent between several different houses for a given set of prices and other conditioning variables. To avoid issues of indeterminancy, the function $\theta^*(.)$ can be made unique by assuming that the household chooses the maximum quality house whenever it is indifferent between two or more quality-price options.

work put in place and a measure of building capacity in the industry χ_t:

$$P_t^B = P(Q_t^B, \chi_t) \tag{3}$$

where P_t^B is increasing in production and decreasing in capacity. Assuming that it takes one period to finish a building project, a project (θ_1, θ_2) is expected to be profitable if

$$\gamma(\theta_1, \theta_2) P(Q_t^B, \chi_t) \leq \frac{1}{1 + r_t} P_{t+1}^e(\theta_2) - P_t(\theta_1) \tag{4}$$

A non-rationing building equilibrium will be a set of projects Γ_t in which each project is profitable, and each possible project outside this set is unprofitable. In turn, the quality profile of the housing stock in period $t + 1$ will be

$$N_{t+1}(\theta) = N_t(\theta) + \sum_{j=1}^{j=J_t} I(\theta, \theta_2^j) - I(\theta, \theta_1^j) \tag{5}$$

Note that an alteration simultaneously reduces the number of low quality houses and increases the number of high quality houses.

Housing market equilibrium

The way that house prices and housing supply respond to an economic shock depends on the way that price expectations are formed. There are two main theories of expectation formation: rational expectations, and adaptive expectations.[7]

Rational expectations

When price expectations are formed rationally, agents take the future income and wealth distribution and the response of the construction sector into account when forming their expectations about future house prices. In this world, the price schedule adjusts to a level $P_t^*(\theta)$ that equates the demand for housing (equation 1) to the supply:

$$D(\theta | \mathbf{Y_t}, \mathbf{W_t}, r_t, P_t^*(\theta), P_{t+1}^e(\theta)) = N_t(\theta) \tag{6}$$

[7] We are ignoring learning models here.

This price schedule can be expressed as a function

$$P_t^*(\theta) = P^*(\mathbf{Y_t}, \mathbf{W_t}, r_t, P_{t+1}^e(\theta), N_t(\theta)). \tag{7}$$

Because the individual demand functions are assumed to be non-decreasing in income and wealth and non-increasing in real interest rates, an increase in real incomes or a decrease in long term real interest rates will lead to an immediate increase in property prices, as agents compete to purchase better quality property but the supply of property $N_t(\theta)$ is fixed. Some of this price increase will be temporary, because the price schedule $P_t^*(\theta)$ will decline to a new equilibrium level through time as new and higher quality properties are constructed. It will be above its long term equilibrium level for as long as the construction boom lasts and new houses can be profitably built. If the rise in demand is sufficiently small, the desired improvement in the quality of the housing stock will take place within a period and the schedule of house prices will reach its long term level by $t+1$. If the rise in demand is large, capacity constraints in the construction sector mean that only a fraction of the demand for new or improved houses will be met immediately, and construction costs and house prices will rise. Thus a sudden increase in demand can temporarily cause house prices to rise above their long term levels, because of the difficulty of rapidly altering the quality profile of the housing stock.[8]

Equation 7 indicates two of the inherent difficulties of analyzing the relationship between house prices and migration. First, while a migration flow has an immediate and direct effect on house prices by altering the size of the population and its income and wealth distribution ($\mathbf{Y_t}$, $\mathbf{W_t}$), there may also be an indirect effect through the effect on expected future prices. Expected future prices will not only depend on how quickly the stock of housing changes in response to the current migration flow, but on how long the migration flow is expected to last. If shocks to migration flows have positive serial correlation, so that any excess demand for housing can be expected to last for many quarters, there will be a larger immediate response to house prices than if the shock is temporary.

[8] There is a natural parallel here with the manner that spot and futures prices are related in commodity markets. When the long run supply function of a commodity is price elastic, but there are capacity constraints that make the short run supply function inelastic, a sudden increase in demand for a commodity will cause prices to be in backwardation, ie the spot price will exceed the futures price. The extent to which prices will be in backwardation, and the length of time that situation is expected to remain, will depend on how quickly the supply can increase. See Wright and Williams (1989).

Second, any attempt to estimate the relationship between migration and house prices using equation (6) directly will be beset by the difficulty of including expectations about future house prices and incomes in the equation. If these variables are not included in the conditioning set, and if migration flows are also a function of these variables, the relationship between migration and housing will be upwardly biased because migration flows will be a proxy for the omitted variables. Since it is highly likely that migration flows are responsive to expectations about income growth, this problem will be a major difficulty unless a means of identifying migration flows that are exogenous to income expectations is found. Put differently, if migrant inflows are occurring when local residents expectations about their future incomes are rising, a simple regression of house price changes against migration flows will attribute most of the rising demand for property to the migrant inflows when in fact much will be due to an increase in the demand for better quality properties by local residents.

Adaptive expectations

Expectations do not need to be formed rationally. Indeed, unless a problem is reasonably easy to formulate and solve, the cost of making a well informed prediction about the future path of prices will be excessive for most agents.[9] These difficulties are likely to be more pronounced when the commodity in question has many different quality levels, for then it is difficult for agents to distinguish between factors that affect the price of a particular quality level and those that that affect the price of all quality levels. In these circumstances expectations are likely to be formed by extrapolating trends from the past. In general, when expectations are formed adaptively, prices and transactions volumes can diverge from a fundamental or equilibrium value for an extended period of time after a shock occurs (Ezekiel, 1938). If expectations about real estate prices are formed adaptively, a temporary migration shock can have a long term effect on the real estate market by creating a false impression among local sellers and buyers about the value of their property.

[9] If the market is dominated by professional agents who have rational expectations, it will not matter that ordinary agents do not have rational expectations, because they will not be the marginal actors. However, professional speculators are likely to be a minority in the residential property market, partly because the number of ordinary people active in the market is large, and partly because the market does not have a full set of financial instruments enabling speculation. In particular, short selling is difficult in real estate markets, so that speculators cannot take a position that house prices will fall when they are perceived to be over-valued.

There are now a variety of models of real estate markets that examine how the process of search and expectations formation affect the path of real estate prices and real estate transactions volumes (eg Wheaton 1990; Stein 1995; Berkovec and Goodman 1996; Krainer 2001). Berkovec and Goodman is somewhat typical. In their model, a fraction of local people decide to place their property on the market, with a reservation price that depends partly on the volume and price of recent sales activity. Some of these people will purchase a different house in the market; others will move away. At the same time, a variety of agents look to purchase a house that meets their particular requirements. Some of these agents will be local, who have just sold or who are in the process of selling a house; others are migrants into the region. Their willingness to purchase a particular house will depend on the suitability of the house, their particular financial circumstances, and their expectations about average house prices. In equilibrium, there will be a stable pattern of transactions volumes and prices. However, a demand shock can destabilise these equilibrium patterns. An influx of migrants into the market, for example, would lead to an increase in sales, a decline in the average time a property is on the market, a shortage of listed properties, and an increase in prices. Even if price expectations were rational, the shortage of listings and the rapid speed of sales would generate upward pressure on prices for some time after the initial shock, for it would take a while for sufficient new properties to be listed on the market to clear the backlog. However, if price expectations were formed adaptively, a temporary shock could generate a long lasting increase in prices, by causing the reservation prices of sellers and the price expectations of buyers to be revised upwards. This process is quite natural: a prospective seller notices houses in the neighbourhood sold for $50,000 more than expected, and increases the listing price accordingly.[10] Most home purchasers are also sellers, and can afford to pay the higher price as their own property has increased in price. In these circumstances, the market could "run hot" for some time before prices returned to long term equilibrium levels (Novy-Marx 2005).

Some aspects of these costly search models have received empirical confirmation. In particular, it is well documented that sales volume and real estate

[10] The New Zealand housing market may be particularly prone to adaptive expectations, because home-owners recurrently receive a ratings valuation from their local council. Revisions to these valuations are based in part on the prices achieved in recent sales in the immediate neighbourhood.

prices are related in most markets, including New Zealand.[11] These relationships should not exist in models with frictionless trading. In New Zealand the correlation between sales volume and price changes is particularly pronounced. Since 1991, the simple correlation between quarterly house price changes and the volume of real estate transactions is 0.86. Moreover, because sales volumes is highly correlated with the lag of immigration flows (but not emigration flows), there is prima facie evidence that immigration flows could have an exaggerated effect on prices through a costly search mechanism.[12]

3 An empirical model of housing

In the absence of a well identified exogenous shock to migration, there are three major problems in estimating the effect of migration on the housing market: exogeneity, timing, and feedback loops. The first concerns the problem of trying to identify the separate effect of migration flows from the effect of other factors, such as the unemployment rate, that may affect both migration flows and house prices. One needs to include a variety of conditioning variables in a regression, and have a means of identifying a shock to migration which is unrelated to changes in other variables. The second concerns the length of time that it may take for migration to affect house prices. It is not clear whether the effect should be immediate and occur in the same quarter that migrants arrive, or whether it is gradual as migrants take some time to purchase or sell a house. The third concerns the way that the supply of housing ultimately responds to changes in migration. If construction activity quickly responds to changes in the migration flow, any immediate price effect may be subsequently offset by an increase in the supply of housing.

The estimation strategy used in this paper is to model the migration and housing relationships using structural vector autoregressions. By estimating a set of equations that include a variety of variables and lags, the chance of omitting important factors that jointly affect housing and migration activity, or excluding important lagged relationships, is reduced. The variables included in the vector autoregression are net permanent migration flows, real house prices, housing starts, the unemployment rate, and the average

[11] See Clayton, Miller and Peng (2007) for a review of international evidence; and Grimes, Aitken, and Kerr (2004) for some New Zealand evidence.

[12] The basic relationships between sales volumes, prices, and migration are discussed in Appendix B.

mortgage interest rate.

3.1 Data

Data are available for the period 1962-2006, but separate regressions are estimated over two sub-periods 1962-1982 and 1991-2006. The data for the whole of our sample are shown in figure 2. The first two panes of figure 2 depict net migration per 1000 people of the existing population and the number of housing starts per 1000 people of the existing population.[13] Neither series show a strong trend, although the housing starts series has a significant decline in the mean starting in the late 1970s. The real house price index, constructed by deflating the nominal house price index with the consumer price index (CPI), is depicted in the first pane of the second row of figure 2. It clearly has a trend. The average first mortgage interest rate and unemployment series show a large increase during the 1980s followed by a sharp decline during the 1990s.[14] The unemployment rate is used to control for income changes, as a consistent series is available for both periods. To check on the robustness of these results, real GDP and the employment rate were used in a separate model of the 1991-2006 period. The results for GDP are presented in appendix A; those for the employment rate were similar. Additional information about the historical evolution of the housing market in New Zealand is provided in appendix B.

Unit root tests

Before these series are used to estimate the parameters of our structural vector autoregression (SVAR), their orders of integration must be determined. To do this we use a number of unit root tests: the test of Elliot, Rothenberg, and Stock (1996) (ERS); and, if necessary, the test of Lanne, Lütkepohl, and Saikkonen (2003) (LLS) that tests for a unit root with an unknown structural break. Each test is based on the unit root test of Dickey and Fuller (1979).

Results from the unit root tests are reported in table 1. The results in the column titled ERS are the results from the Elliot et al (1996) variant of the

[13] The first series is (permanent and long term arrivals minus permanent and long term departures) divided by estimated beginning-period population. The second series is the number of building permits issued in urban areas per quarter.

[14] The unemployment rate is the Household Labour Force Survey rate. For data prior to 1985, when the survey began, a standard backdated series compiled by the NZIER was used.

Figure 2
Data used in SVAR

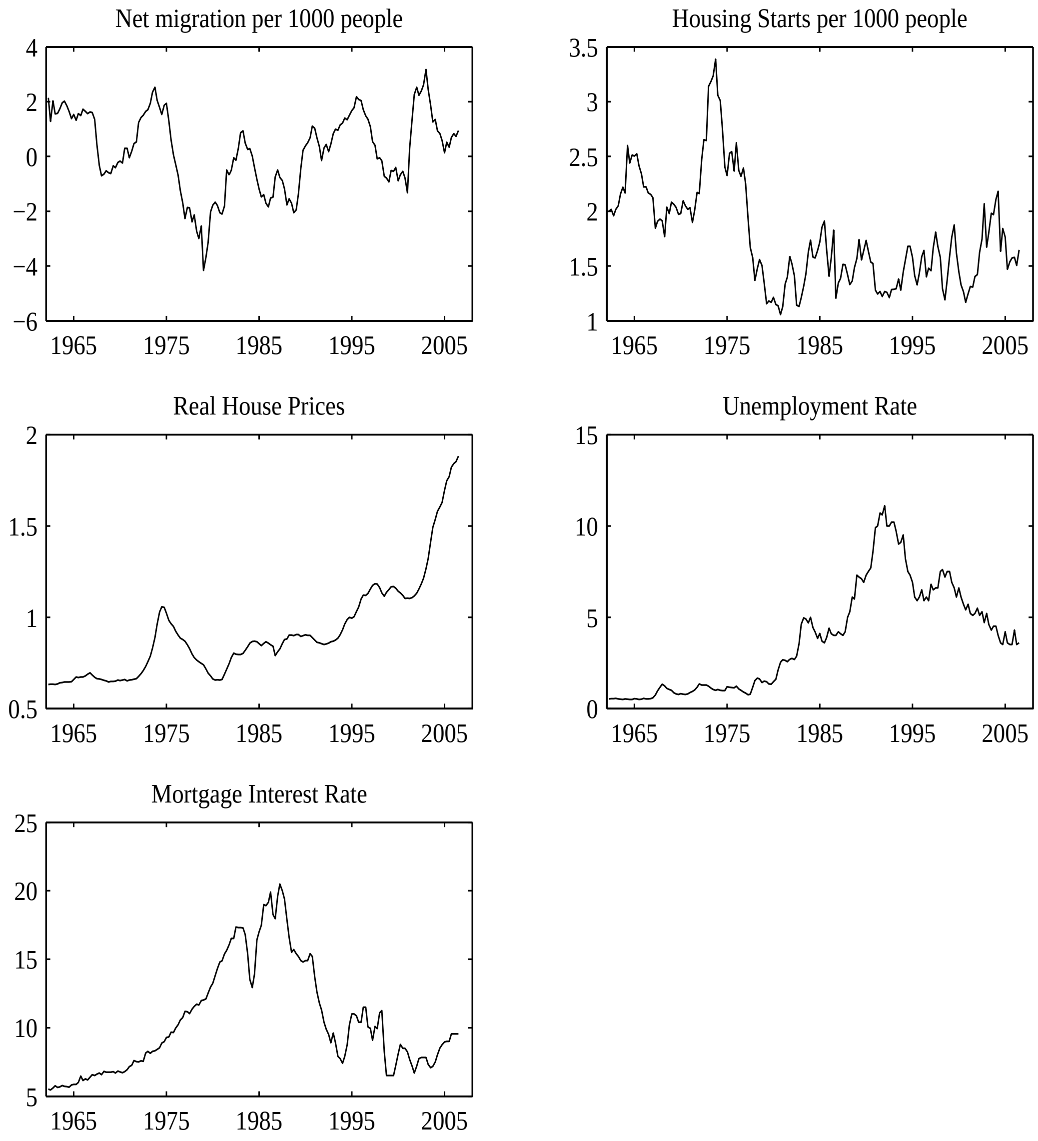


Table 1
Unit root test results

Variable	ERS	ERS(I)	ERS(II)	LLS	LLS(I)	LLS(II)
Net migration[1]	-2.72‡	–	–	-3.53‡	–	–
Housing starts[1]	-2.06‡	–	–	-2.86*	–	–
Real house prices[2]	-2.37	–	–	-1.97	–	–
Unemployment[1]	-0.70	3.88	-0.74	-1.55	2.60	-2.31
Interest rate[1]	-0.88	6.42	-1.17	-1.76	3.58	-3.07†

Notes: * significant at 10% level, † 5% level, ‡1% level, [1] constant only, [2] constant + trend included

augmented Dickey-Fuller (ADF) test for the full sample while the results in column LLS are the results for the Lanne et al (2003) version of the ADF test with a level shift at an unknown date. For the case of net migration the unit root regression was run with only a constant in the deterministic part of the regression. The results for both tests suggest that net migration is an I(0) process. Similarly, both tests suggest that the housing starts series is an I(0) process.

The results for real house prices are reported in the third row of table 1. As there is a significant trend in real house prices, we include both a constant and a linear time trend in the deterministic part of the model. Neither the GLS nor the LLS test reject the null hypothesis that the real house price series is an I(1) process. As such we include real house prices in our vector autoregressions in first differences.

The last two series are less clear cut. The interest rate series and the unemployment rate series both have a significant positive trend until the early 1990s, followed by a significant negative trend. However, it does not make sense to include a time trend in the regression for either series as it is not plausible that either time series will grow at a constant rate on average. Both interest rates and the unemployment rate are bounded series, precluding the possibility of a time trend. More problematically, the behaviour of these two series might be quite different before and after the major structural reforms of the 1980s. In particular, the Reserve Bank substantially altered its conduct of monetary policy after 1985.

As such, we decided to test for a unit root in the two sub-samples of the unemployment and interest rate series. In both cases we only include a constant in the deterministic part of the regression. The results for the unemployment rate can be found in the fourth row of table 1. We find that neither test can reject the null that unemployment is an I(1) process for the whole sample nor for the two sub-samples of 1962Q2 to 1982Q4 (sub-sample I) and 1991Q1 to 2006Q3 (sub-sample II). Therefore we conclude that unemployment is an I(1) process so that the unemployment rate enters the models in first differences.

The results for the mortgage interest rate series are found in the last row of table 1. Again we report results for both tests for the full sample and for both sub-samples. The results here suggest that interest rate are an I(1) series during the first sub-sample but an I(0) process during the second sub-sample. The LLS test statistic rejects the null at the 5 percent level for the second sub-period but the ERS does not. As a further check the ordinary ADF test rejects the null that the interest rate series is I(1) in the second subperiod at the 1 percent level while the test by Kwiatkowski, Phillips, Schmidt, and Shin (1992) suggests that the hypothesis that the interest rate series is I(0) cannot be rejected at the 10 percent level. Therefore we conclude that the interest rate series is an I(1) process before 1983 and an I(0) process after 1991.

3.2 Structural vector autoregression models of New Zealand house prices

In this section we construct a structural vector autoregression model of the aggregate New Zealand housing market in order to identify a number of structural shocks hitting this market and thus isolate the impact of an immigration shock on the housing market. To identify different structural shocks we employ the A-B model of Amisano and Giannini (1997). In particular we use short-run restrictions to identify five orthonormal structural shocks, of which one is a shock to net-migration.[15]

The general A-B SVAR model of Amisano and Giannini (1997) is

$$Ay_t = \mu' D_t + \sum_{j=1}^{p} \Pi_j y_{t-j} + Bu_t, \tag{8}$$

[15] The reason we can only identify five structural shocks is because the VAR we utilize is of order 5. This is obviously a simplifying assumption as there could, in reality, be many more than five structural shocks affecting the five time series in our VAR but the structural VAR methodology employed here does not allow for this possibility. See Sims (1982) for a discussion of this issue.

where u_t is a vector of structural shocks such that $E(u_t u_t') = I_k$. The reduced form version of this model is

$$y_t = c' D_t + \sum_{j=1}^{p} C_j y_{t-j} + \epsilon_t, \tag{9}$$

where ϵ_t is a vector of reduced form shocks such that $E(\epsilon_t \epsilon_t') = \Sigma$, and $\Sigma = A^{-1} B B' (A^{-1})'$. The relationship between the reduced form errors (ϵ_t) and the structural errors (u_t) is therefore

$$A\epsilon_t = Bu_t, \tag{10}$$

where it is assumed that $det(A) \neq 0$.

Consistent estimates of the parameters of (9) are obtained by estimating each equation in (9) by ordinary least squares.[16] Once obtained, consistent estimates of the structural parameters in (8) can be obtained using the scoring algorithm described in Amisano and Giannini (1997) by imposing suitable restrictions on the parameters that make up matrices A and B.

In the sections that follow we describe the particular identifying restrictions used in our model. We believe that we need to impose different identifying restrictions for the periods before and after the major economic reforms that took place in New Zealand during the 1980s. With this in mind we estimate and analyze separate structural VAR models from the second quarter of 1962 to that last quarter of 1982 (1962Q2–1982Q4) and from the first quarter of 1991 to the third quarter of 2006 (1991Q1–2006Q3). The conduct of monetary policy was quite different in these two periods. In the first period there was a fixed exchange rate, the Reserve Bank imposed restrictions on the quantity of funds the banking sector could lend, and the interest rate was set reactively to adjust the demand and supply for loans. In the second period there was a flexible exchange rate, the Reserve Bank imposed few quantitative lending restrictions, and it proactively changed interest rates to target the inflation rate. These differences, particularly the assumption about the proactivity of interest rate changes, lead to quite different identifying assumptions that are outlined in the following two sub-sections.

3.3 An SVAR for the 1991Q1–2006Q3 period

The five variables used in the model are (i) net-migration per 1000 members of the population (NETMIG), (ii) the number of housing starts per 1000

[16] These estimators are equivalent to the conditional maximum likelihood estimator of (9).

members of the population (HSTARTS), (iii) the natural logarithm of real house prices (RHPRICE), (iv) the unemployment rate (UNEMP), and (v) the mortgage interest rate (INT). Given that NETMIG, HSTARTS, and INT were I(0) processes while RHPRICE, and UNEMP were I(1) processes, the data vector, y_t, is

$$y_t = \begin{pmatrix} NETMIG_t \\ HSTARTS_t \\ \Delta RHPRICE_t \\ \Delta UNEMP_t \\ INT_t \end{pmatrix}. \tag{11}$$

Identifying restrictions

Net migration
We assume that the net-migration series is directly affected by the residual to unemployment and by the first structural shock, which we interpret as the net-migration shock. Furthermore, we assume that the residual to the housing starts equation, the house price equation and the interest rate equation do not directly affect net-migration.[17] Consequently, the relationship between the residual to the net-migration equation and the other residuals and structural shocks is given by:

$$\epsilon_{1t} = -a_{14}\epsilon_{4t} + b_{11}u_{1t}. \tag{12a}$$

Housing starts
We assume the residual to the housing starts equation is affected directly by the residual to real house prices, the residual to unemployment and the residual to the interest rate. This is summarized as

$$\epsilon_{2t} = -a_{23}\epsilon_{3t} - a_{24}\epsilon_{4t} - a_{25}\epsilon_{5t} + b_{22}u_{2t}, \tag{12b}$$

where u_{2t} is the structural shock directly affecting housing starts, which we shall later interpret as a housing supply shock. This identification is predicated on the idea that the decision to build a new house depends on current real house prices, the current interest rate and the rate of unemployment. The decision to include the unemployment residual in this equation is based on our desire to allow for general aggregate conditions to directly affect the

[17] As the contemporaneous impact matrix is given by $A^{-1}B$, the residuals to these variable can have a contemporaneous impact on net-migration but only through indirect channels.

decision to start building a new house. Clearly the unemployment residual should enter into this equation with a negative sign.[18]

Real house prices
We assume real house prices directly affect housing starts, but housing starts only affect prices with a lag. Consequently, only net-migration, unemployment and the interest rate are allowed to directly affect the residual to real house prices:

$$\epsilon_{3t} = -a_{31}\epsilon_{1t} - a_{34}\epsilon_{4t} - a_{35}\epsilon_{5t} + b_{33}u_{3t}, \tag{12c}$$

where the structural shock, u_3 will be interpreted as a housing demand shock.

Unemployment
We assume that the unemployment residual is directly affected by the residual to net-migration, the residual to housing starts, and the residual to interest rates:

$$\epsilon_{4t} = -a_{41}\epsilon_{1t} - a_{42}\epsilon_{2t} - a_{45}\epsilon_{5t} + b_{44}u_{4t}. \tag{12d}$$

Interest rates
This equation is the key component of the identification strategy. We assume the interest rate residual is only negligibly affected by contemporaneous shocks to the other variables and can be represented as:

$$\epsilon_{5t} = b_{55}u_{5t}. \tag{12e}$$

The underlying assumption is that the Reserve Bank is forward looking and only alters interest rates in response to information that changes its forecasts about the future inflation rate. Consequently, interest rates only respond to information about contemporaneous activity levels to the extent that they affect their forecasts. The Bank typically does not respond immediately to isolated data releases; rather it responds when current information confirms a pattern evident from previous data releases. The Bank is unlikely to respond to an increase in migration inflows in a particular quarter, for instance, unless this change confirms earlier data that immigration is persistently higher

[18] Note that this identification restriction means that builders do not immediately respond to migration flows, except indirectly through the effect that migration flows have on aggregate economic conditions and house prices. (There is a non-zero element in the (2,1) element of the initial impact matrix, $A^{-1}B$). In keeping with this assumption, there is very little contemporaneous correlation between net migration and housing starts in the post 1990 data.

than previously expected and unless the migration flow is likely to exacerbate inflation pressure stemming from other sources. In addition, the Bank smooths interest rates, typically responding to information gradually and only when there is a weight of evidence in favour of one position or another. The reaction function is thus gradual, non-linear, and context dependent. In addition, there are specific reasons why we believe the Reserve Bank does not respond to contemporaneous information about GDP, unemployment, and house prices. First, publication lags mean that the bank is unable to respond to data about the contemporaneous value of GDP, for accurate data is only released with a delay of several months. Second, while information about the unemployment rate is released rapidly, it is a lagging indicator which is little used in forecasting. Third, the Bank, in common with other central banks, does not target asset prices and thus does not respond to changes in house prices.[19]

It is obviously possible to question aspects of this identification scheme. Nonetheless, as is discussed below, it passes two informal "eyeball" tests that would indicate if the scheme was clearly inconsistent with the data. First, the impulse response functions are sensible and in accordance with standard macroeconomic theory (see figure 3). For example, a shock that increases interest rates reduces housing starts and house prices but increases unemployment; a shock that increases the unemployment rate reduces inward migration and house prices and ultimately leads to a reduction in interest rates. Second, the reduced form covariance matrix is broadly consistent with the identification scheme (see table 3). For example, there is almost zero correlation between the innovation to the interest rate equation and the innovations to the unemployment, housing starts and migration equations; and the correlation between the innovation to the interest rate and house price equations is negative, as would be expected if house prices responded to negatively to interest rates (as assumed in equation 12c) but interest rates did not respond to house prices (equation 12e).

To summarise, the particular A and B matrices we use in (8) for the period

[19] Current standard practice is that central banks respond to asset prices only to the extent that they are expected to change the future inflation rate. There is little evidence that swings in asset prices have a major effect on the inflation rate.

from 1991Q1 to 2006Q3 are

$$A = \begin{bmatrix} 1 & 0 & 0 & a_{14} & 0 \\ 0 & 1 & a_{23} & a_{24} & a_{25} \\ a_{31} & 0 & 1 & a_{34} & a_{35} \\ a_{41} & a_{42} & 0 & 1 & a_{45} \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \tag{13a}$$

and

$$B = \begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 \\ 0 & 0 & 0 & 0 & b_{55} \end{bmatrix} \tag{13b}$$

respectively. This A-B model is exactly identified. With this identification we interpret the structural shocks as a shock to net-migration (u_1), a housing supply shock (u_2), a housing demand shock (u_3), an aggregate activity shock (u_4), and an interest rate shock (u_5) with all shocks being orthogonal to each other.

Results

The reduced form VAR given in (9) is estimated by OLS with three lags of the endogenous variables included in the model.[20] The estimates are reported in table 2. All of the equations except the interest rate equation contain a significant third lag of at least one variable.

The estimated residuals of the reduced form VAR are used to estimate the variance-covariance matrix (table 3). This matrix together with the short-run identifying restrictions described in section 3.3 are used to compute the A and B matrices that make up the structural form VAR given in (8) using the scoring algorithm described in Amisano and Giannini (1997). Once these estimates are obtained, structural impulse response functions are calculated in the usual way. That is, let

$$y_t = \epsilon_t + \Phi_1\epsilon_{t-1} + \Phi_2\epsilon_{t-2} + \dots \tag{14}$$

[20] A number of methods were used to determine the appropriate number of lags including various information criteria and sequential likelihood tests. The Schwarz and Hannan-Quinn information criteria both suggest a lag length of 1 while the Akaike information criteria suggests a lag length of 5. The sequential likelihood ratio test suggests a lag length of 3. We use a lag length of 3 as we believe that a lag length of 1 is too small to reflect the dynamics in the data while, given the small sample size, a lag length of 5 leaves far too few degrees of freedom.

Table 2
Estimates of reduced form VAR: 1991Q1-2006Q3

Equation	NM	HS	ΔP	ΔU	R
NM(-1)	1.044	-0.012	0.003	-0.044	-0.110
	[7.468]	[-0.273]	[1.006]	[-0.260]	[-0.480]
HS(-1)	0.577	0.254	-0.007	0.467	1.468
	[1.233]	[1.729]	[-0.708]	[0.830]	[1.914]
ΔP(-1)	4.211	-0.604	0.510	-8.781	1.899
	[0.673]	[-0.308]	[3.711]	[-1.168]	[0.185]
ΔU(-1)	0.025	0.040	-0.002	-0.354	-0.111
	[0.215]	[1.121]	[-0.728]	[-2.583]	[-0.591]
R(-1)	-0.043	-0.082	-0.007	-0.077	1.178
	[-0.457]	[-2.755]	[-3.401]	[-0.677]	[7.583]
NM(-2)	-0.119	-0.034	0.005	0.101	0.117
	[-0.580]	[-0.522]	[1.036]	[0.410]	[0.348]
HS(-2)	-0.524	-0.021	-0.028	0.061	-0.922
	[-1.067]	[-0.138]	[-2.627]	[0.103]	[-1.145]
ΔP(-2)	1.459	3.998	-0.012	-2.549	5.270
	[0.236]	[2.062]	[-0.092]	[-0.343]	[0.520]
ΔU(-2)	-0.113	0.033	-0.001	-0.212	-0.287
	[-0.969]	[0.897]	[-0.550]	[-1.504]	[-1.494]
R(-2)	0.280	0.003	0.003	-0.113	-0.295
	[1.938]	[0.061]	[1.045]	[-0.650]	[-1.246]
NM(-3)	-0.096	0.115	0.000	0.022	-0.130
	[-0.602]	[2.289]	[0.077]	[0.115]	[-0.496]
HS(-3)	-0.664	0.042	0.034	0.418	-0.109
	[-1.710]	[0.343]	[3.981]	[0.895]	[-0.172]
ΔP(-3)	-2.676	1.033	0.039	-0.324	3.558
	[-0.447]	[0.551]	[0.296]	[-0.045]	[0.363]
ΔU(-3)	-0.158	0.030	0.000	-0.267	-0.354
	[-1.374]	[0.835]	[0.107]	[-1.938]	[-1.885]
R(-3)	-0.238	0.009	0.001	0.286	0.084
	[-2.387]	[0.288]	[0.527]	[2.390]	[0.515]
constant	1.036	1.638	0.025	-2.438	-0.516
	[1.041]	[5.246]	[1.147]	[-2.037]	[-0.316]

Notes: The numbers in square braces are the t-values. NM ≡ Net migration, HS ≡ Housing Starts, P ≡ Real House Prices, U ≡ Unemployment, and R ≡ Mortgage Interest Rate.

Table 3
Estimates of reduced form covariance and correlation matrices: 1991Q1-2006Q3

Covariance					
*	NETMIG	HSTARTS	ΔHPRICE	ΔUNEMP	R
NETMIG	0.01448	-0.00435	0.00057	0.00779	-0.00683
HSTARTS	*	0.01423	0.00009	0.00173	-0.00110
ΔHPRICE	*	*	0.00007	-0.00058	-0.00236
ΔUNEMP	*	*	*	0.20930	0.00147
R	*	*	*	*	0.38956
Correlation					
*	NETMIG	HSTARTS	ΔHPRICE	ΔUNEMP	R
NETMIG	1.000	-0.096	0.180	0.045	-0.029
HSTARTS	*	1.000	0.087	0.032	-0.015
ΔHPRICE	*	*	1.000	-0.152	-0.453
ΔUNEMP	*	*	*	1.000	0.052
R	*	*	*	*	1.000

be the reduced form vector moving average representation (impulse response function) of (9). Then the structural moving average representation (impulse response function) is

$$y_t = \epsilon_t + \Psi_1 u_{t-1} + \Psi_2 u_{t-2} + \dots, \tag{15}$$

where

$$\Psi_k = \Phi_k A^{-1} B \text{ for } k = 0, 1, 2, \dots . \tag{16}$$

A consistent estimate of the structural impulse response function is

$$\hat{\Psi}_k = \hat{\Phi}_k \hat{A}^{-1} \hat{B} \text{ for } k = 0, 1, 2, \dots . \tag{17}$$

Figure 3 reports the estimated structural impulse response function together with 90 percent bootstrapped confidence intervals using the method of Hall (2002).[21] Each column of figure 3 represents a structural shock and each row represents a variable. Thus the impulse response reported in the second row and first column of figure 3 represents the impact on housing starts of a one standard deviation change to the first structural shock. This is the shock to net migration that is orthogonal to shocks to housing supply and housing demand, aggregate activity and the monetary policy. While this

[21] See Lütkepohl and Krätzig (2004, p 177).

is the shock in which we are most interested, its interpretation depends on the extent to which the identification of the other shocks makes economic sense. Consequently, we first discuss these shocks before analyzing the net migration shock.

The structural shocks that directly affect housing starts and real house prices are separately identified by the assumption that a shock hitting housing starts does not contemporaneously affect house prices while the shock to real house prices immediately affects both housing starts and real house prices. The effects of these shocks can be seen in the second and third column of figure 3. The structural shock that directly affects housing starts has a positive impact on housing starts but a negative impact on house prices suggesting that this shock can be interpreted as a housing supply shock. The structural shock that directly affects real house prices has a positive impact on both housing starts and real house prices suggesting that this shock can be interpreted as a housing demand shock.

The unemployment shock could either be a demand shock, a supply shock, or an amalgam of both. It is most likely a demand shock because a shock that increases unemployment has negative impact on house prices. The unemployment shock also has a significant negative effect on net migration.

The shock to interest rates is interpreted as a monetary policy shock. The impulse response functions for this shock are sensible as a positive shock to interest rates has a positive impact on unemployment, a negative impact on house prices and housing starts, but a negligible effect on migration. Table 4 indicates an increase in interest rates has its largest effect on house prices and housing starts. For example, a 100 basis point increase in interest rates leads to a reduction of 0.13 building permits per 1000 people per quarter after a year (compared to an average of approximately 2 building permits per 1000 people per quarter), a 2.9 percent reduction in house prices, and a 0.15 percent increase in the unemployment rate.

The impulse response functions can be used to answer the main questions asked in the paper: by how much do housing starts and house prices respond to a migration change; and how much of the variation in real house prices can be explained by migration shocks? The impact of the net migration shock on the five endogenous variables is depicted in the first column of figure 3. Here we see that a positive net migration shock has a positive impact on housing starts, real house prices and unemployment. The initial impact of the net migration shock on housing starts is equal to -0.008 with a bootstrapped 90 percent confidence interval of $[-0.032,\ 0.010]$. Thus it appears that there is little significant impact on housing starts initially. However, housing starts

Figure 3
Structural impulse response functions: 1991Q1-2006Q3

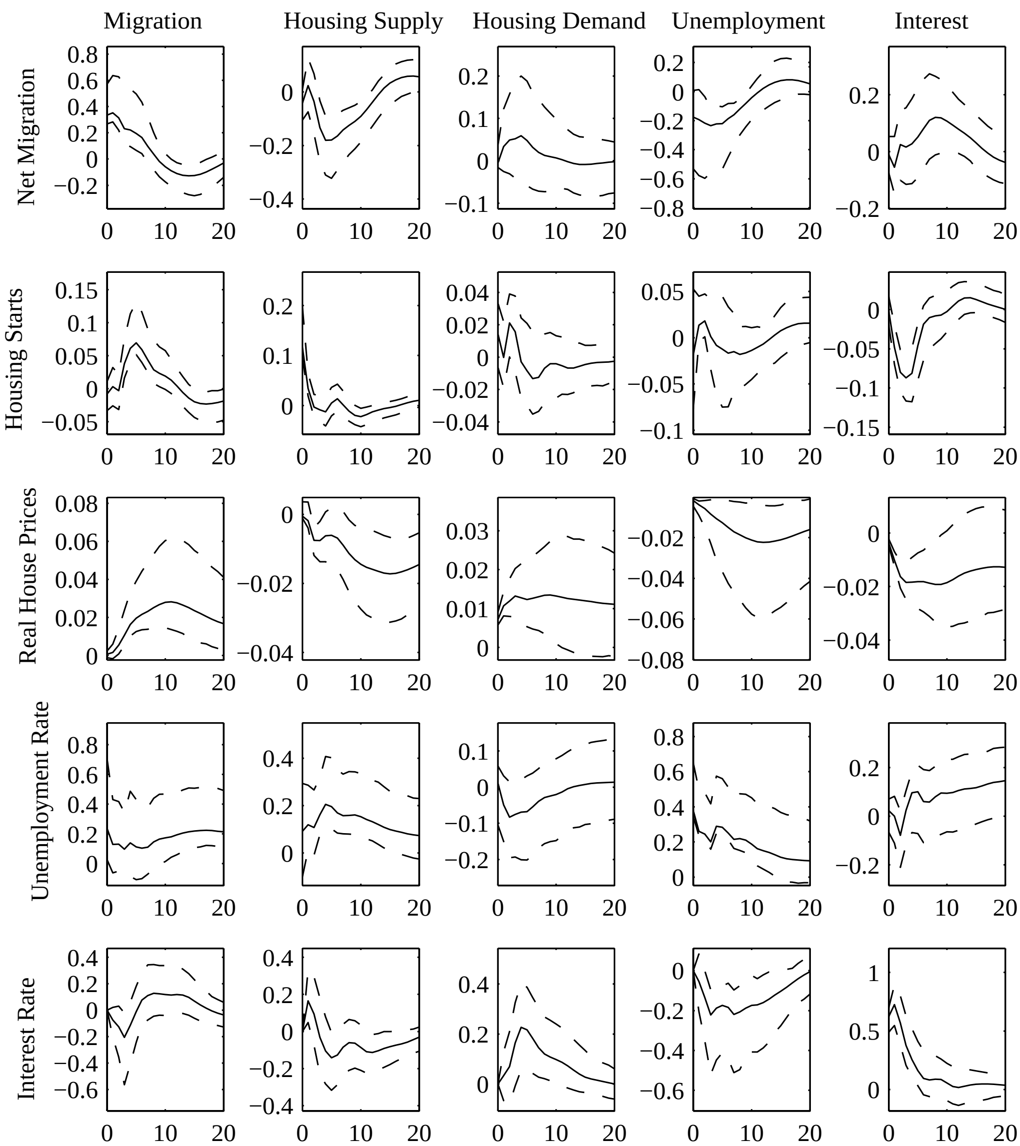


Table 4
Responses to 100 basis point interest rate shock, 1991Q1-2006Q3

Horizon (Quarters)	Net migration	Housing starts	Real house prices	Unemployment
0	-0.017/1000	-0.003/1000	-0.609 %	0.038 %
4	0.044/1000	-0.130/1000	-2.932 %	0.154 %
8	0.193/1000	-0.013/1000	-3.076 %	0.128 %
12	0.126/1000	0.018/1000	-2.580 %	0.170 %
100	0.000/1000	0.000/1000	-2.500 %	0.231 %

The results indicate the response to a 100 basis point change in interest rates.
Net migration: the number of net immigrants per 1000 people.
Housing Starts: the number of housing starts per 1000 people.
Real house prices: the percentage price change in house prices.
Unemployment rate: the percentage point change in the unemployment rate.

begin to rise until the fifth quarter where the response is equal to 0.0694 with a bootstrapped 90 percent confidence interval of [0.053, 0.126]. After the fifth period the number of housing starts declines. Thus the peak impact of the net migration shock on housing starts takes about five quarters to appear.

The impact of the net migration shock on real house prices also shows a similar pattern. The initial impact of the net migration shock on real house prices is 0.0007 with a bootstrapped 90 percent confidence interval equal to $[-0.001, 0.002]$. Real house prices increase until the eleventh quarter where the impact of the net migration shock on real house prices is equal to 0.0282 with a bootstrapped 90 percent confidence interval equal to [0.0152, 0.0591]. Moreover, the rate of increase in real house prices is at a maximum after four quarters, when the increase in housing starts reaches its maximum. Thus the net migration shock has a large impact on house prices and housing starts with the maximum impact on housing starts and house price inflation being around one year after the shock and the maximum impact on real house price levels occurring between two and three years after the shock. It is clear that the effect of the net migration shock on the housing sector is is substantial and that the full impact occurs relatively quickly.

Table 5 provides a summary of the response of house prices and housing starts to a change in migration flows over different time horizons. Because migration flows are serially correlated, the elasticities compare the accumu-

Table 5
Elasticities of response of real house prices and housing starts to a net migration shock, 1991Q1-2006Q3

Horizon(Quarters)	Housing starts	Real house prices
0	-0.024	2.09
4	0.062	11.27
8	0.150	12.92
12	0.210	16.55
100	0.182	15.609

lated n-period change in housing prices or housing starts to the n-period accumulated migration flow stemming from an original shock to migration. The first column measures the number of houses built per migrant over a particular time horizon. The figures suggest that the housing response is initially slow, with less than a tenth of a house built per migrant over the first year. The response is much larger after three years, with 0.2 houses built per migrant. This ratio is somewhat lower than the average housing ratio in New Zealand between 1996 and 2006, which is 0.35 houses per person. The second column indicates that a migration flow equal to 1 percent of the population is associated with an immediate 2.1 percent increase in house prices, rising to 11.3 percent after one year and 16 percent after 3 years. While the increase after one year is similar in magnitude to the slope of the simple correlation between annual migration flows and annual changes in real house prices (7.8 percent), these results suggest there is little tendency for house prices to fall after the initial increase. The magnitude of the elasticity is extremely large, compared to the overall growth of population and house prices in New Zealand during this period. It should be emphasised that these price rises occur despite the construction of new houses for the migrants.

The results of a second structural vector autoregression in which the unemployment variable is replaced by real GDP are reported in appendix A. The results for the elasticity between migration and house prices are very similar, but the elasticity between migration and housing starts is smaller, only 0.12 after three years. Both vector autoregressions suggest that construction activity is slow to respond to migration inflows, particularly in the first year. As shown below, construction activity was noticeably faster to respond to migration flows prior to 1982. These lower elasticities are consistent with the simple correlation results reported in appendix B. These indicate that there is a much smaller contemporaneous correlation between migration flows and construction starts than between migration flows and construction prices, and that the response of construction starts to migration flows has diminished through time.

To examine the extent to which variation in real house prices can be explained by migration shocks, we turn to the structural forecast error decomposition which tells us the relative contribution of each shock to n-step ahead forecast errors from our model. Table 6 depicts the contribution of each identified shock on real house prices for this period. We see that the most important shock for all forecast horizons except the first period is the interest rate shock. The interest rate shock accounts for as much as 43 percent of the forecast error variance in the early periods and this drops to 27 percent after 20 quarters. The relative importance of the housing demand shock (the structural shock that directly impacts real house prices) declines from 74 percent to 17 percent as the forecast horizon increases. The net migration shock appears to have little impact over the short horizon but has a sizeable impact (around 29 percent) for the longer forecast horizons. Thus it appears that while the net migration shock is not the most important shock in the early periods after the shock, it does have a significant impact eventually.

To summarize, the estimated set of five orthogonal structural shocks – a net migration shock, a housing supply and a housing demand shock, an aggregate activity shock and a monetary policy shock – yield qualitatively sensible responses in the five variables in the VAR. Our main findings are that the net migration shock has an important impact on the housing market, both to housing starts and real house prices. It appears that the full impact of a net migration shocks occurs between one and three years after the initial impact of the shock. However, while the net migration shock is important it is not the most important shock that affects real house prices. The monetary policy shock accounts for at least a third of the forecast error variance with the other four shocks accounting for roughly equal shares of the other two thirds of the forecast error variance. Thus we conclude that net migration had an important and significant effect on house prices in New Zealand during this period but that the large increase in real house prices that occurred between 1991 and 2006 is most likely the result of a number of different shocks reinforcing each other rather than the result of a single economic factor.

Table 6
Structural forecast error decomposition: real house prices (1991Q1-2006Q3)

Period	Net Migration	Housing Supply	Housing Demand	Unemp.	Interest Rate
1	0.01	0.00	0.74	0.05	0.21
2	0.01	0.02	0.49	0.06	0.43
3	0.07	0.16	0.30	0.05	0.42
4	0.16	0.13	0.26	0.07	0.37
5	0.25	0.12	0.22	0.08	0.32
6	0.27	0.12	0.21	0.09	0.31
7	0.28	0.11	0.21	0.10	0.30
8	0.28	0.12	0.20	0.11	0.29
9	0.28	0.14	0.19	0.11	0.28
10	0.28	0.14	0.19	0.12	0.27
11	0.28	0.14	0.19	0.12	0.27
12	0.28	0.15	0.19	0.12	0.27
13	0.27	0.15	0.19	0.12	0.28
14	0.28	0.15	0.18	0.12	0.28
15	0.28	0.14	0.18	0.12	0.28
16	0.28	0.14	0.18	0.12	0.27
17	0.29	0.14	0.18	0.12	0.27
18	0.29	0.14	0.18	0.12	0.27
19	0.29	0.14	0.18	0.12	0.27
20	0.29	0.14	0.17	0.12	0.27

3.4 An SVAR for the period 1962Q2–1982Q4

The 1970s is another period when New Zealand experienced large migrant flows and large changes in real house prices. Prior to 1974, there was a large inflow of migrants from the United Kingdom, and a large increase in house prices; after 1975, there was a large outflow of migrants from New Zealand, mainly to Australia, and real house prices fell significantly.

The poor economic conditions faced during this period led to an economic crisis in the early 1980s. The government imposed wage, price and rent freezes and then was forced to significantly reform the economy. We therefore end our sample in the last quarter of 1982 as this was the last quarter before the price freeze came into effect. The period covers most of the 1960s, a period of good economic performance for the economy, the 1970s, and the early 1980s.

The structural VAR has the same variables as the VAR for the period 1990-2006. Because the mortgage interest rate variable is not stationary during this period, even when allowing for the possibility of a structural break in the underlying trend, the vector of endogenous variables contained in the VAR is:

$$y_t = \begin{pmatrix} NETMIG_t \\ HSTARTS_t \\ \Delta RHPRICE_t \\ \Delta UNEMP_t \\ \Delta INT_t \end{pmatrix}, \tag{18}$$

where the variables have identical definitions as before.

Identifying restrictions

The identifying restrictions imposed for this period are different than those imposed for the post 1990 period because of the differences in the way monetary policy was implemented in the two periods. In particular, interest rates were not actively changed to ensure future inflation was kept low during this period. Consequently, in contrast to the post-1990 VAR, the interest rate is modelled reactively in the sense that it is the product of the supply and demand for loans. Thus interest rates are contemporaneously affected by economic events. This is the only major difference in our identification strategy for the two models. Nonetheless, there are some other changes that needed to be made for our model to be locally identified. The identifying restrictions that we impose are as follows.

Net migration
As before, we assume that the net-migration series is directly affected by the residual to unemployment and by the first structural shock. Hence, the relationship between the residual to the net-migration equation and the other residuals and structural shocks is:

$$\epsilon_{1t} = -a_{14}\epsilon_{4t} + b_{11}u_{1t}, \tag{19a}$$

Housing starts
The housing starts equation is the same as equation (12b) :

$$\epsilon_{2t} = -a_{23}\epsilon_{3t} - a_{24}\epsilon_{4t} - a_{25}\epsilon_{5t} + b_{22}u_{2t}. \tag{19b}$$

Real house prices
The identifying restrictions we make for the house price variable are:

$$\epsilon_{3t} = -a_{34}\epsilon_{4t} - a_{35}\epsilon_{5t} + b_{33}u_{3t}. \tag{19c}$$

This is different to equation (12c) as there is no longer any direct impact from the net migration innovation. This change is done purely to yield a locally identified structural model and in fact this restriction has little impact on the overall result as the (3,1) element of $A^{-1}B$ is not equal to 0. Thus the net migration structural shock does have a direct impact on house prices even though the innovation to net migration does not have a direct impact on the real house price innovation.

Unemployment and interest rates
In section 3.3, the unemployment rate responds to shocks from other variables including the interest rate, but the interest rate is unaffected by contemporaneous changes in other variables. In contrast, in this identification scheme the unemployment shock is unaffected by other variables but the interest rate responds reactively. The unemployment equation is:

$$\epsilon_{4t} = b_{44}u_{4t}, \tag{19d}$$

and the mortgage interest rate equation is:

$$\epsilon_{5t} = -a_{51}\epsilon_{1t} - a_{52}\epsilon_{2t} - a_{53}\epsilon_{3t} - a_{54}\epsilon_{4t} + b_{55}u_{5t}. \tag{19e}$$

The effect of these restrictions is to make the interest rate more reactive to current economic conditions, reflecting our view that in this period the monetary authority did not use interest rates as a forward looking policy instrument.

To summarise, the particular A and B matrices we use in (8) for the period from 1962Q2 to 1982Q4 are

$$A = \begin{bmatrix} 1 & 0 & 0 & a_{14} & 0 \\ 0 & 1 & a_{23} & a_{24} & a_{25} \\ 0 & 0 & 1 & a_{34} & a_{35} \\ 0 & 0 & 0 & 1 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{bmatrix} \tag{20a}$$

and

$$B = \begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 \\ 0 & 0 & 0 & 0 & b_{55} \end{bmatrix} \tag{20b}$$

These restrictions yield an exactly identified structural VAR that is also locally identified (satisfies the rank condition for identification locally). These restrictions allow us to identify structural shocks that, as was the case in section 3.3, can be thought of as a net migration structural shock, a housing supply shock, a housing demand shock, an aggregate activity shock, and an interest rate shock. The differences here is that the interest rate shock can no longer be thought of as a monetary policy shock.

Results

The VAR was estimated using equation by equation OLS. As was the case in section 3.3, three lags of the endogenous variables were included in the model. Again, information criteria suggested using less than three lags but the sequential likelihood ratio test suggested that three lags should be included. A shift dummy starting in the first quarter of 1978 was also included. It is apparent from figure 2 that the housing starts variable has a level shift around this period and that the interest rate variable has a break in trend close to this period as well. Since the housing starts series enters our model in levels and the interest rate series enters as a first difference, the shift dummy is the appropriate variable to include for each series.

Table 7
Estimates of the reduced form VAR: 1962Q2-1982Q4

Equation	NM	HS	ΔP	ΔU	Δ R
NM(-1)	0.961	0.130	0.004	0.052	0.052
	[7.613]	[2.837]	[1.144]	[1.491]	[0.849]
HS(-1)	0.498	0.819	0.024	-0.313	-0.025
	[1.348]	[6.090]	[2.340]	[-3.058]	[-0.140]
ΔP(-1)	5.162	1.440	0.824	-0.657	-1.131
	[1.148]	[0.880]	[6.585]	[-0.527]	[-0.516]
ΔU(-1)	0.172	-0.013	0.013	0.468	-0.002
	[0.318]	[-0.067]	[0.863]	[3.123]	[-0.008]
ΔR(-1)	0.025	0.027	-0.004	0.106	-0.235
	[0.094]	[0.284]	[-0.536]	[1.463]	[-1.836]
NM(-2)	-0.149	-0.037	0.004	0.030	-0.075
	[-0.789]	[-0.535]	[0.673]	[0.568]	[-0.811]
HS(-2)	-0.408	0.218	0.009	0.108	0.060
	[-0.880]	[1.296]	[0.731]	[0.843]	[0.266]
ΔP(-2)	-4.352	-1.597	-0.125	0.701	1.511
	[-0.696]	[-0.702]	[-0.716]	[0.404]	[0.496]
ΔU(-2)	-0.403	0.350	0.024	-0.282	-0.215
	[-0.703]	[1.675]	[1.506]	[-1.774]	[-0.770]
ΔR(-2)	-0.162	-0.059	-0.003	0.033	0.175
	[-0.616]	[-0.610]	[-0.390]	[0.452]	[1.362]
NM(-3)	0.061	-0.060	-0.008	-0.041	0.030
	[0.434]	[-1.186]	[-2.110]	[-1.046]	[0.435]
HS(-3)	-0.461	-0.101	-0.024	0.106	0.043
	[-1.306]	[-0.787]	[-2.410]	[1.084]	[0.250]
ΔP(-3)	11.010	-1.680	-0.032	-0.882	-0.959
	[2.241]	[-0.939]	[-0.233]	[-0.648]	[-0.400]
ΔU(-3)	0.003	0.088	0.003	0.011	0.078
	[0.006]	[0.496]	[0.193]	[0.080]	[0.327]
ΔR(-3)	-0.061	0.033	0.004	0.012	0.225
	[-0.231]	[0.337]	[0.608]	[0.162]	[1.739]
$D78Q1$	-0.304	-0.075	0.003	0.045	0.285
	[-1.249]	[-0.840]	[0.513]	[0.671]	[2.401]
constant	0.845	0.133	-0.020	0.200	-0.103
	[1.866]	[0.809]	[-1.603]	[1.591]	[-0.466]

Notes: The numbers in the square braces are t-values. NM ≡ Net migration, HS ≡ Housing Starts, P ≡ Real House Prices, U ≡ Unemployment, and R ≡ Mortgage Interest Rate.

The estimates are presented in table 7. We are, however, more interested in what these estimates imply about the effect on the endogenous variables of the structural shocks that we identify. To identify our shocks we use the approach outlined in equations (14) to (17) and the restrictions given in (20). The structural impulse response functions together with their 90 percent bootstrapped confidence intervals are reported in figure 4.

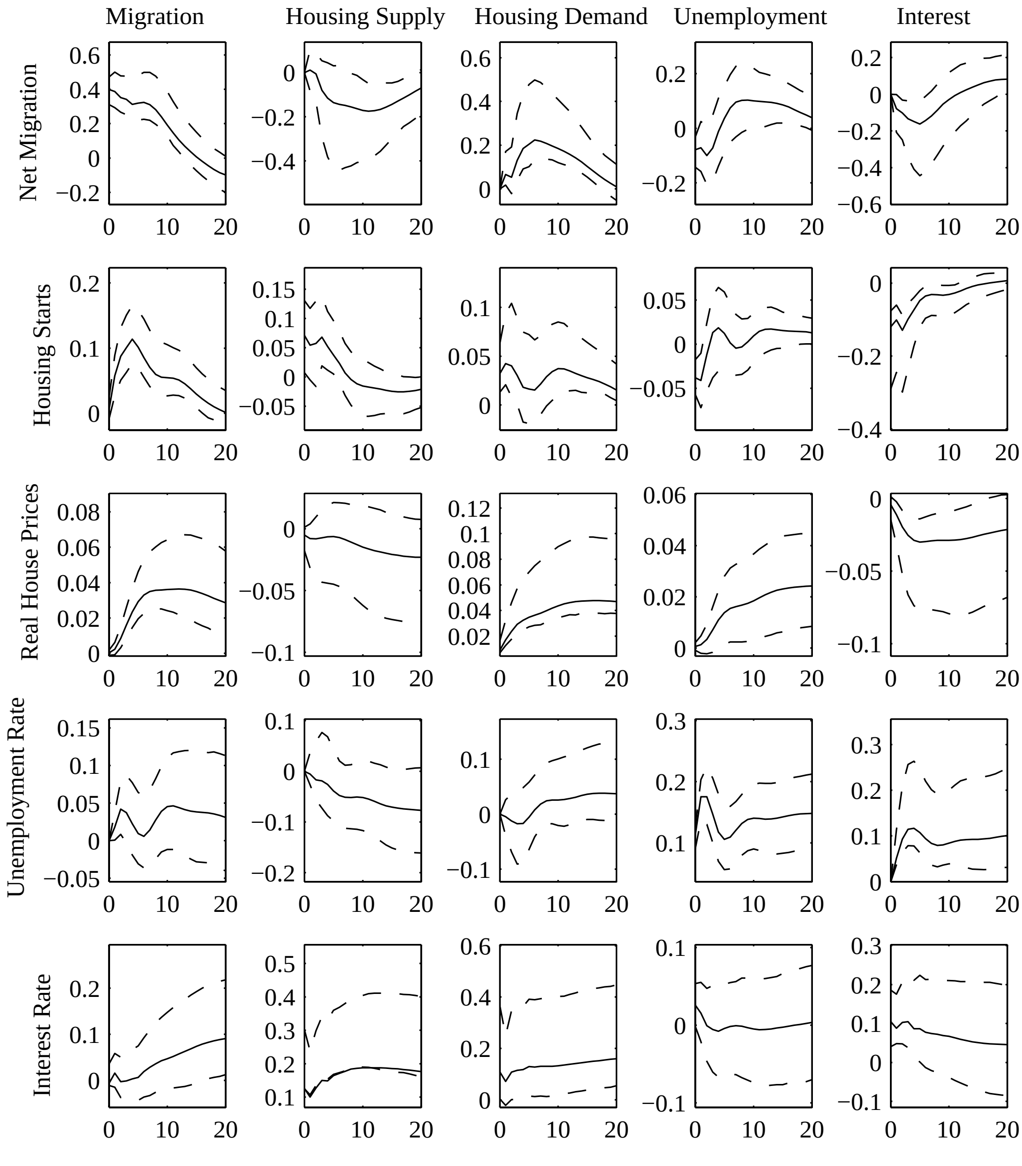
The second column of figure 4 reports the impact of the second identified structural shock on all five endogenous variables of our system. As in section 3.3 we interpret this shock as a housing supply shock given that this structural shock has a positive impact on housing starts and a negative impact on real house prices. The third structural shock is interpreted as a housing demand shock as this shock has a positive impact on both housing starts and real house prices.

The fourth column of figure 4 depicts the impact of the aggregate activity shock on all all five endogenous variables. We see that this shock has a negative impact on housing starts and a positive impact on real house prices. This shock is contractionary in that unemployment increases and interest rates decline suggesting that we may be identifying a negative supply shock for this period. This is in contrast to the results from the post-1990 period where it appeared that we had identified a negative demand shock. It may not seem that surprising that we would identify a negative supply shock for this period as the sample period encompassed the two major oil shocks of the 1970s.

The effects of the fifth structural shock is depicted in the fifth column of figure 4. This is an interest rate shock. In the sample from the 1990s we interpreted this shock as a monetary policy shock but for this period we are unable to do this. We do not have the appropriate variables in our model to distinguish a shock to the supply of loans from a shock to the demand for loans so we are left with little interpretation to this shock except that it is a shock to the mortgage interest rate that is orthogonal to the other structural shocks of the system. This interest rate shock is contractionary in that it has a significant positive impact on unemployment and has a significant negative impact on housing starts and real house prices.

Overall, these results suggest that we have identified a set of structural shocks that each have a reasonable interpretation and that have sensible impacts on the endogenous variables of the system. This suggests that the net migration shock that we have identified is a shock to net migration that is orthogonal to housing supply and demand shocks, an aggregate activity shock and an interest rate shock.

Figure 4
Structural impulse response functions: 1962Q1–1982Q4



The response of each variable to the net migration shock is depicted in column one of figure 4. The response of housing starts to the net migration shock is very similar to what we observed in the post-1990 sample; that is, the initial impact on housing starts is small and insignificant, then housing starts increase until the fourth quarter after the shock and thereafter decline back to zero. The estimated initial impact of the net-migration shock on housing starts is 0.0067 while the 90 percent bootstrapped confidence interval of this initial impact is [−0.008, 0.025]. The maximum response occurs at quarter 4 and is equal to 0.1136 with a 90 percent bootstrapped confidence interval of [0.077, 0.165]. This is slightly larger than the response of housing to a net-migration shock in the post-1990 sample.

The response of real house prices to the net-migration shock follows a similar pattern. The initial impact is positive, small, and insignificant. The point estimate of the initial impact of the net-migration shock on real house prices is 0.0002 with the 90 percent bootstrapped confidence interval equal to [−0.001, 0.002]. This is again similar in magnitude to the results we obtained using the post-1990 sample. The maximum response of real house price occurs after twelve quarters and is equal to 0.0364 with a 90 percent confidence interval equal to [0.022, 0.067]. The pattern of price increase is identical to the post-1990 case in that real house price inflation reaches a maximum three quarters after the shock and then declines in response to the house building activity. Similar to the post-1990 sample we also see that the response of unemployment to the net-migration shock is positive and significant, at least for the first couple of quarters after the shock.

Table 8 reports the estimated response of house prices and housing starts to a migration shock over different horizons. The estimates are similar after eight quarters to the later sample period, but there is a noticeably higher response of housing starts after 4 quarters and lower response of house prices after 12 or more quarters. This suggests housing construction responded much faster to migration shocks in the 1960s and 1970s than after 1990. (The faster response is in keeping with the discussion in appendix B about the changes in the construction industry in New Zealand – and consistent with the policy directives of the Kirk government in 1974.) Once again, however, the estimated response of house prices to migration flows is much larger than the long term relationship between house prices and population growth.

Lastly the response of the interest rate to the net-migration shock is positive and significant. This accords with our identification assumption that the interest rate in this period reflects the market for loans so that a positive shock to net-migration would cause an increase in the demand for loans

Table 8
Elasticities of response of real house prices and housing starts to net migration shock, 1962Q2-1982Q4

Horizon(Quarters)	Housing starts	Real house prices
0	0.017	0.05
4	0.205	13.07
8	0.226	11.76
12	0.242	9.81
100	0.345	8.94

thereby increasing the market interest rate.

Once again, these results seem sensible. The net migration shock has a positive and significant impact on the housing market with both the number of housing starts and real house prices increasing. As with the post-1990 sample, the maximum impact on house starts and house price inflation occurred after 4 quarters and the maximum impact on prices occurred after about three years. The remaining question concerns the importance of net migration in explaining house price changes during this period.

Table 9 contains the forecast error variance decomposition for the structural shocks that we identified earlier. It is clear that the housing demand shock is the most influential shock for all forecasts but the interest rate shock is also an important shock. The net-migration shock is not important for short horizons but for longer horizons it accounts for close to 30 percent of the forecast error variance. Again we see that the net-migration shock, while not the most important shock, contributes substantially to forecast errors from our model. One point to note is that in this period the housing supply and aggregate activity shock play little or no role at all on house price changes.

4 Discussion and conclusions

4.1 Summary of empirical results

The results of the structural vector autoregressions are plausible. The impulse response functions are qualitatively sensible and robust to reasonable changes in the specification. Very similar results are obtained when the unemployment rate is replaced by real GDP, for example, or when the lag length

Table 9
Structural forecast error decomposition: real house prices (1962Q2-1982Q4)

Period	Net Migration	Housing Supply	Housing Demand	Unemp.	Interest Rate
1	0.00	0.21	0.65	0.00	0.14
2	0.02	0.14	0.58	0.00	0.26
3	0.10	0.09	0.46	0.01	0.33
4	0.18	0.07	0.40	0.04	0.31
5	0.24	0.06	0.36	0.05	0.29
6	0.27	0.05	0.34	0.06	0.27
7	0.29	0.05	0.34	0.06	0.26
8	0.29	0.06	0.34	0.06	0.26
9	0.29	0.06	0.34	0.06	0.25
10	0.28	0.07	0.34	0.06	0.25
11	0.28	0.07	0.34	0.06	0.25
12	0.28	0.07	0.34	0.06	0.25
13	0.28	0.07	0.34	0.07	0.24
14	0.27	0.08	0.34	0.07	0.24
15	0.27	0.08	0.34	0.07	0.24
16	0.27	0.08	0.34	0.07	0.24
17	0.27	0.08	0.33	0.07	0.25
18	0.28	0.08	0.33	0.07	0.25
19	0.28	0.08	0.33	0.07	0.25
20	0.28	0.08	0.33	0.07	0.25

is changed. The results suggest that real house prices and house construction activity increase in response to decreases in interest rates or increases in income. They also show a consistent response in real house prices and housing starts to migration flows over a forty five year period marked by very volatile migration and very different monetary policy regimes.

Four results stand out. First, migration flows are important in explaining the size of house price changes. It takes approximately a year for migration to have its largest effects on housing starts and house prices, although the full effect on house prices takes about three years. Second, interest rates are important determinants of house prices. A temporary increase in interest rates reduces housing starts for approximately two years and reduces house prices for somewhat longer. Consequently, monetary policy can be used to counteract some of the effects of migration on the housing market if so desired. Third, house prices are negatively affected by increases in building construction. This result should not be a surprise, but the vector autoregressions indicate that the effect is quite rapid, half occurring within a year of the building permit being issued. This result suggests efforts to reduce impediments to housing construction could prevent house prices from changing so quickly. Fourth, the results confirm that house prices are adversely affected by rising unemployment. This effect occurs through two channels, a direct effect caused by lower demand from resident households, and an indirect effect caused by lower net migration flows.

The most surprising aspect of the results is the magnitude of the relationship between migration flows and real house prices. The point estimates suggest that a net migrant inflow equal to one percent of the population causes real house prices to increase by 11-13 percent after a year. While this estimate is consistent with the simple correlation between real house price changes and migration flows, its magnitude is very large. These estimates are an order of magnitude larger than the difference between the average change in house prices in New Zealand and the average population growth rate since 1962. They are also an order of magnitude larger than Saiz's benchmark estimates of 1-2 percent for the United States. Moreover, the impact on house prices is not substantially unwound after a year, as might be expected from the delayed response of house construction activity. Rather, the long term increase in real house prices from a migrant inflow equal to one percent of the population was 9 percent in the 1962-1982 period, and 12-16 percent in the 1991-2006 period.

4.2 The 2001-2006 migration and housing boom

In the five years to March 2006, the New Zealand population increased by 257 thousand or 6.6 percent, partly because of net immigration of 115 thousand people (433 thousand immigrants and 318 thousand emigrants.) During this time, 137 thousand building permits were issued, or 0.53 permits per new person. This rate of construction was sufficiently rapid that the ratio of houses to people increased from 0.35 in 2001 to 0.36. Many of these houses were very large: 20 percent exceeded $300m^2$ in size, while a further 40 percent were between 200 and 299 m^2. Yet despite this construction boom, real house prices increased by 67 percent, or by 10 times as much as the population increase and 22 times the population increase due to net immigration. The structural vector autoregressions show the 2001-2006 experience was not particularly unusual: the magnitude of the housing market response to net immigration flows is similar to that which has occurred ever since the 1960s. Indeed, the change in house prices that occurred when there was an immigration influx in the early 1970s was even larger.

The discussion in section 2 suggested three possible reasons why this relationship between house prices and migrant flows has been a feature of the New Zealand economy for such a long time. The first was that immigrant flows could create a temporary period of high prices until sufficient houses were built for the migrants. The extent to which prices would rise would depend on how quickly new houses were built, which in turn depends on the capacity of the construction sector. If the sector faced severe capacity constraints, house prices and construction costs would be high until the stock of houses finally caught up with the demand. It is notable that the estimated elasticity between migration inflows and new construction is very low, less than 0.1 house per migrant after a year, and less than 0.2 houses per migrant after 3 years.

This is an attractive story to describe the post-2001 immigration and housing boom. The construction sector was capacity constrained for most of the 2001-2006 period, and construction prices increased sharply in response to these demand pressures. Yet the explanation sits uneasily with the large number of houses that were built between 2001 and 2006: it seems hard to believe that if houses were expensive in 2006, despite the construction boom, it was due to the relatively small net migration inflow since 2001. At a minimum, a more subtle story is needed than a simple story of too many migrants and too few houses. For instance, it could be the case that immigrants were typically wealthier than locals, or had more discerning tastes in housing. In this case, the 80,000 large houses that were built during the five years may have been insufficient to meet the demand for high quality housing by the 430,000 new immigrants, and the houses vacated by the 320,000 emigrants may have been poor substitutes. A similar explanation is that the public infrastructure such as schools and neighbourhood amenities that are associated with new housing developments may not be up to the standard of the infrastructure in existing areas. Again, if this were true, the new houses might not be good substitutes for existing houses. In turn, an inward migration shock could cause house prices to rise above long term equilibrium levels for a considerable period.

The second explanation was that the migration flows are correlated with other factors that are causing house prices and housing activity to increase. One possibility is that net migration is positively correlated with future income expectations. If so, housing demand will increase when there is an increase in net migration not only because of the extra migrants but also because locals are simultaneously trying to move into better quality houses. In this case, the coefficients linking house prices to migration will be biased upwards, capturing not only the direct link between migrants and house prices, but the link between local demand and house prices as well.

There is some evidence that this is part of the story. For example, the estimated relationship between migration flows and house prices is weaker when a more comprehensive measure of incomes (real GDP) is included in the vector autoregression in place of the unemployment rate. Nonetheless, the estimated coefficients are still an order of magnitude larger than expected. At the very least, if this explanation is a significant part of the story, it must be considered unfortunate that income expectations cannot be better forecast by a vector autoregression containing lags of income, unemployment and housing activity.

The third possible explanation was that immigration flows destabilise expectations about house prices, causing a long period of disequilibrium. Various theoretical mechanisms have been proposed to support this idea, largely based around the idea that real estate markets involve costly search activity, and that agents might have adaptive expectations. In some sense, it is easy to imagine such behaviour. All it requires is that an unusually large number of immigrants arrive and “temporarily” drive up prices since only a few properties are listed at any particular time; that local buyers and sellers take the new “temporary” level of prices as indicative of what houses are fundamentally worth; and locals, who typically sell one house while buying another, keep paying these prices even after the migrants have been absorbed. In such models, house prices can deviate from "fundamental" values for a considerable period of time, basically until there is a large oversupply of houses on the market at a particular time. This model has not been formally tested in this paper. Nonetheless, in the absence of other convincing explanations of why there is a strong relationship between relatively small fluctuations in migrant flows and large house price movements, it cannot be ruled out. Some data on real estate trading activity that are consistent with this story are presented in appendix B.

The implications of these last two explanations are very different. If there is a large upward bias in the estimated response between house price movements and migration flows, it means that the observed correlation is not primarily causal. Rather, the large changes in house prices that occur every time there is a large net migration flow are reflecting an additional factor, such as income expectations, that are causing both house prices and migration flows to change. If one believes the underlying elasticity between migration flows and house price changes is in the range of 1-2, it follows that most of the estimated relationship reflects these other factors, and migration only has a modest effect on the housing market. Moreover, migration flows will be a very useful signal to the Reserve Bank that it can expect a period of unusual housing market activity. In contrast, if one believes that the set of conditioning variables included in the vector autoregression are sufficient to proxy for these additional demand factors, it would suggest that migration flows have very large long term effects on real house prices, possibly because they destabilise house price expectations. This prospect should be disturbing to a central bank charged with maintaining a low inflation environment.

One other aspect of the 2001-2006 period deserves mention: the length of inward migration flow. Much has been made of the fact that the estimated short run relationship between migration flows and house prices is an order of magnitude larger than the long run relationship between population size and house prices. Much less has been made of the fact that net migration flows have been near zero over the last forty-five years. It is tempting to wonder whether the long term relationship between house prices and population is so small because the population size usually adjusts through outward migration whenever house prices get too high, causing a downward house price correction. While emigration was very cyclical between 1970 and 2000, with peaks in 1979, 1989, and 2000, emigration since 2000 has been relatively modest.

4.3 Implications for monetary policy

This paper has not directly studied how net-migration shocks may affect the conduct of monetary policy by the central monetary authority. Nonetheless, our results indicate that there are two ways that migration flows affect the conduct of monetary policy.

First, net migration flows appear to assist the use of monetary policy to absorb non-migration shocks. This is because net-migration has some pro-cyclical components, so it amplifies the effect of counter-cyclical interest rate policy. For example, a decrease in interest rates in response to poor economic conditions or low inflation pressures decreases unemployment, which lowers outward migration thereby reducing the downwards pressure on house prices. Naturally, the extent to which the migration channel affects the inflation rate depends on the pass-through from house price changes to general inflation.

Second, net migration flows may be a source of shocks, because some components of net-migration flows are exogenous to New Zealand's economic conditions. The surge of migrants from the United Kingdom in the early 1970s and from East Asia in the 1990s were mainly due to shocks that were independent of New Zealand's business cycle. The Reserve Bank may need to respond to the migration shock to ensure its inflation target is met. Given that the results in this paper suggest that interest rate changes have substantial effects on house prices, the government may also like the Bank to try and smooth house price changes.

In practice, the extent that the Reserve Bank is able to respond to the house price changes that accompany migration shocks may be limited, given that the Bank's primary objective is to achieve its inflation target. The size of an interest rate change necessary to offset the house price changes that typically accompany migration flows may be too large to be consistent with the inflation target, since the elasticity from migration to house prices is very large. Indeed, an explanation for the post 2001 house price boom could be that the net immigration influx coincided with the end of a recession and a decline in international interest rates. In keeping with the trend in international interest rates, New Zealand interest rates were kept lower than necessary to offset the sudden increase in housing demand, and house prices increased as a result.

If it is believed that net migration flows cause undesirable imbalances in the economy, there are two broad classes of options facing the government. First, the government may wish to intervene using policies other than monetary policy to counteract the shock. This was the approach adopted by the Kirk government in 1974, when it attempted to limit inward migration and to accelerate housing construction. Second, the government could ask the Reserve Bank to stabilize the economy and achieve its inflation target by intervening with an additional monetary policy instrument other than interest rates. The form that a second policy instrument would take in the case of large exogenous net-migration shocks is beyond the scope of this analysis. However a second policy instrument need not be anything more than a one-off approach to deal with the problem at hand. There is a long history of monetary authorities in other countries using one-off policy instruments to handle regional or sectoral shocks that can not be easily handled using the existing policy instrument.[22] A multiple policy instrument approach may be necessary if it is considered desirable for the monetary authorities to achieve multiple goals, that is, to achieve its inflation target while preventing migration shocks from causing large house price swings.

This paper has documented that net-migration shocks can have large long term effects on real house prices, and that net-migration shocks and interest rate changes have been equally important determinants of house price volatility since 1962. Nonetheless, it is beyond its scope to analyze how migration affects inflation generally. The potential for net-migration shocks to affect the performance of monetary policy depends on how much house-price increases pass through to general price inflation. The quantification of this pass-through was not the central aim of this paper but would appear to be an important area of future research.

4.4 Conclusion

This paper has estimated the relationship between migration flows and housing market activity in New Zealand since 1962. It has shown that a migration flow equal to 1 percent of the population is associated with an 8-12 percent change in house prices after a year, and a slightly larger effect after three years. While we have documented the importance of migration flows on the housing sector, our analysis has not been able to distinguish between competing explanations for why the statistical relationship between migration

[22] See Landon-Lane and Rockoff (2006) for a discussion of the various additional policy instruments used to handle regional shocks through the history of the United States' monetary union.

flows and housing prices is so large. Nonetheless, it indicates that future work needs to focus on three factors: the ability of the construction sector to quickly respond to migration flows; the responsiveness of migration flows to future income expectations; and the extent to which house price expectations are formed adaptively rather than rationally. Further progress on these fronts may need regionally disaggregated or local level data, to better untangle the housing demands of established and newly arrived households. Detailed high frequency data are not currently available. If such data can be procured, it may be possible to establish whether migration flows are primarily a destabilizing force in housing markets or just a useful signal of future income expectations.

References

Amisano, G and C Giannini (1997), *Topics in Structural VAR Econometrics,* Springer, Berlin.

Berkovec, J and J Goodman (1996), "Turnover as a measure of demand for existing homes," *Real Estate Economics,* 24(4), 421-440.

Clayton, J, N Miller, and L Peng (2007), "Price volume correlation in the housing market: causality or co-movements." *Mimeo*, University of Colorado.

Dickey, D A, and W A Fuller, (1979), "Distribution of the estimators for autoregressive time series with a unit root," *Journal of the American Statistical Association,* 74(366), 427-431.

DiPasquale, D, and W C Wheaton (1994), "Housing market dynamics and the future of housing prices," *Journal of Urban Economics,* 35, 1-27.

Elliot, G, T J Rothenberg, and J H Stock, (1996), "Efficient tests for an autoregressive unit root," *Econometrica,* 64(4), 813-836.

Ezekiel, M (1938) "The cobweb theorem," *Quarterly Journal of Economics,* 52(2), 255-280.

Hall, P (2002), *The Bootstrap and Edgeworth Expansion*, Springer-Verlag, New York.

Grimes, A, A Aitken, and S Kerr (2004), "House price efficiency: expectations, sales, symmetry," *Motu Working Paper,* 04-02.

Junankar, P N, D Pope, and G Withers (1998), "Immigration and the Australian macroeconomy: Perspective and prospective," *Australian Economic Review,* 31(4), 435-444.

Krainer, J (1999), "Real estate liquidity," *Federal Reserve Bank of San Francisco Economic Review,* 1999(3), 14-26.

Kwiatkowski, D, P C B Phillips, P Schmidt, and Y Shin, (1992), "Testing the null of stationarity against the alternative of a unit root: How sure are we that the economic time series have a unit root?" *Journal of Econometrics,* 54, 159-178.

Landon-Lane, J S and H Rockoff (2006), "Regional Interest Rates within a Monetary Union: Lessons from the United States," proceedings of *The 2006 ECFIN research conference – Adjustment under monetary unions: Financial market issues Brussels, 7 - 8 September 2006.*

Lanne, M , H Lütkepohl, and P Saikkonen (2003), "Test procedures for unit roots in time series with level shifts at unknown time," *Oxford Bulletin of Economics and Statistics,* 65, 91-115.

Ley, D and J Tutchener (2001), "Immigration, globalisation, and house prices in Canada's gateway cities," *Housing Studies,* 16(2), 199-223.

Lütkepohl, H and M Krätzig (2004), *Applied Time Series Econometrics*, Cambridge University Press, Cambridge.

Newell, J (2001), "Scoping Regional Migration and its interaction with labour Markets in New Zealand," *New Zealand Department of Labour Occasional Paper* 2001/2.

Novy-Marx, R (2005), "The microfoundations of hot and cold markets." *Mimeo*, University of Chicago.

Ongley, P and D Pearson (1995), "Post-1945 international migration: New Zealand, Australia, and Canada compared," *International Migration Review,* 29(3), 765-792.

Poot, J and B Cochrane (2004), "Measuring the impact of immigration: A scoping paper," *New Zealand Department of Labour Immigration Research Programme.*

Saiz, A (2003a), "The impact of immigration on American cities: An introduction to the issues," *Business Review,* Q4 2003, 14-23.

Saiz, A (2003b), "Immigration and housing rents in American cities," *Federal Reserve Bank of Philadelphia Working Paper,* 3-12.

Saiz, A (2006), "Room in the kitchen for the melting pot: Immigration and rental prices," *Review of Economics and Statistics,* 85(3), 502-521.

Sims, C A (1982), "Policy analysis with econometric models," *Brookings Papers on Economic Activity,* 2, 107-152.

Stein, J (1995), "Prices and trading volumes in the housing market: A model with downpayment effects," *Quarterly Journal of Economics,* 110(2), 379-406.

Wheaton, W (1990), "Vacancy, search and prices in a housing market matching model," *Journal of Political Economy,* 61, 1270-1292.

Wright, B and J Williams (1989), "A theory of negative prices for storage," *Journal of Futures Markets,* 9(1), 1-13.

Appendix A: The SVAR using real GDP instead of unemployment, 1991–2006.

In this section we report the impulse response functions for a VAR estimated over the second period (1991Q1–2006Q3) with real GDP per 1000 people replacing the unemployment rate.

The identification used for the original VAR for this period was

$$A = \begin{bmatrix} 1 & 0 & 0 & a_{14} & 0 \\ 0 & 1 & a_{23} & a_{24} & a_{25} \\ a_{31} & 0 & 1 & a_{34} & a_{35} \\ a_{41} & a_{42} & 0 & 1 & a_{45} \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \tag{21}$$

and

$$B = \begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 \\ 0 & 0 & 0 & 0 & b_{55} \end{bmatrix}. \tag{22}$$

The data vector used is

$$y_t = \begin{pmatrix} NETMIG_t \\ HSTARTS_t \\ \Delta RHPRICE_t \\ \Delta GDP_t \\ INT_t \end{pmatrix}, \tag{23}$$

and the number of lags used is the same as before (ie =3).

Impulse response functions

The impulse response functions for this version of the VAR are depicted in figure 5. They are qualitatively similar to those presented in figure 3, particularly the impulse response functions for the interest rate shock and the housing demand and housing supply shocks. There are two small differences. First, the shock to GDP does not have as clear an effect on net migration as the unemployment shock did. Second, there is a difference in the impact

Table 10
Net-migration elasticities: 1991Q1–2006Q3

Horizon (Quarters)	Housing Starts	Real House Prices
0	-0.0344	3.1754
4	0.0230	10.6451
8	0.0885	11.9515
12	0.1204	13.9662
100	0.0610	12.1050

of the net-migration shock on housing starts. For the first 2 quarters after the shock, housing starts grow slower than population. After 2 quarters the housing starts start to grow with the peak occurring after 5 quarters.

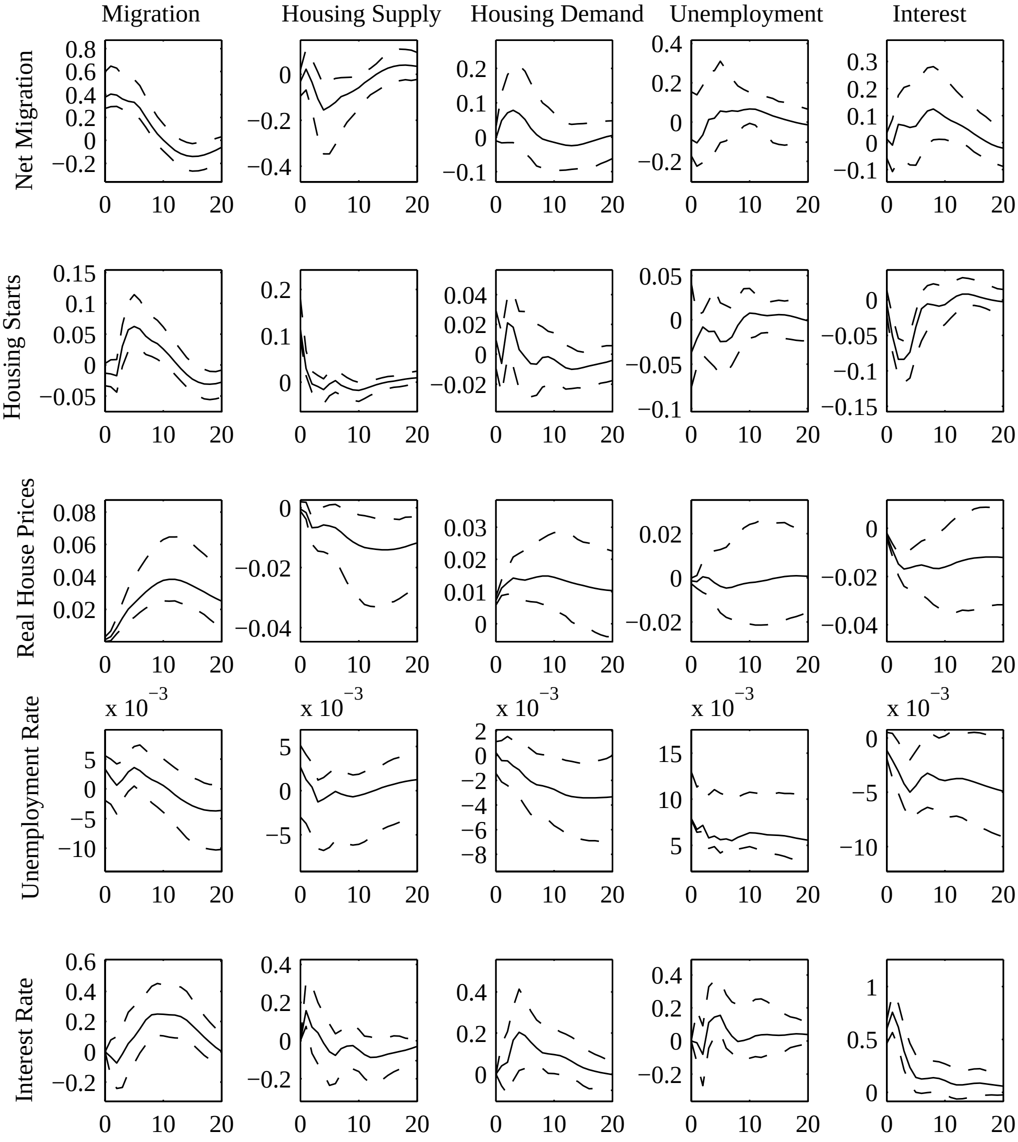
The long-run accumulated impacts of the net-migration shock on net-migration, housing starts, and real house prices are depicted in table 10.

The main difference between these elasticities and those in table 5 concerns the housing starts ratio. In this model there is a smaller response of housing starts to migration: the ratio is never bigger than 0.12 and in the long run only 0.06 houses are built per migrant. If correct, this estimate must be considered very small, given the average ratio in New Zealand is 0.35. The price elasticities are pretty similar to the results obtained with the unemployment rate in the VAR for the initial period and for 4 quarters out from the shock. The price elasticities are smaller at 8, 12, and 100 quarter horizons, although consistent with the elasticities obtained for the first period.

These results differ from those estimated using the unemployment variable by attributing more of the housing cycle to local factors and less to migration. In particular, it suggests that the big swings in construction are primarily caused by income changes rather than migrants. Nonetheless, it appears that migrant flows still have an extremely large effect on house prices.

Figure 5
Structural impulse response functions: 1991Q1–2006Q3

(GDP)



Appendix B: A brief history of migration and the housing market

Migration

Figures 6 and 7 show seasonally adjusted migration flows from 1962 to 2006. Quarterly emigration increased from a low of 0.12 percent of population in 1962 to a peak of 0.70 in 1979: since then it has oscillated between 0.24 and 0.57 per cent, with peaks in 1989 and 2001. The mean and standard deviation of quarterly emigration are 0.36 and 0.11 percent respectively. Immigration has been of similar magnitude, with peaks in 1973, 1996, and 2003. The mean and standard deviation are 0.38 and 0.10 percent. Quarterly flows of immigrants and emigrants are uncorrelated, so the mean and standard deviation of net migration are 0.01 and 0.14 per cent respectively. In comparison, mean population growth was 0.28 per cent per quarter.

New Zealand citizens returning from abroad make up a sizeable fraction of immigrants, including half of the migrants from the United Kingdom, and 60 percent of the migrants from Australia. However, there is relatively little variation in these flows. Since 1990, the number of New Zealand citizens returning from abroad has only varied from 20,000 (1999) to 29,000 (1991), or between 0.13 and 0.19 percent of the population per quarter. Consequently, the major swings in immigrant numbers are due to fluctuations in the number of foreign born immigrants.

The regional pattern of international migration flows is very uneven. A majority of inward migrants go to Auckland, whereas departing migrants leave from all over the country. As a consequence, Auckland tends to gain people from foreign migration irrespective of New Zealand's net migration position. For example, in the five years to 1991 net foreign migration to Auckland was $+10,000$ while net migration to New Zealand was $-70,000$; in the five years to 2005, net foreign migration to Auckland was +63000 while net foreign migration to New Zealand totalled 105,000. Moreover, these inflows are not offset by outflows of Auckland residents to the rest of the country. Auckland only lost 17,000 people between 2001 and 2006, and during the previous fifteen years it gained 8,000 people from internal migration.

Figure 6
Immigration as a fraction of population, seasonally adjusted 1962-2006

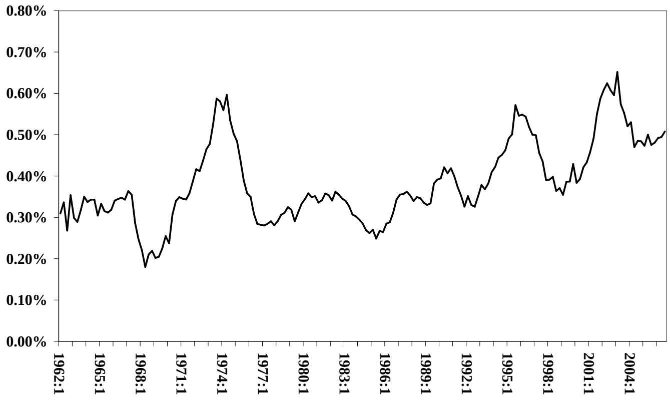
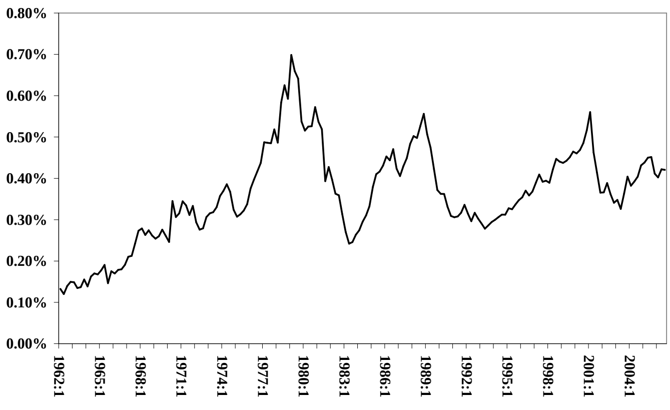


Figure 7
Emigration as a fraction of population, seasonally adjusted, 1962-2006



House prices

Real house prices increased threefold between 1962 and 2006. Between 1962 and 1993, real prices increased by an average of 1.1 percent per year, or by 43 percent in total. This phase was marked by an extremely rapid increase between 1972 and 1974, followed by a six year period of real decline. Since 1993, prices have increased by 105 percent or 5.2 percent per year. The extremely fast increase in house prices that occurred after 2003 is actually smaller in magnitude than that which occurred between 1972 and 1975, although the latter increase was followed by a steep decline.

The pattern of real house prices is broadly similar to that in Great Britain and Australia (see figure 8). The steep increase and subsequent decline of real house prices that occurred in New Zealand in the 1970s is similar to the changes that occurred in Great Britain and Australia at the same time. Moreover, each country has experienced a large increase in real house prices during the last ten years, and they are now twice the 1986 level in all three countries. (The price increase in New Zealand started later than the increases in Australia and Great Britain, but has been more rapid.) This broad similarity of price trends suggests either that common international factors affect all three countries, or that house prices in the three countries are directly linked because houses in each country are substitutes for each other. There is some evidence that trans-Tasman migration is responsive to house price differences, but the size of this response is small, and it seems unlikely that inward trans-Tasman migration causes large increases in New Zealand house prices.[23] Consequently, it seems most likely that house prices in these three countries are responding to common factors such as interest rates or common technological progress and income growth.

Housing construction

The responsiveness of the construction industry to demand pressures is an important determinant of how house prices respond to immigration flows. Fig-

[23] The number of immigrants from Australia is highly correlated with the ratio of real house prices in Australia and New Zealand: the simple correlation between the house price ratio and the number of immigrants in the subsequent four quarters is 0.72, rising to 0.84 if the price differential is lagged four quarters. However, the slope suggests a 10 percent increase in the house price ratio is only associated with a 650 increase in the number of immigrants from Australia, or by about 5 percent of the average number of immigrants from Australia.

Figure 8
Real house prices in New Zealand, Great Britain, and Australia 1960-2006

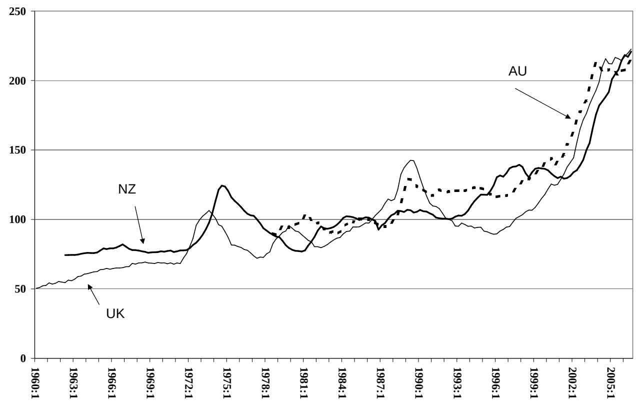


Figure 9
Real residential construction activity per capita, ($1995) 1965-2006

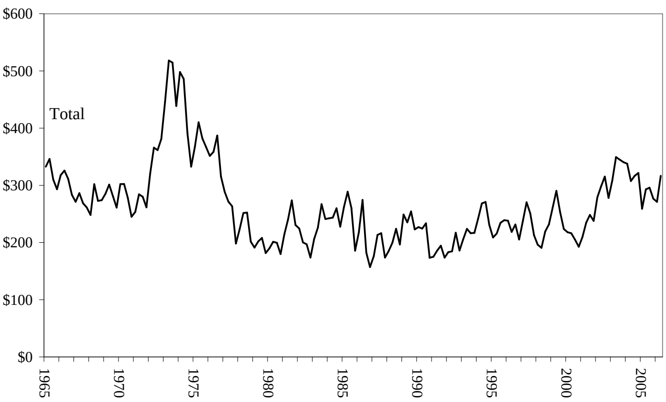


Figure 10
Construction employment in New Zealand 1973-2006

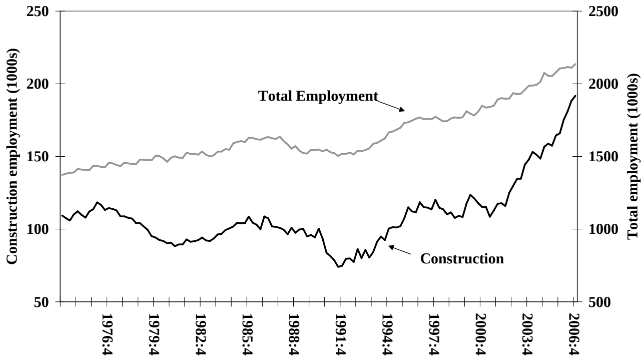
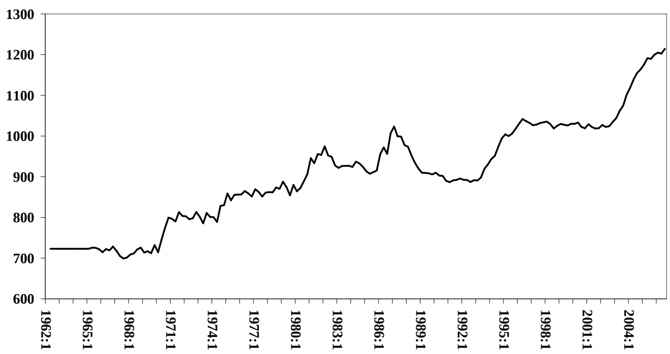


Figure 11
Real construction costs in New Zealand, 1962-2006



ure 9 shows real per capita residential construction activity in 1995-equivalent dollars.[24] Real per capita construction activity was considerably higher in the 1960s and 1970s than subsequently, declining from $280 per person per quarter during 1965-1978 to $170 per person per quarter during 1979-1991, before increasing to $250 per person per quarter during 2002- 2006.

Real residential construction activity per capita reflects three factors: the number of new houses being built; the average size of these houses; and the value of alterations. Of these factors, variation in the number of new houses is the main cause of variation in construction activity. The number of building permits declined sharply after 1979, from 2.23 permits per thousand people per quarter, 1962-1978, to 1.52 permits per thousand people per quarter 1991-2006. The decline in the number of houses was only partially offset by a 20 percent increase in the size of houses.[25] Alterations comprise about a fifth of all residential construction activity, but the real value of alterations only varied between $35 and $60 per person per quarter since 1962.

There are two factors behind the post-1980 decline in residential construction. First, on the demand side, government incentives that favoured the construction of small houses were removed in March 1979. Until then, the government provided heavily subsidised Housing Corporation loans to young families on the condition they built or purchased a new house, rather than purchased an existing house. Since young families could not afford large houses, small houses were built.[26] In March 1979, applicants for subsidised loans were allowed to choose between new and existing homes, removing the subsidy to build. Without theses subsidies, the number of new starts decreased and the average size of houses increased.

Second, on the supply side, the capacity of the construction industry declined

[24] The series is calculated as the nominal value of building permits deflated by the construction cost index divided by the total population.

[25] Even though there has been a substantial increase in average size of new houses, the real quantity of resources used to construct each house only increased by about 20 percent over the period as large houses costs less per square metre to build than small houses. According to the Department of Building and Housing, it costs about 15 percent more per square metre to build a small (145 m^2) house than a large ($202m^2$) house. In addition, many large houses are built en masse in residential subdivisions, which lowers costs by a further 20 percent.

[26] On occasion there was direct intervention to prevent large houses from being built. In the 1974 Budget, at the height of the construction boom, the government legislated that houses over 1500 square feet had to be delayed for 18 months.

sharply after 1975, partly through the migration of construction workers. The number of people employed in the construction sector declined from 110,000 in 1975 to 75,000 in 1991, or from 8 percent to 5 percent of the workforce (see figure 10). Some 17,500 carpenters, bricklayers, and painters emigrated between 1975 and 1981. The sector began to recover after 1991, although it did not return to its early 1970s size (as a fraction of the workforce) until 2003, partly because New Zealand remained a net exporter of construction workers after 1991. Since 2000 the construction sector has expanded particularly rapidly, from 6 percent to 9 percent of the workforce.

The decline and rise of the construction sector since 1975 has had two major consequences. First, fifteen years of relatively subdued construction levels meant that the overall quality of the housing stock was ill-suited for the post 1993 economic revival. The average size of new houses was only 125m^2 between 1980 and 1990; by 2006 it had increased to 190m^2 as an increasing fraction of households chose to purchase new large houses rather than small old houses.[27] Second, the reduced capacity of the industry meant it was ill placed to meet the increase in demand in the middle of the 1990s and after 2001, resulting in a shortage of labour and sharp increases in construction costs.

Figure 11 shows the pattern of real construction costs (residential construction costs deflated by the CPI) over the period. The series is characterised by a sequence of sharp increases, in 1970 (+11%), 1974 (+7%), 1980 (+9%), 1986 (+10%), 1993-1994 (+12.7%), and 2003-2004 (+12.6%), with two intervening declines, 1983 (-5%) and 1988-1989 (-11.1%). The sharp increases in construction costs generally occurred when firms reported they faced shortages of skilled construction labour, including the occasions that building permits reached local peaks in 1974, 1986, 1993, and 2003.[28]

The changes in the size of the construction sector since the 1970s are associated with a change in the link between population change and housing construction. Prior to 1981, building permit numbers changed extremely quickly in response migration flows, but there was little change in construc-

[27] Fifty percent of the 400,000 houses built since 1991 exceeded 200m^2; 16 percent exceeded 300m^2.

[28] The Quarterly Survey of Business Opinion has asked construction firms about the ease of hiring skilled labour since 1975. The response to this question is negatively correlated with changes in real construction costs.

tion costs.[29] Since 1991, however, migration flows have been associated with sharp increases in the cost of construction, but little increase in output, seemingly because of capacity constraints in the industry.[30]

The size of newly constructed houses warrants further mention. Since 1991, there has been a substantial change in the distribution of the size of the houses and apartments built in New Zealand. Between 1973 and 1990, there was only a modest increase in the average size of new dwellings, measured by the size of building permits, from $110m^2$ to $135m^2$. Thereafter, the fraction of new houses less than $100m^2$ declined substantially from 17 percent to 6 percent, while the fraction of houses between 100 and 199 m^2 dropped from 50 percent to 30 percent. In contrast, the fraction of houses over $300m^2$ increased from 8 percent to 22 percent (see figure 12). It is plausible that this shift is a response to a long period of underinvestment in high quality housing during the 1970s and 1980s.

House sales volume

Figures 13 and 14 show the pattern of quarterly real house price changes and quarterly sales volume since 1990. It is apparent that there has been an extraordinarily close relationship: the simple correlation coefficient is 0.86, with an increase in sales volume equal to 1 house per 1000 people per quarter associated with a 1.7 percent increase in house prices.

This relationship is of interest for two reasons. First, since the relationship can be written as

$$ln(P_t) = ln(P_{t-1}) + \beta(Sales\ Volume_t - \overline{SalesVolume}) + e_t \qquad (24)$$

where $\overline{SalesVolume}$ is the mean sales volume and β is estimated to be 1.7, it suggests a temporary increase in sales volume is associated with a permanent increase in house prices.[31] This is surprising. If expectations were formed

[29] The simple correlation between quarterly net migration inflows and quarterly building permits is 0.67, with a slope of 2.0 houses per 10 migrants. The correlation between net migration flows and real changes in construction costs is 0.01.

[30] The correlation between migration flow and quarterly changes in construction costs, 1991-2006 is 0.35. A migration flow equal to one percent of the population is associated with a 2.4 percent increase in real construction costs. The correlation coefficient between migrant flow and building permits in this period is 0.31, but only an additional 0.65 (rather than 2.0) building permits per 10 migrants were issued.

[31] The specification can be changed to estimate the coefficient on $ln(P_{t-1})$, rather than impose it as 1. When the coefficient is estimated, its coefficient is 0.99.

Figure 12
Floor size of new residential construction, 1991-2007

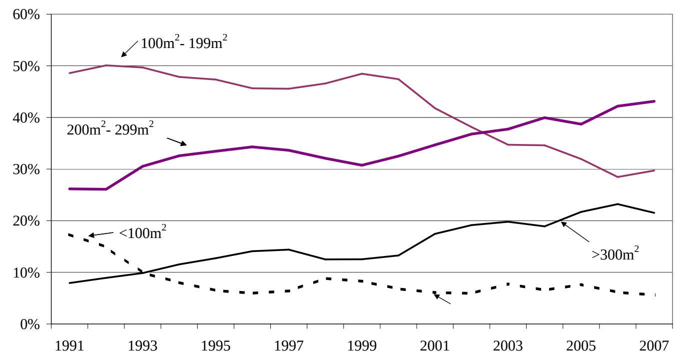
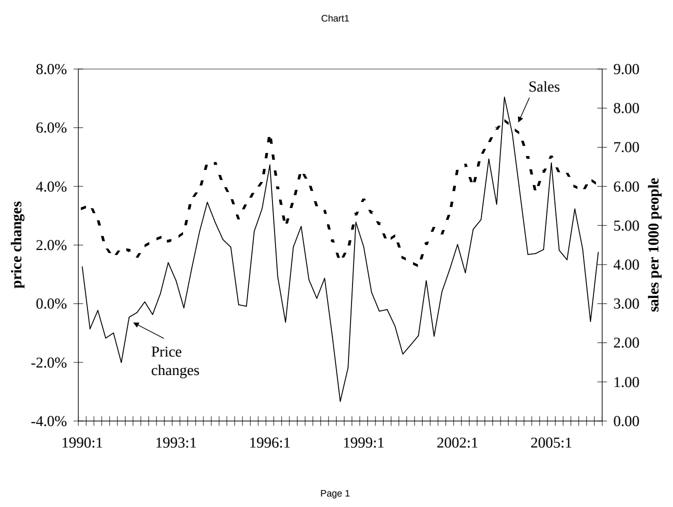


Figure 13
Quarterly house price changes and real estate sales volumes, 1990-2006



rationally, one would expect a relationship of the form:

$$ln(P_t) = ln(E[P_t]) + \beta(Sales\ Volume_t - \overline{SalesVolume}) + e_t \qquad (25)$$

In this case, a temporary increase in sales volume would temporarily increase prices above their expected level, but have no long term effect on prices unless expectations changed. Second, figure 15 shows that sales volumes are highly correlated with the second lag of immigration flows. The simple correlation is 0.76, with a slope of 0.9 (0.9 sales per immigrant).[32,33] Since it is unlikely that immigrant inflows occur in anticipation of real estate sales, this relationship is likely to be causal. If so, it appears that immigrant inflows lead to a direct increase in sales volumes, which in turn leads to an increase in house prices. If, in addition, house price expectations are set adaptively, it is possible that immigration could be destabilising the housing market by their effect on expectations. These empirical relations are thus consistent with the adjustment mechanisms suggested by the costly search literature.

[32] While this coefficient is high, it should be borne in mind that most sales come in pairs: when a migrant purchases a house, the seller usually purchases another one.

[33] More elaborate specifications can be estimated. In particular, it proves that when a measure of consumer confidence is included in a regression of sales volume versus immigration flows, the fit improves further. In this case the slope coefficient falls to 0.8.

Figure 14
Quarterly house price changes and real estate sales volumes, 1990-2006

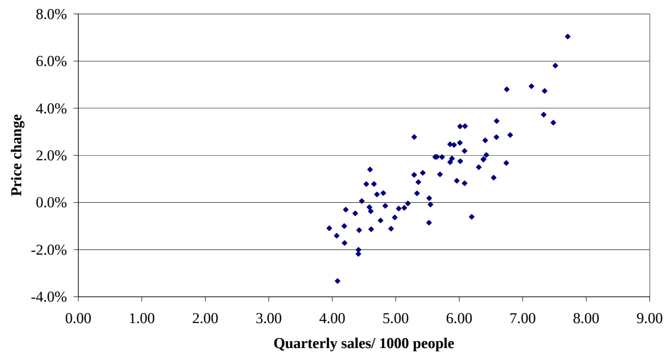


Figure 15
Quarterly immigration flows (lagged 2 quarters) and real estate sales volumes, 1990-2006