An Econometric Time-Series Analysis of Australian Housing Activity from a Macroeconomic Perspective

by

Jammie H. Penm

A thesis submitted for the degree of

Doctor of Philosophy

of the Australian National University

April 1993
In compliance with the requirements relating to Admission to Examination for the Degree of Doctor of Philosophy of the Australian National University, it is affirmed that, unless otherwise stated, the work that follows is my own.

Jammie H Penm
Acknowledgments

I am grateful to my supervisor, Professor Deane Terrell, for his support and supervision on this thesis. I also wish to thank Dr Robert Albon and the Department of Statistics, Faculty of Economics and Commerce, especially the chairman - Dr Trevor Breusch, for the comments and assistance I received during the course of this study. The Department has been a stimulating environment for undertaking a project of this nature. Finally, I would like to thank Dr Jack Penm for his instructions on programming techniques. Discussions with him on theoretical issues in time-series econometrics also significantly enhanced this thesis. This is also acknowledged with gratitude.
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Bibliography
Abstract

The significant fluctuations in housing activity over time can be regarded as "interesting" and "special". The persistence of such cyclical behaviour of housing activity through periods of different economic and demographic conditions has attracted significant research efforts to investigate the underlying influences and the implications for the economy as a whole.

In this thesis, the factors which contribute to cyclical fluctuations in housing activity are examined using econometric time-series techniques. While the commonly used indicators of housing activity are stationary over the sample period investigated, most important economic and financial variables which significantly influence housing activity can be characterised as co-integrated of order (1, 1). A new procedure is therefore developed and utilised widely for examination of such systems which contain both co-integrated and stationary series. This procedure is an innovative way of analysing housing activity as the "error-correction" like processes generated from the co-integrated economic and financial variables form an important part of the system in explaining the cyclical fluctuations in housing activity.

In this thesis, it is shown that the fluctuations in housing activity are related to the policy instruments used by the Government for stabilising the macroeconomy. In particular, housing activity is found to respond significantly to changes in short term interest rates and real income, or general economic activity, although the effects resulting from changes in the money supply and general price level are much less substantial. While the response of housing activity to a change in short
term interest rates is prolonged, the effect of innovations in real income, or general economic conditions, on housing activity only persists for a much shorter period. In addition, policy on immigration is also an important element influencing the level of housing activity. However, over the short to medium terms, changes in economic and financial variables produce more significant effects on housing activity than that generated by net migration or increases in population.

Interestingly, housing activity also feeds back on the level of short term interest rates, which suggest that housing activity may be an important determinant in the decision-making processes of the monetary authorities. In contrast to previous testing for Australia, housing activity is found to "Granger cause" general economic growth in a number of modelling exercises. These results consistently affirm that housing activity contains leading information for changes in general economic conditions and, therefore, can be used as a "leading indicator" of general economic activity.
Chapter 1

Introduction

1.1 Purpose of Study

This thesis examines the underlying factors which contribute significantly to cyclical fluctuations in Australian housing activity. In particular, its purpose is to assess the influences on housing activity from a macroeconomic perspective. The inquiries have embraced several major issues relating to cyclical variations in housing activity. One is the interrelationships between housing activity and changes in the macroeconomic environment. Is the relationship between the building industry and the general economy dependent on the policy instruments used by the Government for stabilising the macroeconomy? A second issue relates to the relationship between housing and macroeconomic variability. Can the fluctuations in housing activity provide some leading information on the changes in general economic growth? After all, fluctuations in housing activity can affect the general economy through the demand for building materials and both skilled and unskilled labour. A third issue is the effect of population growth on housing activity. Population and income growth have long been regarded as the two major factors determining the level of housing activity in the long term. Which source of population growth, net migration or domestic population change, would contribute more to the fluctuations in housing activity? Compared
with the effects of the changing macroeconomic environment, which impact is more significant in the resulting cyclical behaviour of housing activity?

These issues are complex and have not been resolved. In this thesis, the approach used to address these questions is straightforward. Real data are employed to identify the mechanisms associated with the adjustment of the housing industry to external changes. The responses of housing activity to the changing economic and demographic factors are examined, revealing the existence of options which can be used to reduce fluctuations in the construction industry. The methodology used in this thesis is an econometric time-series technique. Housing activity and relevant economic and demographic variables are initially specified as a vector autoregressive (VAR) process. Statistical tests and procedures are employed to identify the long-term relationships as well as the short-term dynamics.

The structure of this thesis is organised in the following way. In the remainder of this chapter, a brief examination is given on the important macroeconomic variables which influence or result in the fluctuations in housing activity. In Chapter 2, the modelling exercises on fluctuations in Australian housing activity are reviewed and attempts are made to evaluate the findings of these important analyses. Chapter 3 explores the linkages between important housing activity indicators - approvals, commencements and completions - and the interrelationships between these and other related financial and economic variables. This examination has been undertaken using a procedure which is specifically designed for time series systems which contain both co-integrated
and stationary series. This developed procedure has proven to be useful in analysing activity in housing construction as many housing and housing-related macroeconomic series are either stationary in levels or around a linear trend. In Chapter 4, the question posed is whether the fluctuations in housing activity can be used as a leading indicator for changes in general economic activity. This chapter forms a basis for the analysis presented in Chapter 5, in which the effects of changes in important macroeconomic instruments on housing activity are simulated using an impulse response approach. Chapter 6 grapples with the difficult but important question of the response of housing activity to increases in population. The major problems encountered in this analysis relate to data availability. Several assumptions and procedures were adopted to obtain the required data for the analysis. Chapter 7 summarises the most important findings of this thesis.

1.2 Australian Housing Activity

The Housing Cycle

Activity in residential construction can be characterised by a high degree of variability in a commonly used indicator, quarterly commencements of private residential dwellings (Figure 1.1). This series provides a measure of the variability in output and resource-utilisation of the construction industry over time. The average difference between consecutive peaks and troughs, over the

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1.1 Examination of the associated power spectrum indicates that the Nyquist
period 1970-90, was about 12,000 commencements, reflecting a variation of about 30 per cent of the average level of around 30,000. In value terms, the average peak to trough over this period is around $600m in 1984-85 prices, representing around 30 per cent of the average value of $1800m in 1984-85 prices.

Figure 1.1 Private Dwelling Commencements

frequency for this series over the sample period is 0.104 cycles per quarter (or around 9.5 quarters per cycle). For details of the calculation, see Robinson (1967).
The fluctuations in housing activity have been volatile (Table 1.1). The volatility was comparatively strong in the early 1970s and late 1980s. The surge in the early 1970s can be characterised by buoyant domestic economic conditions, followed by a sharp slump that reflects the adverse effects of an economic downturn associated with a tightening of monetary policy to reduce high inflation induced by the oil price shock (Figure 1.2). The upturn in late 1980s can also be attributed to a booming domestic economy, but more importantly to a change in the Government immigration program which resulted in the level of net migration increasing significantly from a low of 49,000 in 1983-84 to about 164,000 in 1988-89 (Figure 1.3). The substantial fall after that was again the result of a tightening of monetary policy which was in force in response to a worsening in the level of external balances which pushed the short term interest rates to a record high level. The persistence of this cyclical behaviour over the sample period, through periods of different economic and demographic conditions, clearly indicates that fluctuations in housing activity are likely to continue, at least in the near future.

Besides dwelling commencements, approvals and completions are also commonly used as indicators of housing activity. However, different variations in the cyclical behaviour can be observed for these indicators with the variation decreasing according to the stage of production. These differences could be the result of changing economic conditions and the financial situation of the builders. The fluctuations in construction of other dwellings appear to be more volatile than those for houses, although the share of other dwellings in total construction was normally less than 30 per cent (Table 1.2).
Table 1.1 Volatility of Australian Dwelling Investment

Cyclical Fluctuations

<table>
<thead>
<tr>
<th>Peak to Peak</th>
<th>Trough</th>
<th>Peak to Trough Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar 70 - Sept 73</td>
<td>Dec 70</td>
<td>1.28</td>
</tr>
<tr>
<td>Sept 73 - Dec 76</td>
<td>Jun 75</td>
<td>1.44</td>
</tr>
<tr>
<td>Dec 76 - Sept 80</td>
<td>Sept 78</td>
<td>1.33</td>
</tr>
<tr>
<td>Sept 80 - Dec 84</td>
<td>Mar 83</td>
<td>1.34</td>
</tr>
<tr>
<td>Dec 84 - Jun 89</td>
<td>Mar 87</td>
<td>1.39</td>
</tr>
</tbody>
</table>

Comparison with Domestic Economic Activity

<table>
<thead>
<tr>
<th>Share of GDP</th>
<th>Volatility&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dwelling investment</td>
<td>5.1</td>
</tr>
<tr>
<td>Private consumption</td>
<td>59.2</td>
</tr>
<tr>
<td>Plant and equipment investment</td>
<td>7.0</td>
</tr>
<tr>
<td>Imports</td>
<td>15.5</td>
</tr>
<tr>
<td>exports</td>
<td>13.7</td>
</tr>
<tr>
<td>Gross farm product</td>
<td>4.7</td>
</tr>
<tr>
<td>Gross domestic product</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<sup>a</sup>: Defined as standard deviation of the ratio of actual to trend values divided by the average ratio for the period 1959:3 to 1988:2.
Table 1.2 Composition of Australian Private Dwellings

**Stock**

<table>
<thead>
<tr>
<th>Year</th>
<th>Houses</th>
<th>Houses (%Share)</th>
<th>Other (%Share)</th>
<th>Total Occupied (%Share)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961</td>
<td>2611</td>
<td>88.0</td>
<td>5.8</td>
<td>2782</td>
</tr>
<tr>
<td>1966</td>
<td>3029</td>
<td>88.7</td>
<td>3.7</td>
<td>3155</td>
</tr>
<tr>
<td>1971</td>
<td>3575</td>
<td>89.2</td>
<td>2.4</td>
<td>3671</td>
</tr>
<tr>
<td>1976</td>
<td>4054</td>
<td>88.7</td>
<td>1.9</td>
<td>4140</td>
</tr>
<tr>
<td>1981</td>
<td>4536</td>
<td>88.3</td>
<td>2.6</td>
<td>4669</td>
</tr>
<tr>
<td>1986</td>
<td>5049</td>
<td>88.1</td>
<td>2.4</td>
<td>5187</td>
</tr>
</tbody>
</table>

**New Construction**

<table>
<thead>
<tr>
<th>Year</th>
<th>Houses</th>
<th>Houses (%Share)</th>
<th>Other (%Share)</th>
<th>Total Construction</th>
<th>Total Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961</td>
<td>56.2</td>
<td>86.9</td>
<td>8.5</td>
<td>13.1</td>
<td>80.0</td>
</tr>
<tr>
<td>1966</td>
<td>67.2</td>
<td>70.6</td>
<td>28.0</td>
<td>29.4</td>
<td>110.7</td>
</tr>
<tr>
<td>1971</td>
<td>88.4</td>
<td>70.4</td>
<td>37.1</td>
<td>29.6</td>
<td>142.2</td>
</tr>
<tr>
<td>1976</td>
<td>101.8</td>
<td>77.9</td>
<td>28.9</td>
<td>22.1</td>
<td>143.8</td>
</tr>
<tr>
<td>1981</td>
<td>94.9</td>
<td>69.2</td>
<td>42.3</td>
<td>30.8</td>
<td>146.5</td>
</tr>
<tr>
<td>1986</td>
<td>86.5</td>
<td>80.1</td>
<td>20.5</td>
<td>19.9</td>
<td>121.7</td>
</tr>
</tbody>
</table>

In thousands. a: Includes self-contained flats. b: Total of private and public construction.
The cyclical fluctuations in housing activity have been mainly driven by demand changes. The level of housing activity has been under the influences of macroeconomic instruments, especially monetary policy. Before deregulation of mortgage interest rate ceilings in April 1986, activity in the housing market was, perhaps, subjected more to quantitative controls on mortgage lending associated with so-called "credit rationing" than to the direct effects of mortgage interest rates. Over this period, variations in housing activity and finance approvals were more related to the tightness of monetary conditions, as shown by the 90 day bank bill rate, than to the mortgage interest rate (Figure 1.2). The mortgage interest rate has moved more freely and more in line with the commercial rates since deregulation. However, there have been concerns regarding a continued practice of "credit rationing" by financial institutions to control the flow of funds into the housing market since deregulation (Bassanese, Horn and Simes, 1989). Accepting these concerns have basis, financial markets would continue to contribute to fluctuations in housing activity over and above the effects arising from mortgage interest rates. The commercial interest rates, in these circumstances, would influence housing activity more significantly than the mortgage interest rate even in a deregulated environment.

The other important factor which results in cyclical fluctuations in housing activity is variations in income. Although expected income, rather than present income, may be more important in the consumers' decision-making on the consumption of housing services, financial institutions use only present income,
Figure 1.2 Interest Rates

The 90 day bank bill rate

The saving bank mortgage rate

Figure 1.3 Natural Increase and Net Migration

Natural increase

Net migration
not expected income, in the assessment of loan application and the size of mortgage lending for an individual household. As a result, the ability of households to meet mortgage repayments out of their current income becomes an important constraint in their demand for dwellings. Such a constraint is commonly referred to as lack of "affordability". Understandably, both expected and current income are important in the households' purchase of dwellings. A temporary increase in the households' current income may temporarily increase the short-term affordability, however, continued ability to meet the mortgage repayments, if a purchase was made, could be difficult over the longer term. On the other hand, an increase in the households' expected income without a rise in their current income will not improve the households' ability to meet the affordability constraint set by the financial institutions. Consequently, the purchases of dwellings, if borrowing is required, would have to wait until the households' current income actually rises.

The distribution of the effect of changes in income is different from the interest rate effect. While the fluctuation in income may be used by both the builders and consumers as an indicator of general economic conditions, this effect impacts more on the middle and low income classes, especially the first-home buyers, than on the high income group. However, higher interest rates will increase not only the construction costs for new dwellings, and hence their prices, but also the costs of housing services in general. Consequently, higher interest rates will affect all the income groups in the community without exception.

Another major source of instability comes from increases in population or
households. In Australia, the flow of net migration has been particularly volatile compared with the natural increase in population (Figure 1.3). While most studies in the field emphasise the long-term relationship between population increase and the "underlying requirements" for housing, the short-term effect of changes in the level of net migration could be very significant for housing activity. For example, the surge in housing construction in late 1980s has been widely regarded as attributable, at least to a significant extent, to the increase in the level of net migration. During that period, net migration surged from about 118,000 in 1986-87 to a high of 164,000 in 1988-89, compared with an upturn in private dwelling commencements from around 103,000 in 1986-87 to 165,000 in 1988-89. Similar influences from demographic changes to housing activity are also evident from the earlier cyclical movements in dwelling commencements.

To examine how these factors generate cyclical behaviour in housing construction, let us consider examples of an increase in income, a decrease in interest rates or a surge in the level of net migration. All these changes will induce an increase in the demand for dwellings and lead to a rise in the price of established dwellings which provides an incentive for more new construction. As housing construction increases, this will increase the demand for outputs from the industries which provide services or goods for the construction of new houses as well as more work opportunities for both skilled and unskilled labour. As both housing and general economic activity become buoyant, this may induce a response from the monetary authorities to tighten monetary policy and so to increase the domestic interest rate structure, which in turn results in reduced housing activity. In addition, the sluggish response of dwelling supply is also
likely to accentuate the cyclical fluctuations. It takes time for the supply of dwellings to respond to the surge in demand, and this response in supply may not satisfy the increase in demand exactly. If the situation of excess demand persists, then more construction will follow. If the increase in supply overshoots the excess demand and creates a situation of over-supply, then another response will begin, adding more volatility to the housing cycle.  

The Effect of Housing Cycle on the Economy

The activity of housing construction will induce demand for outputs from building-related industries and increase work opportunities. Another area which will also be affected is consumer durables such as electrical appliances and furniture, as newly constructed houses need these facilities to be properly inhabitable. In value terms, housing investment makes up around 5 per cent of the gross domestic product (GDP). However, the size of the fluctuations and the second round effects on housing-related industries mean that the housing cycle can have an important bearing on general economic activity. As a result, housing activity has often been used as a leading indicator of changes in general economic

1.2 Changes to the institutional and regulatory arrangements may also be a factor which influences the level of housing activity. These changes include the introduction of first home owner grants, changes in the interest deductibility schemes and a number of changes in taxation on housing properties. Given that these changes are unlikely to contribute significantly to the persistence of cyclical fluctuations in housing activity, no discussion is given on these changes for the reason of brevity.
growth. Especially in times of recession, attention is often focused on the housing market in a search for signs of recovery. In economic downturns, housing activity is often expected to lead the general economy on the way out of recession.

Although it may be difficult to quantify the detailed interrelationships between housing and general economic activity, some studies in this field were undertaken using the Department of Treasury's NIF-88 macroeconomic model (Simes 1988 and Bassanese et al. 1989). The major findings indicate that GDP will expand more than the direct impact of the increase in construction activity and the higher housing and economic activity will, later on, induce a rise in the domestic interest rate structure which will in turn result in adverse effects on housing and general economic activity. These results clearly indicate that there are significant interrelationships between housing and general economic activity and the domestic interest rate structure is an important factor in explaining the fluctuations in housing activity.

The cyclical fluctuation in housing activity is common in countries other than Australia. Despite differences in government regulation and the housing industry characteristics, a high degree of similarity is evident in terms of the volatility and the importance of housing construction for each individual domestic economy (Table 1.3). An interesting issue in the overseas, or more specifically the US, debate on the relationship between housing and general economic activity was whether the housing cycle could be used to counter the business cycle in general economic activity. It was argued, that this counter-cyclicality of housing activity
could lead to higher efficiency in resource-utilisation for the economy as a whole. However, many economists disputed this counter-cyclical role of housing activity. For example, Rosen (1984) argues that, because of its higher sensitivity to changes in monetary policy, the counter-cyclical phenomenon of housing activity observed in the US reflects the fact that housing activity precedes, rather than counters, the booms and slowdowns in general economic activity. Housing activity, argued Rosen, can be taken as a measure of the effectiveness of monetary policy or a leading indicator of general economic activity. Any sharp decline in housing activity can be regarded as a symptom of excessively stringent monetary policy.

Table 1.3 Housing Volatility in Selected Countries/1960-88

<table>
<thead>
<tr>
<th>Country</th>
<th>Share of GDP</th>
<th>Volatility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>5.1</td>
<td>0.114</td>
</tr>
<tr>
<td>USA</td>
<td>5.1</td>
<td>0.143</td>
</tr>
<tr>
<td>UK</td>
<td>4.1</td>
<td>0.126</td>
</tr>
<tr>
<td>Japan</td>
<td>6.6</td>
<td>0.250</td>
</tr>
<tr>
<td>Sweden</td>
<td>5.0</td>
<td>0.086</td>
</tr>
<tr>
<td>Canada</td>
<td>6.0</td>
<td>0.093</td>
</tr>
</tbody>
</table>

Volatility is defined as the coefficient of variation of the ratios of actual to trend values. Source: Bassanese et al. (1989) and Anderssen and McEvoy (1990).
1.3 Issues in Methodology and Data

Unit Roots

One approach to modelling the activity of housing construction without using a complex and full-scale macroeconomic model is an econometric time-series technique. There is considerable evidence that the interactions between many macroeconomic time series can be well described by vector autoregressive (VAR) models. There are, at least, two important issues associated with this technique which could have significant effects on the estimation results. One is the "trending" nature of the individual series involved so that "differencing" or "detrending" the data may be necessary to achieve stationarity in the system. The other is that the total number of unit roots in the system formed by these series may be less than the sum of the number of unit roots in each of the univariate time series. The major problem of the presence of trend and unit roots is that, if not removed, the standard errors obtained from the estimation will be biased and the distribution of the associated test statistics will be substantially distorted. If the number of unit roots in the system is less than the sum of the number of unit roots in the individual series, this implies that there is "co-integration" between the integrated series in the system. In this situation, the coefficient estimates obtained using a VAR in first differences will be biased because this estimation ignores the reduced number of unit roots in the system and results in mis-specification and "over-differencing" in a system context.

The concept of co-integration has important implications for the underlying
economic relationships in the system under investigation. Economic theory may suggest that there are certain long-term equilibrium relationships between certain economic variables and a test for co-integration between them could be a test for these implications (provided that these variables can be characterised as integrated processes). If co-integration does exist in the system, then such relationships should be imposed explicitly when forecasting. Although the benefits to the short-term forecasts, compared with a VAR system without this restriction of co-integration, appear to be in doubt, recent empirical studies have demonstrated that imposing such a restriction would significantly benefit the forecasts in the longer term (see Engle and Yoo 1987, LeSage 1990 and Clements and Hendry 1992a, b).

To ensure that the trend and unit root properties are adequately accounted for, a pre-testing strategy has been adopted in the empirical studies presented in this thesis. That is, before selecting a suitable representation for the system under investigation, the presence of trend and unit roots in both the individual series and the system they form is properly tested. This consists of a test for the presence of unit roots at both the seasonal and zero frequencies and, if two or more series are found to contain unit roots at the same frequency, a test for co-integration at that frequency will follow. In these tests, the influence of trend or seasonal dummies is incorporated. As suggested by Dickey, Bell and Miller (1986), seasonal dummies, which are deterministic, can be removed prior to the application of tests for unit roots. This approach has been followed in these studies. Seasonal dummies, if significant, are being removed prior to the testing for unit roots or co-integration.
Naturally, the findings of our studies are also based on these results of testing for unit roots and co-integration. It is well known that the power of the popular tests for unit roots such as the Dickey and Fuller (1979) test against a borderline stationary alternative is low and that the limiting distributions of these test statistics are affected by nuisance parameters. However this does not appear to be a serious problem in these studies as the test results for unit roots obtained from different test procedures produce consistent conclusions. Interestingly, consistency is also established between the monthly and quarterly observations for the variables under test. For example, while the test results for the monthly dwelling approvals accept the stationary alternative, a similar conclusion was obtained for the quarterly dwelling approvals using the same test procedures for unit roots.

**Aggregation in Data**

The data used in this thesis are mainly the aggregate monthly or quarterly observations. Although monthly data are preferred for studies in this context, the availability of data imposes a serious limitation on such a practice. The use of quarterly data in some of the studies may have important implications on the empirical findings as aggregation in data may result in distortions of the underlying relationships and the short-term dynamics. As suggested by Rossana and Seater (1992), temporal aggregation can have significant effects on the specification or order of the underlying VAR system. For example, a system may be found to be a complex VAR model with a high order of lag, say 5 or 6, using the monthly data. However, when quarterly data are used, the same system may
become a simple VAR of order 1 or 2. Understandably, the coefficient estimates could also be affected by aggregation. However, given that most of the data required for these studies are not available on a monthly basis, this data deficiency is difficult to overcome.

One approach usually used by researchers to overcome such a difficulty is to interpolate the required monthly data from the relationships of its quarterly series with other variables. However, this method is not appropriate in this context especially for the testing for co-integration. This is because when the interpolation is undertaken, the property of unit roots in the generated monthly series would depend on the presence of unit roots in the explanatory variables used in the interpolation. If the explanatory series used are stationary or stationary around a linear trend, then the generated monthly data will also be a stationary series. However, even when all the explanatory variables are integrated series, the interpolated monthly data can still be a stationary series if some of the explanatory variables are in fact co-integrated with each other. In addition, even when the generated monthly series can be characterised as an integrated process, any rejection of the hypothesis of no co-integration between the generated and the other series may actually reflect a co-integrating relation between the other series in the testing and one or more of the explanatory variables used in the interpolation. Under these circumstances, no conclusion can be drawn for the co-integrating relations between this generated and other series in the system whether the hypothesis of no co-integration is rejected or not.

In the empirical studies presented in this thesis, temporal aggregation does not
appear to be a serious problem. Consistency is established for the underlying relationships between housing activity and other related variables in systems using either monthly or quarterly observations. Cross-sectional aggregation can also influence the estimation results, however, such effects have been found to be less pronounced (Rossana and Seater 1992). In this thesis, the main interest lies in examining the influences of housing activity for the economy as a whole. As a result, no attempt was made to obtain any regional results. The availability of regional data would also be a serious impediment to such an attempt, as some of the required data are not published on a regional basis.
Chapter 2

Review of Modelling Exercises on Australian Housing Activity

2.1 Introduction

In this chapter, a review is presented of the analytical studies on Australian housing activity. The discussion is focussed on academic research published by both government and private institutions. Given the vast range of literature involved, this review concentrates on the latest Australian modelling studies in which the characteristics of the Australian housing market are investigated.

The approach adopted in this review is generally critical. Modelling strategies are emphasised and findings developed which are relevant to the issues investigated in the following chapters. Considerable effort is directed to a full description of the models so that underlying strategies and implications can be examined in full. Given that the objective of this chapter is to "review" the relevant modelling strategies for forecasting or estimation of Australian housing activity, but not to "survey" issues relating to the housing market in general, efforts are limited on developments outside the scope of this thesis. For the latter, readers are referred to Smith, Rosen and Fallis (1988) for details.
In essence, this review concentrates on four different strategies which have been used for modelling Australian housing activity. In Section 2.2, a simple static approach is first discussed. Although this approach may seem to be less relevant to the dynamic modelling techniques adopted in the following chapters, we nevertheless include this approach as it provides some insight into the housing market operations, especially the determination of price-rent relationship, in response to external shocks such as changes in mortgage interest rates or taxation. Compared with other dynamic approaches presented in this chapter, this discussion would also allow us to distinguish the differences between the static and dynamic modelling techniques and the usefulness of each modelling technique in examining different issues which are important to housing activity.

In Section 2.3, an examination of the use of portfolio choice decisions for modelling fluctuations in housing activity is presented. Strictly speaking, there are two different portfolio choice decisions which could influence housing activity. The first portfolio choice concerns the way individuals allocate their personal savings among various financial assets. The second concerns the portfolio decisions of financial institutions which may influence the availability of funds to the housing market. The latter is commonly referred as the effect of "credit rationing". While the review presented in Section 2.3 focuses more on the portfolio choice of consumers, the issue of "credit rationing" is addressed in Section 2.4 in which a discussion on a model using availability of funds as the core for forecasting housing activity is presented. Section 2.5 examines the strategy of using population growth and net migration to forecast long-term housing demand. A comparison of the forecasting performance of such a model
is also presented.

2.2 A Simple Static Approach to Housing Activity

The common static approach to housing activity involves consideration of a partial-equilibrium modelling of the housing market. Homogeneous dwelling units are assumed and traded in the market at a price per unit. A constant flow of housing services is generated from these dwelling units.

For simplicity, it is generally assumed that total housing services available are fixed in the short term. There are two types of tenure in the housing market - owner-occupation and renting. The demand for rental housing services is negatively related to rent, and that for owner-occupied housing services is a negative function of the house price. Since the supply of housing services is common to both forms of tenure, the equilibrium price and rent are determined simultaneously to clear the housing market.

An example of this modelling for the Australian housing market was demonstrated by Nevile, Vipond, Tran-Nam and Warren (1987). In this model, both forms of tenure, owner-occupation and renting, are involved. The house price and rent are determined simultaneously and the model was used to qualitatively examine the effects on the residential property market of changes in the 1985 tax package.

The model developed by Nevile et al. was constructed under a series of
assumptions which simplify the operation of the housing market. It assumes that owner-occupiers and tenants cannot switch tenure (no substitution) and the model does not permit new construction, alterations or changes in the housing stock. These assumptions imply that the demand for housing by owner-occupiers can be separated from that by renters. Since the total supply of housing services is assumed to be fixed, if renters increase their consumption of housing, then owner-occupiers must reduce their housing consumption accordingly.

In essence, the equilibrium in both the rental and owner-occupied housing markets depends on the supply and demand for housing services. The supply of rental housing service, $S^r$, can be described as a function of a set of variables including the unit price of the housing stock, $p$, the rent, $r$ and the opportunity cost of owning a dwelling. Assuming that the other variables are exogenously determined, $S^r$ can be specified as a function of $r$ at a given $p$, or a function of $p$ at a given $r$. Let $p^*$ and $r^*$ denote the set of prices and rent which make the landlords indifferent to investing in the rental market or other financial assets under given opportunity costs. The amount of rental housing supplied can be set out as:

$$S^r = \begin{cases} \{0, Q^*\} & \text{if } r < r^* \\ \{0, Q^*\} & \text{if } r = r^* \\ Q^* & \text{if } r > r^* \end{cases} \quad \text{or} \quad S^r = \begin{cases} \{0, Q^*\} & \text{if } p = p^* \\ Q^* & \text{if } p < p^* \end{cases}$$

where $Q^*$ is the total housing services available.
In Nevile et al. (1987), the demand for rental housing, $D^r$, was postulated to be a function of variables including $r$, but not $p$, and the demand for housing by owner-occupiers, $D^o$, was related to variables including $p$, but not $r$. Since the total housing stock, $Q^*$, is fixed, the supply of housing services available to the owner-occupied market can be seen to be those left after deducting the supply to the rental market.

**Figure 2.1 Adjustment of the Housing Market to An External Shock**
The equilibrium situation for the housing market can be demonstrated in Figure 2.1. For simplicity, the demand curve for rental housing services is drawn as a straight line. The amount of housing services provided to the rental and owner-occupied markets are denoted by $X^r$ and $Q^*-X^r$ respectively. Any external shock to the housing market which changes the level of house prices will shift the supply curve for rental housing services as well as the $Q^*-D^0(p)$ curve and result in disequilibrium. Consequently, $r$ will adjust accordingly until a new equilibrium position is established.

The operation of this model can be demonstrated by, say, an economic shock which shifts $S^r$ upward (Figure 2.1). When this happens, the amount of housing services used by the rental sector will decrease and the supply of housing services to the owner-occupiers will be able to increase and result in a decrease in the house price. The lower house price will result in an increase in the demand by owner-occupiers, so that $Q^*-D^0(p)$ shifts to the left. The supply curve of rental housing services will also move downward. The new equilibrium position, $E^e$, will lead to a higher rent level but a lower level of house prices. The amount of housing services used by the rental sector will be lower than the initial level and that used by owner-occupiers will be higher.

Various points can be made with this simple static model which are mostly related to the assumptions regarding the fixed tenure choice and the lack of response in total housing supply. Relaxing these assumptions will introduce complications into the model and distort the rent-price relationship. For example, in the above demonstration of a change in the economic environment which shifts
the rental supply curve upward, if total housing services are allowed to increase over time, then a higher rent-price ratio will lead to a supply of new housing services flowing into the rental market and so a lowering of the level of rent. Therefore, the extent of the change to the rent-price ratio in a dynamic sense would depend on the model's ability to introduce an increase in the demand and supply of housing services over time. On the other hand, the supply of new housing services would also depend on the existing dwelling prices compared with the costs to builders for constructing new dwellings. Such a linkage between the new construction and the current market conditions is not addressed in a static approach, which limits the use of this model in explaining the short-term dynamics of dwelling commencements and housing activity.

2.3 Dynamic Approach Using Portfolio Choice

In contrast to the theoretical static approach, housing activity has been modelled within a dynamic framework of portfolio choice, see Williams (1984), Parkin et al. (1975) and Purvis (1975). In this dynamic modelling, the existing stock of houses is held within the consumer portfolio and the price of dwellings is determined by the demand generated by the portfolio allocation decisions. New dwellings are supplied on the basis of the price of existing dwellings and absorbed into household portfolios. If the increase in demand is not equal to the increase in supply, then the dwelling prices will change over time and result in adjustment in the household portfolio decisions.

A study which examines the linkage between the supply of new dwellings and
the market conditions for established dwellings is Williams (1984). Unlike Nevile et al. (1987) in which the rental and owner-occupied markets are separated, Williams examines the household portfolio decisions ignoring the different tenure purposes. The essence of his model is based on the relationship of the asset price of private housing to the prices of other financial assets in household portfolios. Equilibrium holdings of housing and financial assets are dependent on the expected rates of return, asset prices and income. The asset price of housing is an endogenous variable in his model and is determined by a generalised asset adjustment framework. This endogeneity of asset price of housing is different from the conventional approach using the theory of portfolio choice, ie Clements (1976) and Parkin et al. (1975), in which rates of return and asset prices are usually assumed to be exogenous and the influences of supply response to asset prices ignored.

The success of portfolio choice analysis depends critically on the quality and availability of data used in the estimation. An important point in this portfolio choice analysis is how the expected rates of return and the asset prices are obtained. In Williams (1984), the expected rate of return for dwellings was derived from survey information for Sydney and Melbourne and by fitting a second-order Almon polynomial to annual rates of changes in dwelling prices. The asset price of dwellings was calculated using census data on the stock of dwellings, average sales price data for 1976 collected by the Valuers-General and a series of median price indices for capital cities (see Williams 1983). The major estimation results indicate that the asset price of dwellings is positively related to the rate of return for housing investment, and the number of dwelling
commencements is negatively affected by lagged construction costs and interest rates, but positively influenced by lagged asset price of dwellings (Table 2.1).

Table 2.1 Estimation Results - Williams (1984)

<table>
<thead>
<tr>
<th>Equation for Asset Price of Housing</th>
<th>Equation for Private Commencements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adjustment coefficients</strong></td>
<td><strong>One-period-lagged variables</strong></td>
</tr>
<tr>
<td>Housing</td>
<td>Asset Price</td>
</tr>
<tr>
<td>0.35</td>
<td>1.31</td>
</tr>
<tr>
<td>(0.11)</td>
<td>(0.22)</td>
</tr>
<tr>
<td>Loans</td>
<td>Construction cost</td>
</tr>
<tr>
<td>0.43</td>
<td>-0.91</td>
</tr>
<tr>
<td>(0.11)</td>
<td>(0.32)</td>
</tr>
<tr>
<td>Financial assets</td>
<td>Vacancies^a</td>
</tr>
<tr>
<td>-0.87</td>
<td>-0.40</td>
</tr>
<tr>
<td>(0.16)</td>
<td>(0.18)</td>
</tr>
<tr>
<td>Rate of Return</td>
<td>Interest rate</td>
</tr>
<tr>
<td>Housing</td>
<td>Liquidity^b</td>
</tr>
<tr>
<td>0.08</td>
<td>0.39</td>
</tr>
<tr>
<td>(0.02)</td>
<td>(0.20)</td>
</tr>
<tr>
<td>Loans</td>
<td>Loan approvals^b</td>
</tr>
<tr>
<td>-0.13</td>
<td>0.19</td>
</tr>
<tr>
<td>(0.06)</td>
<td>(0.07)</td>
</tr>
<tr>
<td>Financial assets</td>
<td></td>
</tr>
<tr>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>(0.04)</td>
<td></td>
</tr>
<tr>
<td><strong>Other variables</strong></td>
<td></td>
</tr>
<tr>
<td>Inflation</td>
<td></td>
</tr>
<tr>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>(0.01)</td>
<td></td>
</tr>
<tr>
<td>Income</td>
<td></td>
</tr>
<tr>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>(0.12)</td>
<td></td>
</tr>
</tbody>
</table>

Standard errors in parentheses. All variables are in logarithms. a: Two-period lagged variable. b: Current variable.
A critical question relating to this portfolio analysis is, as acknowledged by Williams, that this modelling may be more suitable to explain the investors' behaviour on the demand for dwellings rather than for owner-occupiers. Because housing is a necessity, the relationship with other asset holdings in an owner-occupier's portfolio may not be so straightforward as demonstrated by the price relationships (Nevile et al. 1987). There are many economic and non-economic reasons why households would not substitute their own homes or their demand for housing for financial assets. For example, favourable taxation policies on owner-occupied houses and social prestige of owning a home may work against such substitution. Although households generally would regard their own homes as part of their investment portfolio, this investment behaviour may be reflected more by extensions and alterations to their existing homes than by the demand for extra dwelling units. These could be the reasons why a wrong sign was obtained by Williams in the estimation of the substitution coefficient between the demand for dwellings and financial assets (Table 2.1). Note that if the rate of return for financial assets rises, then a substitution effect will occur which leads to an increase in the demand for financial assets and a decrease in the demand for housing. As a result, the price of housing will fall. Therefore, the estimated coefficient on the rate of return for financial assets in the equation for asset price of housing should be negative, not positive as estimated by Williams.

As mentioned before, availability of data is a common problem for empirical analysis of portfolio choice, especially in the field of housing. In Williams (1984), the postulated housing system consists of 13 equations. However, due to data availability, only two were successfully estimated. There is a concern
regarding the use of average and median prices of dwellings in the construction of asset prices for the rate of return on dwellings. As indicated by Bailey, Muth and Nourse (1973), the major problem appears to be the great variation in quality and characteristics among dwellings. If quality or characteristics of the dwellings sold from period to period are quite different or if there is a progressive change in the quality of dwellings sold at different times, then the average or median price indices are likely to be biased in reflecting the movements in ‘standard’ dwelling prices over time. Given the importance of house price indices to housing studies, more discussion is presented below on this issues of "unbiasedness". Currently, there is no "unbiased" house price index available for the Australian housing market. For this study, an attempt was made to generate an "unbiased" house price index using the method proposed by Bailey et al. (1973). However, this attempt was not regarded as successful due mainly to insufficient observations. Consequently, this study was abandoned and is not included in this thesis.

The significance of quality and characteristics in the formation of Australian dwelling prices was investigated by Abelson (1979) using the data collected by the New South Wales Valuer-General for two suburbs in Sydney. His findings indicate that quality and characteristics are important factors which significantly influence the formation of dwelling prices.

One way to eliminate the influences of quality and characteristic differences and generate meaningful indices for dwelling prices is to use a regression analysis on the sale prices of dwellings, see Pendleton (1963). For this method, dummy variables measuring important quality and characteristic differences as well as
period effects are used to analyse the formation of dwelling prices. This regression yields information on the influence of variation in quality and characteristics on sales prices of dwellings as well as providing a dwelling price index which is free from the influences of quality and characteristic differences. But, where quality and characteristic differences are numerous and difficult to measure, this method may not yield satisfactory results and the data required for such a regression analysis would be extremely demanding.

Another method which generates meaningful price indices for dwellings was introduced by Bailey et al. (1973). They argue that most of the difficulties of specifying and measuring the numerous quality and characteristic differences can be avoided by basing a price index on sales prices of the same dwellings at different times. They suggest using sales prices of dwellings sold at least twice in a sample period with no major changes or improvements to the dwelling structure to generate the price index. Case and Shiller (1987) utilised this method to generate dwelling price indices for four American cities - Atlanta, Chicago, Dallas and San Francisco. Their results indicate that the indices generated from the repeated sales are significantly different from those of median dwelling prices, raising doubts on the ability of median price indices to accurately reflect the price movements in the housing market.

In some traditional Australian housing models, loans to owner-occupiers play an important role in explaining the fluctuation in housing activity. However, "if short-term dynamics are to be explained", argued Williams, "attention needs to be directed towards the economic agents who initiate construction". In Williams
(1984), the usefulness of including the number of loans to owner-occupiers for new dwellings was examined alongside the economic variables which dominate the household portfolio decisions in his model. Williams' intention in including the number of finance approvals for new dwellings was to examine whether there would be any gain in the estimation of new dwelling commencements. If the analysis of portfolio choice is a correct approach, Williams argues, then there would be little gain by adding this loan variable to the estimation. However, the estimation results indicate that the current, but not the lagged, number of finance approvals for new dwellings is significant in the estimation of dwelling commencements, although the estimated elasticity for the current number of loans for new dwellings is small in magnitude and less well-defined than are the coefficients on asset price and construction costs (Table 2.1).

2.4 Short-Term Forecasting of Housing Activity

There are some practical gains in using finance approvals in the forecasting of housing activity. One obvious benefit is the data availability. Unlike variables, such as house prices which suffer frequently from the problems of measurement and availability, the data on finance approvals have been steadily published for a long time by the Australian Bureau of Statistics (ABS) on a monthly basis. The number of finance approvals incorporates the effects of changes in house prices, mortgage interest rates and income so that it could be used as an approximation for conditions in the housing market.
Figure 2.3 Framework for Housing Investment in NIF-88/ Bassanese, Horn and Simes (1989)

- Change in money supply
- Relative interest rates
- Total value of mortgage
- Value of approvals for new dwellings
- Valuation ratio for dwellings
- Commencements of other dwellings
- Commencements of houses
- Commencements of alterations
- Investment in dwellings
- Stock of dwellings at replacement cost
- Relative price of other dwellings and houses
One model which uses finance approvals for new dwellings as the core for forecasting dwelling commencements is the NIF-88 macroeconomic model developed by the Department of Treasury. In this model, the values of housing commencements, other dwellings, alterations and additions are each estimated separately. While other sources of funds are implicitly important for other commencements, one of the determinants of house commencements is the availability of finance. A number of financial and economic variables are included in this forecasting model which, as expressed by the Treasury, is used to approximate the nature of the adjustment process for dwelling investment. Given the complexity of the structure of this model, only the framework is presented in Figure 2.3.

In this model, the degree of tightness in financial markets is postulated to have a bearing on new construction activity. Both interest rates and changes in the money supply relative to total mortgage finance were found to be significant in explaining changes in house commencements. Alterations are assumed to be related to house commencements and the ratio of the two is postulated to be a function of the ratio of the housing stock to total population, the real mortgage interest rate, inflation and the state of the housing cycle. The value of commencements of other dwellings is assumed to be related to variables which are used to approximate the rate of return on such investment. These variables include the ratio of prices of other dwelling to houses and the q-ratio for the business sector.

One force which determines the value of new construction in this model is the
availability of funds. This approach appears to raise a question regarding the importance of availability of funds to housing activity after deregulation in 1986 and its impact on the mortgage ceiling. The effect of so-called "credit rationing" on housing activity is argued in the following way. During periods of credit restraint, mortgage interest rates generally rise relatively less than do commercial interest rates. This could be due to a higher interest rate elasticity of demand for mortgages by consumers (Smith et al. 1988). As a result, lending to mortgages becomes less attractive to financial institutions compared with that to other investment or commercial purposes. Consequently, financial institutions would apply "credit rationing" on lending to the housing market.

This argument of "credit rationing" in a deregulated environment has been met with disbelief. If the capital market is perfectly competitive and mobile, then the availability of funds would not be a major influence on the fluctuations in housing activity (in a deregulated environment). Although the interest rate for a mortgage is usually lower than those charged for investment or business lending during periods of monetary tightness, the risks associated with the latter type are generally higher. Since risk is an important element in determining the level of an interest rate, these differences in rates could be reflecting the risk characteristics associated with different forms of lending, rather than an evidence of practice of "credit rationing" by financial institutions.

It is difficult to determine the nature and extent of the effect of "credit rationing", if it exists, on housing activity. There have also been arguments which downplay the importance of the influences of "credit rationing" even before the
deregulation. While the mortgage interest rate ceilings were applied only to banks, non-bank financial institutions were not subjected to these regulations. Unsatisfied consumers could have obtained finance from building societies, credit unions or other non-bank financial institutions at slightly higher rates. Also, while regulated, mortgage interest rates were nevertheless adjusted during periods of monetary tightness, suggesting that any effect of "credit rationing", if it exists, would have only been a short-term phenomenon (for more discussion, see Smith et al. 1988). Given the difficulty in determining the effect of mortgage interest rate ceilings on housing activity, it is equally difficult to examine the implications of their removal and whether there has been a continued practice of "credit rationing" in lending to the housing market.

To examine whether the housing loan market after deregulation is competitive or not, a conjectural model of bank lending for the owner-occupied market was estimated by Fahrer and Rohling (1992) for the period since deregulation. The estimation results reject the hypothesis that the Australian housing loan market is perfectly competitive, as well as the hypothesis that banks collude to form a cartel. Although the hypothesis that the housing loans market is a Cournot oligopoly can not be rejected according to the estimation results, Fahrer and Rohling express concerns over these conclusions due to the imprecision of the parameter estimates. In conclusion, Fahrer and Rohling describe the Australian housing loan market as reasonably competitive, but not perfectly so.

The major problems of Fahrer and Rohling’s study appear to be the validity of the estimation results. In their study, 68 monthly observations - from 1986(5) to
1990(12) - were used in the estimation of a system of 6 equations with 19 explanatory variables (including seasonal dummies) in each equation and with cross-equation-restrictions imposed. The estimation results are disappointing because most of the estimated coefficients are insignificant or have wrong signs, indicating that the specification used in their study could not satisfactorily capture the variation in lending to the housing market. Consequently, the testing results for perfect competition, cartel or Cournot oligopoly based on these estimation results appear to be of doubtful value.

Availability of credit has been incorporated as an explanatory variable in some modelling works on Australian housing activity. Changes in the money supply or liquidity (M3, M4 or private sector LGS plus SDR) together with nominal interest rates were used as a measure of credit availability (see Williams 1984 and Bassanese et al. 1989). Although both of the variables were found to be significant in explaining total dwelling commencements by Williams (1984), the estimated elasticity of the commercial interest rate was slightly higher in value and more significant in the t-statistic than is the measure of liquidity, reflecting the relative importance of these two measures in explaining variations in housing activity. It is also interesting that, in Williams (1984), the availability of credit was found to be insignificant in the estimation of commencements of other dwellings.

In a modelling exercise presented in Chapter 3, changes in the money supply or liquidity, which are used as a measure of credit availability, are also included in an examination of the relationships between approvals, commencements,
completions and finance approvals for new and established dwellings. Interestingly, in contrast to Williams (1984), the measure of credit availability was not selected in the equations for approvals and commencements by the order selection criteria - Akaike (1973), Schwarz (1978) and Hannan and Quinn (1979) - utilised in this study. This is due mainly to two reasons. Firstly, the effect of "credit rationing", if it exists, could be reflected by other explanatory variables included in the model. Besides the lagged approvals, commencements and completions, the major explanatory variable which was selected in the equations for approvals and commencements is finance approvals for established dwellings. Since this variable represents the major source of funds flowing into the housing market, the effect of "credit rationing", if it exists, would be reflected, at least to a significant extent, by the fluctuations in this finance variable. Consequently, any additional measure of this effect, such as changes in the money supply or liquidity, could become insignificant in these equations. Similar results were also reported by Williams (1984). When including a variable, finance approvals for new dwellings, in the estimation of total commencements, the coefficient estimate for the measure of credit availability falls significantly in value and the associated t-statistic reduces from significance at the 5 per cent level to only 1.95. Given that both the value and number of finance approvals for established dwellings are equivalent to about 90 per cent of those for total dwelling commencements or completions, compared with only about 10 per cent for finance approvals for new dwellings, the ability of the approvals for established dwellings to reflect the effect of "credit rationing" would be much greater than those for new dwellings.
The second reason relates to the selection criteria used in this study to determine the model specification. For example, the Schwarz criterion used in this study can be expressed as $SC = \log |Gl| + \left( \log \frac{T}{S} \right) \frac{S}{T}$, where $|Gl|$ is the determinant of the estimated residual variance-covariance matrix, $T$ is the sample size and $S$ is the number of functionally independent parameters estimated. The chosen specification produces the minimum value for $SC$. For the steps of the procedure, see Penm, Penm and Terrell (1992a). It can be seen from this expression that if the gain in fit, a smaller $|Gl|$, is not large enough to outweigh the penalty, a larger $(\log T)\frac{S}{T}$, for including extra explanatory variables, such as credit availability, then these extra variables will not be selected or included in the model specification. Such selection criteria are very different from merely examining the t-statistics for the associated coefficient estimates in a regression. Also, it should be noted that the specification presented in Chapter 3 was determined by the order selection criteria in a system context, compared with estimations of single-equation undertaken in these previous studies.

In NIF-88, the use of finance approvals for new dwellings as the core for forecasting dwelling commencements also appears to be questionable. Over the 1980s, the units and total values of quarterly finance approvals for new dwellings were equivalent to only about 10 per cent of those for quarterly private dwelling commencements or completions. These small percentages do not appear to support the framework which relies on the finance approvals for new dwellings to forecast housing activity. There are two possible channels for new dwellings to be sold. New dwellings may be sold to investors or first-home buyers who finance the purchases through bank borrowings, or to consumers
who have sold their established dwellings to other consumers and use the prices received from the sales to assist with purchase of new dwellings. The information contained in the finance approvals for new dwellings would reflect the sales of the former but not necessarily the latter. As a result, the use of financial approvals for new dwellings to forecast housing activity or dwelling commencements may not be an appropriate approach. As indicated by Williams (1984), if the supply of new dwellings is related to the market conditions for established dwellings, then total finance approvals or the approvals for established dwellings could be more appropriate in representing this relationship. Consequently, finance approvals for established dwellings could be more useful in forecasting housing activity than could those for new dwellings. A more extensive investigation of this issue is presented in the following chapter in which real data are utilised to examine the relationship between finance approvals and housing activity.

As mentioned before, the housing cycle can significantly influence activity elsewhere in the economy, especially in the labour market and in other industries directly or indirectly supplying the housing industry. More generally, the fluctuations in housing activity will have implications on the availability of resources to the rest of the economy. Despite the comments made above regarding the model specification, the NIF-88 has an advantage in performing examinations of such implications. Two simulations were undertaken by Bassanese et al. (1989) to examine the linkages of housing activity to the general economy using NIF-88. In the first simulation, an increase of 20 per cent in the level of housing investment, sustained for five years, was simulated (Table 2.2).
In the second simulation, a cycle was assumed to "peak at 20 per cent above the control after the fifth and sixth quarters before falling to 20 per cent below the control after the tenth and eleventh quarters". Similar results were obtained in both simulations. The major features of these results indicate that gross domestic product (GDP) would expand more than the direct effect of higher housing activity, reflecting both an income effect on private consumption and an acceleration effect on business investment. Short term interest rates would be trending upward over time and the effect of poorer incentive would, later on, lead to falling business investment. These results appear to be in line with those obtained in a study presented in Chapter 4. These results also indicate that the length of the cycle in the general economy is similar to that in the housing sector.

Table 2.2: NIF-88 Simulation Results for a Sustained 20 Per Cent Increase in Dwelling Investment

<table>
<thead>
<tr>
<th>Quarters</th>
<th>1</th>
<th>4</th>
<th>8</th>
<th>12</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Consumption(^a)</td>
<td>-</td>
<td>0.3</td>
<td>0.4</td>
<td>0.3</td>
<td>-</td>
</tr>
<tr>
<td>Business Investment(^a)</td>
<td>0.2</td>
<td>0.5</td>
<td>-1.1</td>
<td>-2.9</td>
<td>-4.8</td>
</tr>
<tr>
<td>GDP(^a)</td>
<td>1.5</td>
<td>1.4</td>
<td>1.1</td>
<td>0.9</td>
<td>0.3</td>
</tr>
<tr>
<td>2 Year Government Bond(^b)</td>
<td>0.2</td>
<td>0.7</td>
<td>1.1</td>
<td>1.9</td>
<td>2.4</td>
</tr>
<tr>
<td>Established to New House Price</td>
<td>1.4</td>
<td>2.7</td>
<td>1.8</td>
<td>1.3</td>
<td>0.8</td>
</tr>
</tbody>
</table>

a: Percentage points deviation from control. b: Deviation from control.

Source: Bassanese et al. (1989)
2.5 Longer-term Forecasting of Underlying Requirements

While the short-term dynamic effects of a changing economic environment on housing activity have been examined in many studies, a different modelling approach was undertaken by the Indicative Planning Council for the Housing Industry (IPC), which uses population and household formation to forecast the underlying requirements for housing. This model provides projections of underlying demand for new dwellings based on assumptions regarding growth in population, income and housing costs (Figure 2.4). A constant vacancy rate and constant net stock loss are assumed in the model. Projections of the population used in the model are prepared by ABS and the propensity of the population to form households is postulated to be a function of real incomes and housing costs. The responsiveness of household formation to these variables is assumed to vary according to age. Thirteen age groups have been used in this model to project the formation of households for the medium to longer terms.

In IPC (1989), the estimation of the rate of household formation was done by pooling cross section and time series data. Although it was found that current period income produced a better fit, a weighted average of real household disposable income over the current and previous three years was used in the estimation. The series used to measure housing costs includes rent, an average of median price indexes for Sydney and Melbourne, the mortgage interest rate, government charges and maintenance and repair costs. According to IPC, this measure of housing cost made only a small improvement in the overall fit of the estimation. Rent was found to be insignificant when it was included in the
estimation separately as an explanatory variable and a strong correlation was detected between this variable and real per capita income.

Figure 2.4 Framework for IPC (1989) Methodology

- Births, deaths and migrations
- Income Housing costs
- Projections of population
- Projections of rates of household formation
- Projections of households
- Vacant dwellings
- Total underlying requirement

\[
\text{Underlying requirement in current year} = \text{Total requirement in current year} - \text{Total requirement in previous year} + \text{Net stock loss}
\]
Three important assumptions are taken up by IPC (1989) to forecast household formation. Growth in real per capita income is assumed to be around 1.0 per cent per annum, with an underlying inflation rate of about 5 per cent. Growth in real housing costs is assumed to be half a percentage point faster than real income. For the medium term, the annual gain from net migration is assumed to be around 140,000. However, two scenarios on net migration gain are used for the longer term. In one scenario, the net migration gain is assumed to be maintained at the above level, while in the other scenario the level of net migration is assumed to decline to 80,000 per annum from 1997-98. Although these assumptions appear to be on the high side given recent developments in the domestic economy and migrant intakes, at this point the IPC has not updated its medium to long term projections. As a result, we concentrate the discussion on the modelling strategy of IPC(1989), rather than the projection results. The sensitivity of these assumptions to the projections is presented in Table 2.3.

There appear to be some questions regarding the strategy and assumptions used in the model for the longer-term projections. In this model, no consideration is given to the possible supply side influences or constraints. The longer-term projections are determined mainly by the potential demand based on assumptions regarding growth in income and housing costs. These estimates could be very different from the likely real situation when the supply side constraints are taken into account. Interestingly, changes in housing activity are postulated in this model to have no effects on income or general economic activity, and growth in income and housing costs are independent of growth in population and changes in the underlying demand for housing. For example, the assumptions of growth
in income and housing costs are the same for the two scenarios under the different levels of net migration. This appears to be economically implausible, especially over the longer term. A stronger underlying demand for dwellings would place upward pressure on housing activity and hence increase housing costs which in turn would influence household formation. Adopting the same growth rate in real per capita income for a higher level of migration is in fact implying a production technology of increasing returns to scale. Unless capital investment increases or production technology improves following the higher level of migration, it is difficult to see how the growth rate in real per capita income can be maintained for a different level of migration over a period of 20 years.

Apparently, there should be interrelationships between housing activity, real income, housing costs and population. Higher real income or lower housing costs would stimulate household formation and hence increase the housing demand. However, buoyant housing activity is likely to increase housing costs and consequently induce an adverse effect on household formation. The relationship between population and real per capita income is also complex. Increases in population may lead to a temporary fall in real per capita income in the short term, placing downward pressure on household formation. However, over the longer-term, a positive effect may be obtained depending on the increase in capital investment and technology improvement. So far, most economic analyses of the effects on housing activity of increases in net migration or population have tended to rely on the "partial-equilibrium" approaches by ignoring the interrelationship between population and the economic environment.
Table 2.3 Contributions to Growth in Households and Sensitivity of Projections

**Contributions to Growth in Households (%)**

<table>
<thead>
<tr>
<th>Structure</th>
<th>Population growth</th>
<th>Household formation</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976-1981&lt;sup&gt;a&lt;/sup&gt;</td>
<td>86.1</td>
<td>5.8</td>
<td>8.2</td>
</tr>
<tr>
<td>1981-1986&lt;sup&gt;a&lt;/sup&gt;</td>
<td>86.8</td>
<td>2.5</td>
<td>10.7</td>
</tr>
<tr>
<td>1988-1993</td>
<td>79.9</td>
<td>2.6</td>
<td>17.7</td>
</tr>
</tbody>
</table>

**High Migration**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Population growth</td>
<td>75.3</td>
<td>90.0</td>
<td>83.4</td>
</tr>
<tr>
<td>Household formation</td>
<td>7.7</td>
<td>8.4</td>
<td>9.4</td>
</tr>
<tr>
<td>Age</td>
<td>17.1</td>
<td>10.6</td>
<td>7.2</td>
</tr>
</tbody>
</table>

**Low Migration**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Population growth</td>
<td>73.5</td>
<td>76.7</td>
<td>75.9</td>
</tr>
<tr>
<td>Household formation</td>
<td>8.5</td>
<td>9.8</td>
<td>11.1</td>
</tr>
<tr>
<td>Age</td>
<td>18.5</td>
<td>11.1</td>
<td>13.0</td>
</tr>
</tbody>
</table>

**Sensitivity of Projections**

<table>
<thead>
<tr>
<th></th>
<th>Annual average (%)&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income - growth 0.5 % p.a. higher</td>
<td></td>
</tr>
<tr>
<td>Immigration - 60,000 p.a. lower</td>
<td></td>
</tr>
<tr>
<td>Housing costs - growth 0.5% p.a. higher</td>
<td>-4.1</td>
</tr>
</tbody>
</table>

a: Estimated by IPC from census data. b: Changes from high migration scenario.
There is no satisfactory framework currently available for an examination on this longer-term issue in the context of "general-equilibrium".

The performance of the IPC model can be assessed by comparing the historical estimation of underlying requirements and housing activity. Such a comparison is presented in Figure 2.5, in which estimates of underlying requirements for the period 1961-62 to 1987-88 and dwelling commencements are shown. The estimates of underlying requirements display significant differences from dwelling commencements, although both the series demonstrate a similar trend in the period before 1970.

**Figure 2.5 Commencements and Underlying Requirements, 1962-1989**
As demonstrated by Figure 2.5, a strong level of underlying requirements through to the mid-1970s was buoyed by the entry of the "baby boomers" into the household forming age groups (IPC 1989). A deterioration in economic conditions and a reduction in the immigration intake in the mid-to-late 1970s resulted in a decline in underlying requirements, compared with a much more substantial decrease in the level of commencements in the same period. The housing boom in 1984-85 can be seen partly as a response to a surge in underlying requirements in the early 1980s and, despite increases in housing costs, the upturn in 1986-87 is attributable to the increase in the immigration program which lifted sharply the level of underlying requirements. Generally speaking, the estimates for underlying requirements after the mid-1970s seems to lead commencements of residential dwellings.
Chapter 3

Co-integration and Australian Housing Activity

In this chapter, a procedure proposed for analysing systems containing both co-integrated and stationary series is used to develop a housing model. While housing approvals, commencements and completions appear to be stationary over the period 1970(1) to 1990(2), the financial and economic variables which influence housing activity are found to be integrated of order 1 and are also co-integrated. Three specifications of the housing model are determined by the proposed procedure. They consistently indicate that new construction activity will be better forecast using finance approvals for established dwellings than using those for new dwellings. This finding is supported by a comparison of forecasting performance between this specification and several competing models using both the bootstrap technique and real data. In either situations, such specifications outperform the alternatives.

3.1. Introduction

Activity in the housing market is commonly seen as an important leading indicator of general economic activity. A buoyant housing market is usually
suggested as a forerunner of strong general economic activity. A weakening in housing activity is often followed by a general economic slowdown. Many economic agencies have devoted considerable efforts to forecasting housing activity, especially in times of recession when attention is focused on the housing market for signs of recovery. The commonly used measures of housing activity are approvals, commencements and completions. In this paper, a forecasting exercise is undertaken on these housing variables, recognising the need to test for co-integrating relations among integrated variables.

Co-integration of economic variables is associated with "error-correction" models, which allows the specification to capture, where necessary, long term relations as well as the short term dynamics. Specifically, co-integrated systems permit individual time series to be integrated of order 1, I(1), but certain linear combination of these series can be stationary, integrated of order 0, I(0). Recent empirical research in time series analysis has demonstrated that the relative success of forecasting exercises depends importantly on the issue of integration or stationarity of the variables in the systems investigated. For example, if an I(1) system is co-integrated, then the commonly used vector autoregressive (VAR) models in levels or first differences will be mis-specified. Granger (1986) and Engle and Granger (1987) showed that, if two variables are co-integrated of order (1, 1), then they can be modelled by an error correction model (ECM). The forecasting ability of the ECMs, compared with the unrestricted VAR models, for co-integrated systems was examined by Engle and Yoo (1987) and LeSage (1990) using either a simulation approach or real data. They concluded that, compared with the VAR models, the ECMs produce more accurate forecasts for
longer horizons.

The ECM derived by Engle and Granger (1987) for estimation of a cointegrated system is based on the assumption that every component in the system investigated is integrated of order 1 and co-integrated (designated as of order 1, 1 hereafter). In reality, there are many economic systems involving both integrated and stationary series. The co-integrating relations between these integrated series, if any exists, would also have important implications for forecasting the stationary series in the system if the integrated set and the stationary variables are related. As will be shown later, the housing model used in this study is such a system which involves both integrated and stationary series. While approvals, commencements and completions are found to be stationary over the sample period investigated, other financial and economic variables which influence housing activity, such as finance approvals for established dwellings and real aggregate income, are detected to be I(1) and co-integrated. In this chapter, we derive the associated ECM-like representation for such a system and utilise the order selection procedure developed by Penm, Penm and Terrell (1992a) to identify the specification for estimation and forecasting.

While most traditional modelling uses finance approvals for new dwellings as the central component for forecasting the construction of new dwellings, see the Treasury's NIF-88 model, the results of the present analysis indicate that new construction is better forecast using finance approvals for established dwellings. Several competing models are compared with those determined by the proposed procedure using both the bootstrap technique and real data. The bootstrap results
indicate that the specifications determined by the proposed procedure exhibit superior forecasting characteristics to their alternatives. In the case of forecasting using real data, these specifications, compared with other competing models, bring significant gains to forecasts of new housing construction.

3.2. A Housing System for Forecasting

Modellers of Australian housing activity appear to have made different assumptions on the underlying relationships in the housing market. The Treasury's NIF-88 model uses an approach in which the variable, finance approvals for new dwellings, plays a major role in the forecasting of new construction. The ratio of loans for new dwellings to that for total dwellings, in that model, is postulated to be related (negatively) to the change in total finance approvals for both new and established dwellings (Bassanese, Horn and Simes 1989). This framework seems to suggest that, among other influences, changes in the market activity for established dwellings would influence new construction mainly via changes in the finance approvals for new dwellings. A different approach is to model the construction of new dwellings directly using variables representing the market conditions for established dwellings. Williams (1984) argues that the market price of established dwellings sets an upper bound on the price at which new dwellings may be sold, and builders will reduce or abandon activity if the total cost of construction is not sufficiently below the price of established dwellings. If this is true, then new construction activity could be better explained and forecast using information directly linked market activity for established dwellings such as the finance approvals for established dwellings.
Which approach will perform better in the forecasting of new construction is an interesting question and will be best investigated using real data.

In this study, an analysis is set up which focuses mainly on the activity of residential construction. A housing system is constructed which consists of seven housing, financial and economic variables - approvals, commencements, completions, numbers of finance approvals for new and established dwellings, real aggregate income and real construction costs. The underlying economic relationships between these variables appear complex. Clearly, there are relations between approvals, commencements and completions. If there are no leakages, all approvals will become commencements and all commencements will become completions. However, in reality, there are always leakages between these housing activity variables. These leakages may be related to changes in those economic factors which influence the housing market. In this system, the levels of finance approvals for new and for established dwellings are both used to explain housing demand as finance approvals will be influenced by changes in mortgage interest rates and house prices. We separate the finance approvals for new and established dwellings in an attempt to look at the relative importance of finance in each market on the construction of new dwellings. There may also be some feedback from housing activity to these finance approvals. For example, in a situation of over-supply of new dwellings, the price of new dwellings would become relatively cheaper in the short term compared with established dwellings, increasing the demand for new dwellings and hence the associated requests for finance approvals. Assuming an unchanged total demand for dwellings in the short term, the demand for established dwellings would fall as substitution
occurs, resulting in a decline in the demand for finance approvals for established dwellings.

However, the interactions between housing activity and changes in price and financial factors are not instantaneous and there is certain price stickiness in the very short term. This is mainly because the construction of new dwellings takes time. Therefore, there is a lag period before dwelling supply can actually respond to any change in prices or other relevant factors. Also, these adjustments may have long memories. For example, an unexpected surge in dwelling demand leads to an increase in established house prices which provides an incentive for more new construction. This effect will first be reflected by an increase in approvals and then, perhaps with a time lag, an increase in commencements. Eventually, completions will increase after a further time lag. However, this increase in dwelling supply may not correspond exactly with the surge in demand. If the condition of excess demand persists, then the incentive for more new construction will continue. If the situation reverts to over-supply, then a reverse effect will begin, adding more volatility to house prices and housing activity.

The importance of real aggregate income in influencing housing activity is apparent. Real income plays an important role in determining affordability. It is also an indicator of general economic conditions: an important factor in builders' decision-making on the commencement of dwelling construction. Generally, it is believed that a long term relation exists between real aggregate income and total housing demand. Therefore, if finance approvals and real aggregate income
are I(1) series, it would not be surprising if co-integration is detected between these series. The series of real construction costs is used in the system to reflect the impact of short-term restrictions on the supply side. In the absence of an accurate index for the price of new dwellings, this series has often been used as a proxy in housing studies. For this reason, this series is also possible to be involved in any co-integrating relation(s) which may exist between finance approvals and real income, provided that they are all found to be I(1).

3.3 Unit Roots in the System

As briefly mentioned above, the analysis of this study presumes that the housing system constructed contains only I(1) or I(0) series. There are many differences between I(1) and I(0) series. An I(0) series has a mean and there is a tendency for the series to return to that mean, so that the series will fluctuate around the mean. An I(1) series will move widely and rarely return to an earlier value. Whether time series variables are I(1) or I(0) can only be determined by empirical testing. In this section, we present the necessary testing results for unit roots for each of the series used in the system. These results form the basis for an analysis of co-integration presented later.

In this study, original data obtained from the Australian Bureau of Statistics (ABS) were used. These series cover the period from the March quarter 1970 to the June quarter 1990. While most data series can be directly retrieved from the ABS database, the series for real construction costs was obtained by dividing the total value of construction by the number of units constructed and then dividing
the result by the price index of materials used in building construction. This series may have a tendency to reflect the changes or improvements in quality of new houses. However, given the data availability, little can be done to improve this proxy. The series of real total household disposable income is used to approximate real aggregate income. All the series are in logarithms.

The use of quarterly original data brings in the problem of possible seasonality, especially the presence of seasonal unit roots. If unit roots are detected in these series at both seasonal and zero frequencies and if these series are co-integrated at both the seasonal and zero frequencies, then the testing for co-integration at the zero frequency using original data may not be appropriate because the co-integrating vectors may not be consistently estimated. In this situation, a feasible choice may be to "filter out" the relevant seasonal-unit-root components and proceed with the testing for co-integration at zero frequency with the filtered data, see Kunst and Neusser (1990) for an example. However, caution should be exercised in this situation because different treatment of seasonal factors in each individual series would result in a general deterioration in the ability to measure the underlying relationships in the system.

For each of the quarterly series used in this study, the procedure developed by Hylleberg, Engle, Granger and Yoo (1990) was utilised to test for the presence of unit roots at both seasonal and zero frequencies. Several specifications with different deterministic terms were considered in this testing. These deterministic terms include an intercept, seasonal dummies, an intercept and a linear trend and a linear trend and seasonal dummies. The maximum order of the quarterly
autoregressive process was initially set to six, however following Hylleberg et al. (1990), non-significant lag terms were then deleted. As indicated by Hylleberg et al. (1990), the distribution of the test statistics under the null hypothesis depends on the specification used and selected fractiles for the test with different deterministic terms are provided in their paper. The results of this testing are presented in Table 3.1.

For each series, the test results suggest that the hypothesis of no seasonal unit roots is acceptable. Seasonal dummies were found to be significant in most series and their presence, in some cases, influence the test results. To account for this influence, the significant seasonal dummies were removed from these series. It is interesting that the test results reject the hypothesis of a positive unit root in the series of approvals, commencements and completions. In other words, these series appear to be stationary over the sample period investigated. Another series which may be stationary around a linear trend is the finance approvals for new dwellings. In a specification including a linear trend and seasonal dummies, the test statistic for a positive unit root at the zero frequency is more negative than the corresponding critical value at the 5 per cent level. The linear trend and seasonal dummies are both significant in this specification.

Although the Hylleberg et al. procedure tests for the presence of unit roots at all seasonal and zero frequencies, it gives no consideration to the need for testing for the presence of more than one unit root at zero frequency once the hypothesis of a unit root is accepted. For this reason, we also utilised the Dickey and Pantula (1987) procedure to test for the presence of more than one unit root at zero
Table 3.1: Test Results for Seasonal Unit Roots

<table>
<thead>
<tr>
<th>Variable</th>
<th>Specification</th>
<th>$t_1$</th>
<th>$t_2$</th>
<th>$F_{3&amp;4}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_1$</td>
<td>Intercept</td>
<td>-7.27*</td>
<td>-2.02*</td>
<td>7.84*</td>
</tr>
<tr>
<td></td>
<td>Intercept+trend</td>
<td>-7.27*</td>
<td>-2.00*</td>
<td>7.75*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies</td>
<td>-4.36*</td>
<td>-4.38*</td>
<td>13.55*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies+trend</td>
<td>-4.35*</td>
<td>-4.33*</td>
<td>13.05*</td>
</tr>
<tr>
<td>$X_2$</td>
<td>Intercept</td>
<td>-6.74*</td>
<td>-2.37*</td>
<td>7.90*</td>
</tr>
<tr>
<td></td>
<td>Intercept+trend</td>
<td>-6.79*</td>
<td>-2.31*</td>
<td>7.66*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies</td>
<td>-5.97*</td>
<td>-2.60</td>
<td>6.77*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies+trend</td>
<td>-5.99*</td>
<td>-2.54</td>
<td>6.65*</td>
</tr>
<tr>
<td>$X_3$</td>
<td>Intercept</td>
<td>-6.40*</td>
<td>-0.81</td>
<td>1.72</td>
</tr>
<tr>
<td></td>
<td>Intercept+trend</td>
<td>-6.64*</td>
<td>-0.78</td>
<td>1.54</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies</td>
<td>-4.39*</td>
<td>-4.30*</td>
<td>11.11*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies+trend</td>
<td>-4.50*</td>
<td>-4.18*</td>
<td>10.58*</td>
</tr>
<tr>
<td>$X_4$</td>
<td>Intercept</td>
<td>-0.19</td>
<td>-2.86*</td>
<td>11.15*</td>
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<tr>
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<td>Intercept+trend</td>
<td>-3.77*</td>
<td>-2.71*</td>
<td>10.80*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies</td>
<td>-0.20</td>
<td>-2.74</td>
<td>14.58*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies+trend</td>
<td>-3.60*</td>
<td>-5.18*</td>
<td>24.17*</td>
</tr>
<tr>
<td>$X_5$</td>
<td>Intercept</td>
<td>-2.75</td>
<td>-2.92*</td>
<td>5.65*</td>
</tr>
<tr>
<td></td>
<td>Intercept+trend</td>
<td>-2.40</td>
<td>-2.96*</td>
<td>5.78*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies</td>
<td>-2.61</td>
<td>-3.01*</td>
<td>9.14*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies+trend</td>
<td>-2.40</td>
<td>-3.05*</td>
<td>9.38*</td>
</tr>
<tr>
<td>$X_6$</td>
<td>Intercept</td>
<td>-3.27*</td>
<td>-0.65</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td>Intercept+trend</td>
<td>-3.18</td>
<td>-0.65</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies</td>
<td>-1.03</td>
<td>-3.12*</td>
<td>15.18*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies+trend</td>
<td>-3.06</td>
<td>-3.00*</td>
<td>13.31*</td>
</tr>
<tr>
<td>$X_7$</td>
<td>Intercept</td>
<td>-1.87</td>
<td>-3.34*</td>
<td>13.78*</td>
</tr>
</tbody>
</table>
t1 tests for 1-L, t2 for 1+L and F3&4 for the polynomial factor 1+L2. * denotes that the hypothesis of the presence of unit roots can be rejected at the 5 per cent level according to Hylleberg et al. (1990). X1 denotes log(approvals), X2 log(commencements), X3 log(completions), X4 log(finance approvals for new dwellings), X5 log(finance approvals for established dwellings), X6 log(real income) and X7 log(real construction costs).

The traditional way most practitioners test the number of unit roots in a series is to first test for a unit root in the levels. If the hypothesis of the presence of a unit root is not rejected, then testing in the differences would follow and so on.
However, if the series had more than one unit root, testing for unit roots in this sequence would not have the correct test size because the commonly used tests such as the augmented Dickey-Fuller (ADF) test are based on the assumption of at most one unit root. For testing the situation of more than one unit root, Dickey and Pantula (1987) proposed a test procedure with a different testing sequence. They suggest that one should start with the largest number of unit roots under consideration and work down; that is, decrease the number of unit roots under test by one each time the null hypothesis of the presence of a unit root is rejected. In this study, the test procedure and sequence suggested by Dickey and Pantula was followed. The selected fractiles for testing without deterministic terms, with an intercept or an intercept and a linear trend can be found in Fuller (1976). The maximum number of unit roots under test was three. However, for brevity, only the test results for two unit roots or less are presented in Table 3.2.

For each of the series, finance approvals for established dwellings, real income and real construction costs, the test results suggest the presence of only one unit root. For the remaining series, namely approvals, commencements, completions and finance approvals for new dwellings, the hypothesis of a positive unit root was again rejected by the Dickey and Pantula test. However, it should be noted that the test results for unit roots can sometimes be influenced by the assumed order of the underlying AR process in the testing. For these housing activity series, we repeated the Dickey and Pantula test with different assumed orders. The hypothesis of a unit root was rejected in every case at the 5 per cent level.
Table 3.2: Test Results for Positive Unit Roots and Co-integration

(A) Dickey and Pantula Test Results for Unit Roots

<table>
<thead>
<tr>
<th>Variable</th>
<th>Two unit roots</th>
<th>One unit root</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approvals</td>
<td>-</td>
<td>-4.45*</td>
</tr>
<tr>
<td>Commencements</td>
<td>-</td>
<td>-6.28*</td>
</tr>
<tr>
<td>Completions</td>
<td>-</td>
<td>-4.57*</td>
</tr>
<tr>
<td>Approvals for new dwellings</td>
<td>-</td>
<td>-3.91*</td>
</tr>
<tr>
<td>Approvals for established dwellings</td>
<td>-6.29*</td>
<td>-2.58</td>
</tr>
<tr>
<td>Real income</td>
<td>-7.32*</td>
<td>-3.17</td>
</tr>
<tr>
<td>Real construction costs</td>
<td>-6.46*</td>
<td>-1.87</td>
</tr>
</tbody>
</table>

(B) Stock and Watson Test Results for Co-integration

**Eigenvalues**

<table>
<thead>
<tr>
<th></th>
<th>2.469</th>
<th>0.416</th>
<th>0.114</th>
</tr>
</thead>
</table>

**Eigenvectors**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(Finance approvals)</td>
<td>1.000</td>
<td>0.348</td>
<td>1.000</td>
</tr>
<tr>
<td>(Income)</td>
<td>0.975</td>
<td>0.558</td>
<td>-0.888</td>
</tr>
<tr>
<td>(Construction costs)</td>
<td>-0.884</td>
<td>1.000</td>
<td>0.149</td>
</tr>
</tbody>
</table>
For the series, finance approvals for new dwellings, real income and real construction costs, a linear trend was included in the test for only one unit root. The test statistics for positive unit roots are based on an assumption of an underlying AR(4) process. $q_{tf}^{(3,2)}$ denotes the Stock and Watson test statistic for the hypothesis of three common trends versus the alternative of two common trends. $t$ denotes linear detrending. * denotes a test statistic that is significant at the 5 per cent level according to the associated critical value in either Fuller (1976) or Stock and Watson (1988).

3.4 Co-integration and Error Correction Model

Following Engle and Granger (1987), a set of $n$ time series variables, $X_t$, with no deterministic components is said to be co-integrated of order $(1,1)$, if each series is integrated of order 1 and if there exist $r$, $r < n$, linearly independent vectors, $\alpha^1$, ..., $\alpha^r$, and $\alpha = (\alpha^1, \ldots, \alpha^r)$, so that $Z = \alpha'X$ is stationary. The vectors, the $\alpha^i$s, are called the co-integrating vectors.

Evidence that co-integrating vectors exist provides strong support for long term relationships among a set of variables. However, testing for the existence of co-integration gives rise to non-standard testing procedures because the asymptotic theory of regression in integrated systems is very different from conventional theory for stationary series. For testing co-integration in multivariate systems, a number of approaches have been developed. The method of Phillips and Ouliaris (1988) investigates the rank of the spectral density matrix at zero frequency using
a non-parametric approach. Stock and Watson (1988) present a procedure to test the null hypothesis that a time series system has $p \leq n$ common stochastic trends against the alternative that it has $s < p$ common trends. Using a maximum likelihood approach, Johansen (1988) provides a procedure for testing as well as estimating. This procedure is based on an analysis of the canonical correlations between the levels and the first differences of a VAR system with each individual series corrected for lagged differences and deterministic components. The great strength of Johansen's procedure is the possibility of constructing likelihood ratio tests for steady-state relations in multivariate VAR models. However, Johansen's procedure rests on the assumptions that the order of the VAR is known and each equation of the VAR has exactly the same regressors. In practice, the assumed specification for the VAR model may be quite different from the actual specification and there may also be some zero coefficients in the coefficient matrices of the VAR (Penm and Terrell 1984a). Although, in some studies, statistical tests or order selection criteria were utilised to determine the order of the VAR representation before applying this testing procedure, these tests or criteria are unlikely to provide valid conclusions if the VARs in levels or in first differences are mis-specified for co-integrated systems.

In this study, we applied the Stock and Watson procedure to test for co-integration among the I(1) series in the system. For brevity, no introduction is given to this test procedure, interested readers should refer to Stock and Watson (1988). The results of the Stock and Watson test suggest that there is one co-integrating relation between these series. We present, in Table 3.2, the three eigenvectors obtained from the principal component analysis. Following Stock
and Watson (1988), the associated co-integrating vector for this co-integrated relation can be estimated from the eigenvector with the smallest principal component: that is the last eigenvector presented in Table 3.2. This co-integrating vector can then be used to generate the error correction term for the estimation of the associated ECM.

Co-integration among a set of variables has important implications for estimation of dynamic models and forecasting. It implies rank-reducing restrictions on the coefficient matrices of a vector moving-average representation of the first differences of the integrated series and on the coefficient matrices of a VAR representation in the levels. Engle and Granger (1987) showed a useful way to impose these restrictions is by using an ECM. In the following, we demonstrate that a system which involves both co-integrated and stationary series, $X_t$ and $Y_t$ respectively, can also be represented by an ECM, and this ECM can be used for estimation of such a co-integrated system.

Let $X_t$ and $Y_t$ be time series variables with $n$ and $m$ components respectively. Suppose that each component of $X_t$ is $I(1)$ and co-integrated with $r$ co-integrating relations and that $Y_t$ is $I(0)$, the multivariate system including both $X_t$ and $Y_t$ can be expressed as follows.

$$
\begin{bmatrix}
C(L) & D(L) \\
E(L) & E(L)
\end{bmatrix}
\begin{bmatrix}
X_t \\
Y_t
\end{bmatrix} = 
\begin{bmatrix}
U'_t \\
U''_t
\end{bmatrix}
$$

(3.1)

where $C(L)$, $D(L)$, $E(L)$ and $F(L)$ are polynomials with $C(0)=I_n$, the $nxn$ identity
matrix, $D(0)=0$, $E(0)=0$ and $F(0)=I_m$, the $mxm$ identity matrix and $U_i^x$ and $U_i^y$ are zero mean white noise vectors.

Now, (3.1) can be re-written as

\[
\begin{bmatrix}
C(L)X_t + D(L)Y_t \\
E(L)X_t + F(L)Y_t
\end{bmatrix} = \begin{bmatrix} U_t^x \\
U_t^y
\end{bmatrix}
\]

Noting that any polynomial $C(L)$ can always be expressed as $C(L) = C(1) + (1-L)\tilde{C}(L)$ by re-arranging terms. If $C(L)$ is of finite order, so is $\tilde{C}(L)$.

Substituting this re-arranged polynomial for $C(L)$ and $E(L)$, we get

\[
\begin{bmatrix}
C^*(L)((1-L)X_t) + D(L)Y_t \\
E^*(L)((1-L)X_t) + F(L)Y_t
\end{bmatrix} = \begin{bmatrix} U_t^x \\
U_t^y
\end{bmatrix}
\]

where $C^*(L) = \tilde{C}(L) + C(1)$ and $E^*(L) = \tilde{E}(L) + E(1)$.

Since $X_t$ is co-integrated with $r$ co-integrating vectors, therefore $C(1) = \gamma \alpha'$, where $\gamma$ is a $nxr$ matrix of constants and $\alpha'$ is a $rxn$ matrix formed by the $r$ independent vectors representing the co-integrating relations. Because $X_t$ is co-integrated, each row of $E(1)$ must be a linear combination of the rows of $\alpha'$, which are the co-integrating vectors. Given this matrix, $\alpha'$, which has full row rank $r$, there exists an $mxr$ matrix of constants, $\sigma$, so that $E(1) = \sigma \alpha'$. Substituting $\gamma \alpha'$ and $\sigma \alpha'$ into (3.2), we get
\[
\begin{bmatrix}
C^{*}(L)((1-L)X_t) + D(L)Y_t \\
E^{*}(L)((1-L)X_t) + F(L)Y_t \\
\end{bmatrix}
+ \begin{bmatrix}
\gamma \\
\sigma
\end{bmatrix} \alpha' X_{t-1} = \begin{bmatrix}
U^x_t \\
U^y_t
\end{bmatrix}
\]  \quad (3.3)

or

\[
K(L) W_t + \rho Z_{t-1} = U_t
\]  \quad (3.4)

where \( W_t = [(1-L)X_t \ Y_t]' \), \( K(0) = I_k, k=n+m \), \( K(1) \) has all elements finite, \( \rho = [\gamma \ \sigma]' \), \( Z_{t-1} = \alpha' X_{t-1} \) and \( U_t = [U^x_t \ U^y_t]' \).

In (3.4), short term dynamics are flexible, while the long term restrictions of co-integration are imposed. Because all of the variables in (3.4) are stationary, standard asymptotic results for model selection, parameter estimation and hypothesis testing apply. It can be seen from (3.4) that a VAR representation in levels or first differences or partly in both is mis-specified for such a co-integrated system because it omits the error correction terms. Noting that, in (3.4), \( Y_t \) represents the stationary series. Therefore, the deviations of the integrated series, \( X_t \), from an equilibrium position may also influence the stationary series in the system. This influence could be important for estimating parameters of the system or forecasting \( Y_t \).

3.5. Estimation and Forecasting

Above, we have demonstrated that a VAR system which contains both co-integrated and stationary series can be represented by an ECM. The question we are now facing is how to determine a suitable specification for this resulting
ECM, so that efficient estimation and forecasting can be carried out. A starting point commonly used by researchers is to assume that this ECM is of full order—that is there is no zero entries in the coefficient matrices of this ECM (zero coefficients). However, recent empirical research has shown that it is impractical to ignore the possibility of zero coefficients in error correction modelling and the estimation results could be very different if the presence of zero coefficients is allowed. In this study, we demonstrate, using the above housing system as an example, that an ‘optimal’ specification can be determined for this ECM using the order selection procedure developed by Penm et al. (1992a). Penm et al. provide a method for the recursive fitting of a subset VAR with exogenous variables (VARX). They suggest the use of ascending recursions in conjunction with an order selection criterion to choose an 'optimal' subset VARX and this procedure can be extended to the selection of a subset VARX with zero coefficients.

The ECM expressed by (3.4) can be seen to be a VARX. A time series model of the form \( P(L) V_t + Q(L) R_t = \varepsilon_t \) is known to be a VARX which involves a \( k \times 1 \) regressand vector \( V_t \) and \( r \times 1 \) regressor vector \( R_t \). Suppose \( P(L) = K(L) \), \( V_t = W_t \), \( Q(L) = \rho L \) and \( R_t = Z_t \), then an ECM becomes a VARX. Since all of the terms in the ECM expressed by (3.4) are stationary and the representation is in fact a VARX, the order selection procedure developed by Penm et al. can be applied to this ECM for choosing an 'optimal' specification for estimation and forecasting (for details of this procedure, see Penm et al. 1992a). Note that this proposed procedure is not restricted only to ECMs expressed as (3.4). Its application also includes time series systems involving only co-integrated series. This can be easily seen by assuming that the system expressed by (3.1) contains
only co-integrated series (no stationary series). In this case, (3.4) becomes a standard ECM with \( W_t = [(1-L)X_t]' \) and \( Z_{t-1} = \alpha'X_{t-1} \), which is also a VARX. The procedure developed by Penm et al. (1992a) can then be applied in a straightforward fashion.

In this study, this order selection procedure was applied to the housing system. In applying this procedure, the order of \( Q(L) \) was fixed at 1 and \( Q(0) = 0 \), so that \( Q(L) R_t = \rho Z_{t-1} \), and the maximum order of \( P(L) \) was assigned to be 8, eight quarters or two years, to begin the selection. Since the data on finance approvals for new dwellings used in the system is in levels and contains a linear trend, we therefore also included a linear trend in the regressor vector for the selection.

As there is one co-integrating relation among the \( I(1) \) series in the system, the linear combination generated by the eigenvector with the smallest principal component presented in Table 3.2 was used to generate the error correction term, \( Z_t \). Following Penm and Terrell (1984a), three order selection criteria - Akaike (1973), Schwarz (1978) and Hannan and Quinn (1979) - were used to select the specifications for the ECM.

The ability of these order selection criteria to select the true specification of a stationary time series system was examined using a simulation approach by Penm and Terrell (1984b). The findings of their study indicates that the Schwarz

---

3.1 Given that the error correction term generated by the eigenvector with the smallest principal component presented in Table 3.2 also contains a linear trend, it is preferable to include a linear trend in the selection rather than imposing it as a restriction in the equation for finance approvals for new dwellings.
criterion is more able to identify the true specification. In this study, the specifications determined by each of the three criteria are similar. Therefore, for brevity, we only present the one determined by the Schwarz criterion in the following. This specification was estimated using the generalised least squares (GLS) technique and the results are expressed as (3.5)\textsuperscript{3,2}.

The major differences between the three selected specifications are the equations for approvals and finance approvals for both new and established dwellings. In those determined by the Akaike and Hannan criteria, one-period-lagged real income was found to influence both the level of approvals and the finance approvals for established dwellings and the one-period-lagged real construction costs and completions influence finance approvals for new dwellings, but no such influences are presented in (3.5). Interestingly, the error correction term is included to explain the stationary series, finance approvals for new dwellings, demonstrating that the error correction processes generated from the co-integrating relations could significantly influence the relevant stationary series.

\textsuperscript{3,2} Maximum likelihood (ML) estimation of the restricted VAR is not equivalent to OLS applied separately to each equation of this VAR because the equations are subject to different restrictions. To obtain efficient estimates and correct standard errors, it is necessary to use a GLS procedure to allow for the structure of the cross-equation covariances, as this VAR is a dynamic version of the seemingly unrelated regression equations (SURE). Given that no available computer software for time-series analysis provided the fully iterated ML estimation in this context, the two-step GLS procedure adopted by Penm and Terrell (1984) was used, and this method is henceforth referred to simply as 'GLS'. 
\[
\begin{bmatrix}
1-1.1292L & -0.2289L & 0.2248L & 0 & -1.1661L & 0 & 0 \\
(20.33) & (2.01) & (5.07) & (10.44) & & & \\
-0.3279L & 1-0.1939L & -0.0037L & 0 & -0.2931L & 0 & 0 \\
(6.21) & (19.6) & (8.84) & (2.76) & & & \\
-0.2144L & -0.7227L & 1-0.5554L & 0 & 0 & 0 \\
(3.14) & (4.95) & (9.82) & & & & \\
0 & -0.0307L & 0 & 1-0.8441L & 0 & 0 & 0 \\
(1.47) & (1.47) & (19.28) & & & & \\
0 & 0.2792L & 0 & 0 & 1 & 0 & 0 \\
(3.57) & & & & & & \\
0 & 0 & 0 & 0 & 0 & 0 & 1+0.5619L \\
0 & 0 & 0 & 0 & 0 & 0 & (6.08) \\
0 & 0 & 0 & 0 & 0 & 0 & 1-0.6270L \\
(7.20) & & & & & & 
\end{bmatrix}
\]

\[
\begin{bmatrix}
X_{1t} \\
X_{2t} \\
X_{3t} \\
X_{4t} \\
dX_{5t} \\
dX_{6t} \\
dX_{7t}
\end{bmatrix}
+ \begin{bmatrix}
0 \\
0 \\
0 \\
0.1980 \\
0.0946 \\
0 \\
0
\end{bmatrix}
Z_{t-1} = \begin{bmatrix}
e_{1t} \\
e_{2t} \\
e_{3t} \\
e_{4t} \\
e_{5t} \\
e_{6t} \\
e_{7t}
\end{bmatrix}
\]

(3.5)

t-statistics in parentheses.

where \( X_1 = \log(\text{approvals}) \), \( X_2 = \log(\text{commencements}) \),
\( X_3 = \log(\text{completions}) \), \( X_4 = \log(\text{finance approvals for new dwellings}) \),
\( dX_5 = \text{dlog}(\text{finance approvals for established dwellings}) \),
\( dX_6 = \text{dlog}(\text{real income}) \) and \( dX_7 = \text{dlog}(\text{real construction costs}) \).
The error correction term is also included to explain finance approvals for established dwellings, highlighting the importance of the co-integrating relation for this variable.

The estimation of these specifications presumes that the deregulation of mortgage interest rate ceilings in 1986 did not alter the relationships among variables in the system. This assumption was examined by testing for the stability of the system using the STAB test (Ashley 1984) for all of the three determined specifications. The test results give no support to the hypothesis of instability. For example, the F statistic for testing instability jointly in a system context for (3.5) is 0.85, which is less than the corresponding critical value at the 5 per cent level. A number of measures were also included separately as an exogenous variable in the selection procedure to capture any additional effect of so-called “credit rationing” on the housing activity variables. These measures include changes in M3, money base, total bank deposit and the ratio of bank lending to owner-occupied housing to bank lending to the private sector. None of these measures were chosen in the equations for approvals and commencements by the selection criteria. This result is not surprising as such an effect, if it exists, could be reflected by the movements in the finance approvals. As a result, an additional measure to capture this effect was not necessary and therefore was not included in the specifications chosen by these selection criteria. We also experimented with these measures by including only data points before 1986(2) and assigning zeros to data entries after that date. Similar results were also obtained in which none of these measures were selected in the specifications to explain the housing activity variables. For a discussion of the possible effect of “credit rationing”,...
There are some interesting findings demonstrated in (3.5). First, the finance approvals for established dwellings was found to influence both approvals and commencements. Interestingly, none of the determined specifications relate the housing activity variables to finance approvals for new dwellings and there is no significant causal relationship identified between the finance approvals for new and established dwellings. These results suggest that, for short term dynamics, finance approvals for established dwellings are more important in explaining new construction activity than are approvals for new dwellings. This appears plausible because finance approvals for established dwellings represent the major source of funds flowing into the housing market. For example, in 1989, the value of finance approvals for new dwellings was merely 7 per cent of that for established dwellings and 8 per cent of the value of completions. Second, there is feedback from housing activity to both the finance approvals for new and established dwellings. This appears to suggest that, in the short term dynamics, the finance approvals for new and established dwellings are linked to the activity of new construction. A possible mechanism is that an increase in the market activity for established dwellings (resulting in an increase in the finance approvals for established dwellings) would increase the relative price of established to that of new dwellings (or to construction costs for new dwellings) and so provide the incentive to begin more new construction. When more new dwellings become available, this would put downward pressure on the relative price of new dwellings, increasing the number of finance approvals for new dwellings and inducing a substitution effect against established dwellings. While
short term adjustment proceeds, the long term relation between finance approvals for established dwellings, real income and real construction costs would also come into effect and influence the finance approvals for both new and established dwellings, adding more complexity to the adjustment. For example, an increase in real income which exceeds the long-term co-integrating relationship with finance approvals for established dwellings and real construction costs will result in a positive effect on dwelling demand in the following period and hence increase the requests for finance approvals for both new and established dwellings. On the other hand, a surge in dwelling demand (approximated by an increase in finance approvals for established dwellings) which exceeds this long-term co-integrating relationship will lead to an error-correction process which adversely affects the demand for dwellings in the next period, resulting in reductions in the requests for finance approvals for dwellings, both new and established.

Up to now, we have obtained three specifications for the housing system and all of them appear to be economically meaningful. The major difference between these specifications appears to be on the direct inclusion of lagged real income and lagged construction costs in the forecasting of housing activity. Such an inclusion is supported by the Akaike and Hannan criteria but discarded by the Schwarz criterion. In most examinations of forecasting performance, researchers have discovered that the over-fitting of a (mis-specified) model, which will reduce the in-sample residual errors, does not improve the out-of-sample forecast (Hendry, 1980). Therefore, the question we are facing is whether the inclusion of lagged real income and lagged construction costs in this system would lead to
any improvement, or deterioration, in housing activity forecasts. To answer this question, we first turn to the bootstrap for help.

Table 3.3: Results of Bootstrapping the Housing Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Bootstrap standard error</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X1</td>
<td>X2</td>
<td>X3</td>
<td>X4</td>
<td>dX5</td>
<td>dX6</td>
</tr>
<tr>
<td>Akaike</td>
<td>0.1910</td>
<td>0.1816</td>
<td>0.0889</td>
<td>0.2532</td>
<td>0.0969</td>
<td>0.0274</td>
</tr>
<tr>
<td>Hannan</td>
<td>0.1908</td>
<td>0.1812</td>
<td>0.0887</td>
<td>0.2252</td>
<td>0.0968</td>
<td>0.0275</td>
</tr>
<tr>
<td>Schwarz</td>
<td>0.1852*</td>
<td>0.1731*</td>
<td>0.0874*</td>
<td>0.2203*</td>
<td>0.0959*</td>
<td>0.0272*</td>
</tr>
<tr>
<td>Alternative 1a</td>
<td>0.2553</td>
<td>0.2464</td>
<td>0.1306</td>
<td>0.2857</td>
<td>0.1051</td>
<td>0.0311</td>
</tr>
<tr>
<td>Alternative 2b</td>
<td>0.2653</td>
<td>0.2504</td>
<td>0.1206</td>
<td>0.2698</td>
<td>0.1160</td>
<td>0.0301</td>
</tr>
<tr>
<td>Alternative 3c</td>
<td>0.2006</td>
<td>0.2370</td>
<td>0.1181</td>
<td>0.2632</td>
<td>0.1006</td>
<td>0.0294</td>
</tr>
<tr>
<td>VAR</td>
<td>0.1923</td>
<td>0.2093</td>
<td>0.0933</td>
<td>0.2558</td>
<td>0.0994</td>
<td>0.0278</td>
</tr>
</tbody>
</table>

* denotes the smallest forecasting error for the variable.

a the full order case. b no zero constraints in the equations for approvals and commencements. c finance approvals for established dwellings are constrained to have no effect on approvals and commencements. X1 denotes log(approvals), X2 log(commencements), X3 log(completions), X4 log(finance approvals for new dwellings), dX5 the first difference of log(finance approvals for established dwellings), dX6 the first difference of log(real income) and dX7 the first difference of log(real construction costs). * denotes the smallest forecasting error for the variable.
The bootstrap is a statistical technique which permits the assessment of variability in an estimate using just the data at hand (Efron 1982). The idea is to approximate the theoretical distribution of a disturbance term by its empirical distribution and re-sample the original observations in a suitable way to construct "pseudo-data" on which the estimator is based. Measures of variability, confidence intervals and even estimates of bias can then be obtained by repeating this process. The use of the bootstrap to evaluate forecasting models was first suggested by Peters and Freedman (1985). Penm, Penm and Terrell (1992b) use the bootstrap as an aid in choosing the optimal state space representation for a VAR system. The usefulness of the bootstrap in evaluating forecasting models should be evident from these and many other studies.

In this study, each of the three selected specifications was bootstrapped 200 times and the bootstrap standard errors for 12 forecasts are presented in Table 3.3 (for the bootstrap procedure, see Peters and Freedman 1985). Also presented in Table 3.3 are the bootstrap standard errors for three hypothesised specifications (Alternative 1, 2 and 3 respectively). Alternative 1 is a case of full order, which assumes that there were no zero coefficients in the ECM. This full order case is often used as a starting point in time series analysis. Alternative 2 assumes that there were no zero coefficients in the equations for approvals and commencements but the specification for the remaining equations is determined by the proposed procedure. This specification is based on a hypothesis that all of the financial and economic variables used in the system would influence approvals and commencements in the short term dynamics. We incorporate this hypothesis by restrictions on the proposed procedure and use the Schwarz
criterion to determine, where needed, the nature of the remaining specification. The so-determined specification for the remaining equations is identical to that in (3.5). This hypothesised specification has the same number of parameters in the equations for approvals and commencements as the full order case but less parameters in the remaining equations. We include this specification to examine whether the forecast error could be related to the extent of over-parameterisation in the model. Alternative 3 hypothesises that approvals and commencements were influenced by finance approvals for new dwellings but not by those for established dwellings. We also incorporate this hypothesis by restrictions on the selection procedure and use the Schwarz criterion to determine the remaining specification. In the specification determined, approvals are related to one-period-lagged approvals, commencements, completions, real income and finance approvals for new dwellings; commencements are influenced by one-period-lagged approvals, commencements, completions and finance approvals for new dwellings and the remaining equations are identical to those in (3.5).

The bootstrap standard errors presented in Table 3.3 show clearly that the specification determined by the Schwarz criterion produces the smallest bootstrap standard error for every variable, indicating that this specification has superior forecasting characteristics to the other alternatives. The absolute values of the bootstrap standard errors for this specification appear to be satisfactory given the number of forecasts involved. Examination of the "pseudo-errors" across each replication in this comparison shows very stable results, indicating that the 200 replications are sufficient for this comparison. It is interesting that the bootstrap standard errors for the variables, approvals, commencements and finance
approvals for established dwellings, in the full order specification are slightly lower than those for Alternative 2, although it is vice versa for the other variables. Generally we would expect the full order case to produce larger forecasting errors as this specification is most likely to suffer from over-parameterisation (given that the true specification is an ECM with zero coefficients like (3.5)). These conflicting results may be related to the different estimation and forecasting procedure used in these two cases: that is OLS for the full order case and GLS for Alternative 2 (in a full order case, GLS produces the same results as OLS). While OLS estimates each equation in a system separately, GLS links each equation as a system and hence is more likely to compound errors from any incorrect specification and result in larger forecasting errors for some variables. In any event, the differences between the bootstrap standard errors for these two specifications are small and both specifications produce much larger errors than those from the selected specifications. As a result, these differences were not investigated further.

Comparisons of forecasting performance of the ECMs versus VARs for co-integrated systems have been reported in studies such as Engle and Yoo (1987) and LeSage (1990). The results of their studies indicate consistently that, in the short term, there may be gains in using the unrestricted VAR models, but the ECMs produce longer-term forecasts with lower errors when the variables used in the models satisfy the statistical tests for co-integration. In this study, such a comparison is also undertaken. A VAR model, which is determined using the order selection procedure developed for VAR systems by Penm and Terrell (1984a) together with the Schwarz criterion, was bootstrapped and the results are
also presented in Table 3.3. The determined specification for this VAR model is identical to that of (3.5) without the error correction term, in which new construction is still related to the finance approvals for established dwellings. It is interesting that the bootstrap standard errors obtained for this VAR model are larger than those for the specifications determined by the proposed procedure but smaller than those for the hypothesised ECMs. This result appears to place significant importance on the specification of the short term dynamics (the VAR part of the ECM) as the error correction term is also included in those hypothesised ECMs.

Although the forecasting characteristics of the selected specifications have been demonstrated to be superior in the bootstrapping, it is also interesting to see how these and other competing models perform with real data. A comparison of this nature is undertaken in which each model was estimated over the period 1970(1) to 1987(4) and forecasts for the twelve following quarters (1988(1) to 1990(4)) were generated. These forecasts were then compared with the ABS published data and the mean absolute errors and the root mean squared errors are presented in Table 3.4. For brevity, only results for approvals, commencements and completions are presented.

The results presented in Table 3.4 are consistent with those in Table 3.3. The selected specifications again produce superior forecasts to the hypothesised ECMs. Among the three selected specifications, (3.5) again produces the smallest forecasting errors for the period investigated. However, it should be noted that these results are associated with a forecasting period of twelve quarters. Close
Table 3.4: Forecasting Errors for the Housing Specifications/ 1988(1) to 1990(4)

<table>
<thead>
<tr>
<th>Specification</th>
<th>Mean absolute error</th>
<th>Root mean squared error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$X^1$</td>
<td>$X^2$</td>
</tr>
<tr>
<td>Akaike</td>
<td>0.1075</td>
<td>0.0924</td>
</tr>
<tr>
<td>Hannan</td>
<td>0.1030</td>
<td>0.0918</td>
</tr>
<tr>
<td>Schwarz</td>
<td>0.0956*</td>
<td>0.0837*</td>
</tr>
<tr>
<td>Alternative 1a</td>
<td>0.1684</td>
<td>0.1593</td>
</tr>
<tr>
<td>Alternative 2b</td>
<td>0.1837</td>
<td>0.1738</td>
</tr>
<tr>
<td>Alternative 3c</td>
<td>0.1190</td>
<td>0.1164</td>
</tr>
<tr>
<td>VAR</td>
<td>0.1158</td>
<td>0.1161</td>
</tr>
</tbody>
</table>

* denotes the smallest forecasting error for the variable.
examination of the forecasting errors for each quarter indicates that there may be gains in using the VAR model in the short term. However, the accuracy of the VAR forecasts deteriorates significantly over the longer term. This finding appears to be consistent with those reported by Engle and Yoo and LeSage and may have important implications for the short-term forecasting of housing activity in this context.

To investigate this further, a comparison of forecasting performance was undertaken in which the mean absolute errors of the one-period-ahead through to the eight-period-ahead forecasts were calculated for each model. In this comparison, each specification was used to forecast the period 1988(1) to 1990(4) and a total of 12 one-period-ahead forecasts etc, up to 12 eight-period-ahead forecasts were produced. The mean absolute errors for these 12 one-period-ahead through to eight-period-ahead forecasts were then calculated. For ease of presentation, the mean absolute errors for approvals, commencements and completions were averaged into a single measure (denoted as the average absolute error) and only the results for the three selected specifications and the VAR model are presented in Table 3.5. These results indicate that, compared with the ECMs, the VAR produces better forecasts for the short term (in this case, the first two quarters). However, over the longer term, the forecasting errors for (3.5) are consistently smaller than the other competing models, including the VAR. For the three hypothesised ECMs, the forecasting errors were found, in this comparison, to be consistently larger than those presented in Table 3.5. For example, the average absolute errors of the one-period-ahead forecasts are 0.0790, 0.0904 and 0.0739 for Alternative 1, 2 and 3 respectively,
and those of the three-period-ahead forecasts increase significantly to 0.1366, 0.1503 and 0.1202 respectively.

Table 3.5: Comparison of Forecasting Performance/1988(1) to 1990(4)

<table>
<thead>
<tr>
<th></th>
<th>Average absolute error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Akaike</td>
</tr>
<tr>
<td>One-period-forecasts</td>
<td>0.0570</td>
</tr>
<tr>
<td>Two-period-forecasts</td>
<td>0.0781</td>
</tr>
<tr>
<td>Three-period-forecasts</td>
<td>0.0855</td>
</tr>
<tr>
<td>Four-period-forecasts</td>
<td>0.0883</td>
</tr>
<tr>
<td>Five-period-forecasts</td>
<td>0.1097</td>
</tr>
<tr>
<td>Six-period-forecasts</td>
<td>0.1125</td>
</tr>
<tr>
<td>Seven-period-forecasts</td>
<td>0.1156</td>
</tr>
<tr>
<td>Eight-period-forecasts</td>
<td>0.1161</td>
</tr>
</tbody>
</table>

The average absolute error is the average of the mean absolute errors for approvals, commencements and completions. * denotes the smallest forecasting error.
3.6. Summary and Conclusions

In this chapter, the theory of co-integration has been utilised to examine the dynamics of housing activity. Three specifications were obtained for a housing system using a proposed procedure. These specifications suggest that approvals and commencements are led by finance approvals for established dwellings, but not by those for new dwellings. Other economic variables such as real income and real construction costs were found to influence activity in new construction through the co-integrating relation they have with finance approvals for established dwellings.

Consistent with findings of studies involving only co-integrated series, the results of the forecasting experiments indicate that, compared with the unrestricted VAR, the ECMs determined by the proposed procedure produce more accurate forecasts in the longer term, although it is not so in the very short term. However, the forecasting results also appear to place significant importance on the short term dynamic part of the ECM as this VAR outperforms those hypothesised ECMs in which the error correction term is included.

A new procedure is proposed for the estimation of a system involving both co-integrated and stationary series. The strength of this procedure appears to be the ability to incorporate the concepts of subset VAR and zero coefficients into the co-integration analysis. Although the place of subset VARs is not demonstrated in this example, it is not difficult to imagine such a situation when monthly or even weekly data are used. Another advantage of this procedure is that no
assumption is necessary for the order of the VAR part of the ECM. The order is determined using an order selection criterion (or criteria). Although it is not demonstrated in this study, this estimation procedure can be extended to systems involving only co-integrated series in a straightforward fashion.

The methodology presented in this chapter could be expected to yield richer results for the interactions between housing activity and relevant financial and economic variables if monthly data were available. The use of quarterly data may mean the model specification cannot reflect fully the dynamic relationships among these variables in the very short term. One possibility is that the financial and economic variables may become important in explaining completions in a monthly framework. Also the responses of approvals and commencements to changes in the relevant variables could become more dynamic than in the results presented above. However, unless the availability of data improves, the possibility for a monthly framework in this context appears to be remote.
Chapter 4

Is Housing Activity A Leading Indicator?

Although housing activity has often been used as a leading indicator of general economic activity, this useful relationship has not been supported by empirical testing using econometric procedures. In this chapter, we investigate whether housing activity does prove to be a leading indicator using two dynamic systems. In the national account system, the results indicate that dwelling investment contains leading information for gross national expenditure. In a five-variable system including a measure of economic activity, housing activity, money, prices and a short term interest rate, housing activity is found to provide an important linkage between economic activity and the rest of the system. These results consistently affirm that housing activity is a leading indicator of general economic activity.

4.1 Introduction

Although housing activity has often been used by economic commentators as a major leading indicator of general economic activity, results of empirical testing have not been supportive of this relationship. For example, Edey and Pleban (1991) examined the causal relationship between the national account aggregates
using both bivariate and multivariate vector autoregressive (VAR) systems specified in first differences. Although conclusions were drawn from the bivariate investigation that dwelling investment leads general economic activity, no significant relationship was found between dwelling investment and economic activity in the multivariate analysis. This negative finding from the multivariate study casts serious doubts on the relevance of the bivariate conclusion and, more importantly, the usefulness of housing activity as a leading indicator of general economic activity.

In this study, we re-investigate whether housing activity is a leading indicator or not. In the first part of this chapter, we re-examine the relationships between national account components using the theory of co-integration. We define "the leading indicator" in a very specific way, referring particularly to the non-zero coefficients in our system. That is, if the lagged housing activity variable is found to enter the equation for general economic activity with an expected sign, then we say that housing activity is a leading indicator of general economic activity. This definition is consistent with the "causality" defined by Granger (1969), which is based entirely on the predictability of the objective variables. If movements in housing activity contain leading information that helps in the prediction of general economic activity, then housing activity is said to "Granger cause" general economic activity or, in this context, to be a "leading indicator" of general economic activity. For more discussions on leading indicator characteristics, see Stock and Watson (1989a). As Edey and Pleban did not undertake testing for the presence of unit roots in the national account system used in their study, we suspect that a VAR in first differences may not be an
appropriate specification for this system. Also, there may be co-integrating relations between the national account components as this is supported by economic theory and empirical findings reported for other economies, see Kunst and Nesser (1990) and King, Plosser, Stock and Watson (1991). If co-integration does exist between the national account components, then a VAR system in first differences may be mis-specified for such an analysis.

In the second part of this study, we investigate the role of housing activity in a five-variable system which includes the variables, general economic activity, housing activity, money, prices and a short term interest rate. Besides the housing activity variable, this multivariate system is similar to that used by researchers for testing whether money "Granger causes" output. This testing of the causal relationship between money and output has traditionally been associated with the debate over the effectiveness of monetary policy. We incorporate housing activity in this system to examine the importance of housing activity in the interrelationships among these variables. That is if, for example, the authorities tighten monetary policy and increase the domestic interest rate structure, would this policy change affect housing activity before it impacts on general economic activity. If this is the case, then housing activity can be regarded as a leading indicator of general economic activity. In this investigation, we also examine the lead-lag relations between housing activity and important financial variables such as money. However, it should be noted that the lead-lag relations between money or financial variables and output or economic activity are not universally consistent. For Australia, Bullock, Stevens and Thorp (1988) examined the relationships between economic activity, interest rates, money and
inflation using a VAR in first differences. They concluded that all the financial variables used in their study are only contemporaneous or lagging indicators of economic activity.

Recent empirical testing of the lead-lag relations among macroeconomic variables has demonstrated that using only slightly different specifications can result in disconcertingly different results. Many researchers have argued that the use of different techniques to detrend the data series may contribute significantly to this puzzle. Ohanian (1986) and Christiano and Ljungqvist (1987) reported findings of a substantial rightward shift in the distribution of the F-statistic under the null hypothesis of no causation when the data used in the testing are not co-integrated but contain unit roots. Similarly, distortions will occur in the test distribution if the data series are over-differenced, which consequently introduces unit roots into the moving average of the system. For testing where the series involved are co-integrated of order (1, 1), Granger (1988) argues that the discussion of causal relationship based on a VAR in first differences could reach incorrect conclusions about no causation due to the omission of the relevant error correction terms. These results strongly support the use of a pre-testing strategy to analyse the trend and integration properties of the data series, individually and jointly as a system, and consequently to determine the appropriate specification for testing for lead-lag relations.

In this study, such a pre-testing strategy is followed as we cannot take comfort that some underlying law ensures that the variables that make up any system we need to analyse will all be of the same order of integration. We first undertake
testing for unit roots at all seasonal as well as zero frequencies for each individual series. After detecting the presence of a unit root at zero frequency in some of the data series, testing for co-integration then follows. Interestingly, the test results indicate that, over the sample period investigated, many data series used in this study are stationary in levels or around a linear trend. These results indicate that taking first-differences of these series may not be appropriate as this will result in over-differencing. Also, among those integrated series, co-integration is detected in the national account system which suggests that a VAR in levels or first differences would be mis-specified for analysis of such a system. The lead-lag relations identified in the specifications based on these test results are very different from those obtained from previous studies for Australia. Most importantly, the results consistently indicate that housing activity is a leading indicator of general economic activity.

4.2 Lead-Lag Relations in the National Account System

Integration and Co-integration Properties

In the first part of this study, the following original quarterly time series over the period 1970(1) to 1991(2) are analysed:

\[ C \]
real private consumption expenditure,

\[ I_d \]
real private investment expenditure on dwelling construction,

\[ I_n \]
real private investment expenditure on non-dwelling construction,
I\textsuperscript{e} \hspace{1cm} \text{real private investment expenditure on equipment and plant,} \\
E \hspace{1cm} \text{real exports,} \\
GNE \hspace{1cm} \text{real gross national expenditure.}

These series were obtained from the Australian Bureau of Statistics (ABS) and the logarithm of each series is used in this study. We removed the statistical discrepancy from the series GNE before proceeding with the analysis. In some studies, gross domestic product (GDP) is preferred for measuring general economic activity. We, however, separate the level of exports from the measure of general economic activity as the former is mainly related to conditions in the international economy. In any case, we still include exports as a variable in this system to examine whether changes in real exports provide any leading information on domestic expenditures. Since this study emphasises questions about leading indicators, we concentrate the analysis on the lead-lag interactions and give no discussion of the contemporaneous causality among these aggregates.

For testing the presence of unit roots at seasonal as well as zero frequencies, two procedures - Hylleberg, Engle, Granger and Yoo (1990) and Dickey and Pantula (1987) - were undertaken. While the Hylleberg et al. test uses a strategy which allows each component factor, 1-L, 1+L and 1+L\(^2\), of the seasonal difference, 1-L\(^4\), where L denotes the lag operator, to be tested separately, the Dickey and Pantula (1987) procedure produces test statistics for the presence of one or more unit roots at zero frequency. In the testing using the Hylleberg et al. procedure,
several specifications with different deterministic terms were considered - an intercept, seasonal dummies, an intercept and a linear trend, seasonal dummies and a linear trend. Seasonal dummies were found to be significant for all of the series under test and would influence the test results for seasonal unit roots if not properly allowed for. As a result, seasonal dummies were removed from each series. The results of this testing are presented in Table 4.1.

Testing for the presence of seasonal unit roots the results indicate that this hypothesis can be rejected at the 5 per cent level for every series except for $I^n$. The hypothesis of the presence of a negative unit root in $I^n$ in the specification including seasonal dummies and a linear trend was found to be acceptable at the 5 per cent level but could be rejected at the 10 per cent level. The linear trend and seasonal dummies are all significant in this specification. To assist decision-making in this situation, we also applied the test for seasonal unit roots introduced by Dickey, Hasza and Fuller (1984) on this series. While the Hylleberg et al. test allows individual seasonal-unit-root components to be tested separately, the Dickey et al. procedure tests for the joint significance. In contrast, the result of the Dickey et al. test indicates that the hypothesis of seasonal unit roots can be rejected at the 5 per cent level. Noting that $I^n$ is the only series in the system for which we are uncertain about the presence of a negative unit root, there will therefore be no possibility of co-integration at this seasonal frequency in the system. Therefore, we proceed with our investigation using the results of the Dickey et al. test.
Table 4.1: Test Results for Seasonal Unit Roots in the National Account System

<table>
<thead>
<tr>
<th>Variable</th>
<th>Specification</th>
<th>$t_1$</th>
<th>$t_2$</th>
<th>$F_{3&amp;4}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Intercept</td>
<td>-1.75</td>
<td>-0.60</td>
<td>0.61</td>
</tr>
<tr>
<td></td>
<td>Intercept+trend</td>
<td>-3.32</td>
<td>-0.50</td>
<td>0.59</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies</td>
<td>-1.49</td>
<td>-3.87*</td>
<td>7.84*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies+trend</td>
<td>-3.15</td>
<td>-3.87*</td>
<td>7.20*</td>
</tr>
<tr>
<td>Id</td>
<td>Intercept</td>
<td>-4.47*</td>
<td>-2.26*</td>
<td>4.77*</td>
</tr>
<tr>
<td></td>
<td>Intercept+trend</td>
<td>-6.92*</td>
<td>-1.82</td>
<td>2.91</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies</td>
<td>-3.02*</td>
<td>-5.01*</td>
<td>21.26*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies+trend</td>
<td>-4.88*</td>
<td>-4.42*</td>
<td>12.81*</td>
</tr>
<tr>
<td>ln</td>
<td>Intercept</td>
<td>-1.72</td>
<td>-2.44*</td>
<td>3.85*</td>
</tr>
<tr>
<td></td>
<td>Intercept+trend</td>
<td>-3.45</td>
<td>-2.26*</td>
<td>4.88*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies</td>
<td>-1.35</td>
<td>-2.94*</td>
<td>14.51*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies+trend</td>
<td>-3.07</td>
<td>-2.73</td>
<td>14.48*</td>
</tr>
<tr>
<td>Re</td>
<td>Intercept</td>
<td>-1.01</td>
<td>-0.52</td>
<td>5.82*</td>
</tr>
<tr>
<td></td>
<td>Intercept+trend</td>
<td>-4.32*</td>
<td>-0.38</td>
<td>5.55*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies</td>
<td>-0.58</td>
<td>-4.69*</td>
<td>22.88*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies+trend</td>
<td>-3.94*</td>
<td>-4.36*</td>
<td>10.84*</td>
</tr>
<tr>
<td>E</td>
<td>Intercept</td>
<td>-1.08</td>
<td>-3.10*</td>
<td>13.86*</td>
</tr>
<tr>
<td></td>
<td>Intercept+trend</td>
<td>-1.71</td>
<td>-3.16*</td>
<td>13.21*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies</td>
<td>0.51</td>
<td>-4.92*</td>
<td>17.16*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies+trend</td>
<td>-1.65</td>
<td>-4.69*</td>
<td>16.17*</td>
</tr>
<tr>
<td>GNE</td>
<td>Intercept</td>
<td>-1.39</td>
<td>-0.39</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>Intercept+trend</td>
<td>-5.09*</td>
<td>-0.30</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies</td>
<td>-1.07</td>
<td>-3.51*</td>
<td>14.30*</td>
</tr>
</tbody>
</table>
Seasonal dummies+trend \[-4.33^{*} \quad -3.08^{*} \quad 14.03^{*}\]

t_1 \text{ tests for } 1-L, t_2 \text{ for } 1+L \text{ and } F_{3&4} \text{ for the polynomial factor } 1+L^2. * \text{ denotes a test statistic that rejects, at the 5 per cent level, the null hypothesis of the presence of a unit root at the associated frequency according to Hylleberg et al. (1990). C denotes log(private consumption expenditure), } I_d \text{ log(private dwelling investment expenditure), } I_n \text{ log(private investment expenditure on non-dwelling construction), } I_e \text{ log(private investment expenditure on equipment and plant), } E \text{ log(exports) and GNE log(gross national expenditure).}

The test results in Table 4.1 also indicate that several of the above national account components, namely $I_d$, $I_e$ and GNE, could be stationary either in levels or around a linear trend. For $I_d$, the presence of a unit root at either zero or seasonal frequencies is rejected in three out of the four specifications used in the test. For both $I_e$ and GNE, the hypothesis of a unit root is rejected in the specification including a linear trend and seasonal dummies. The linear trend and seasonal dummies are all significant. These results have important implications for this study as they suggest that taking first differences of these series would result in over-differencing. However, for the remaining series, C, $I_n$ and E, the hypothesis of a unit root at zero frequency was found to be acceptable at the 5 per cent level in all of the specifications used. These test results are also consistent with those obtained using the Dickey and Pantula procedure (Table 4.2). Note that these test statistics which reject the hypothesis of a unit root at zero frequency for $I_d$, $I_e$ and GNE are more negative than, or at least close to, the associated critical values at even the 1% level. Close examination of the data
Table 4.2 Test Results for Integration and Co-integration in the National Account System

(A) Dickey and Pantula Test Results for Unit Roots

<table>
<thead>
<tr>
<th>Variable</th>
<th>Two unit roots</th>
<th>One unit root</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-3.46*</td>
<td>-3.29</td>
</tr>
<tr>
<td>I d</td>
<td>-</td>
<td>-5.01* (-3.60*)</td>
</tr>
<tr>
<td>I n</td>
<td>-3.38*</td>
<td>-3.14</td>
</tr>
<tr>
<td>RE</td>
<td>-</td>
<td>-3.97*</td>
</tr>
<tr>
<td>E</td>
<td>-4.81*</td>
<td>-1.73</td>
</tr>
<tr>
<td>GNE</td>
<td>-</td>
<td>-4.61*</td>
</tr>
</tbody>
</table>

(B) Stock and Watson Test Results for Co-integration

**Eigenvalues**

<table>
<thead>
<tr>
<th></th>
<th>2.672</th>
<th>0.293</th>
<th>0.035</th>
</tr>
</thead>
</table>

**Eigenvectors**

- **(C)**
  | 0.980 | -0.583 | -0.869 |

- **(I n)**
  | 0.915 | 1.000  | -0.163 |

- **(E)**
  | 1.000 | -0.343 | 1.000  |

\[ q_t (3,2) = -84.2^* \]

* denotes that the statistic is significant at the 5 per cent level according to either Fuller (1976) or Stock and Watson (1988). The presented test statistics are based on an assumption of an underlying AR(4) process. The test results are not sensitive to the assumed order of the AR process. A linear trend was included in
the testing for the presence of only one unit root. For $I^d$, the test statistic, not including a linear trend, is presented in parenthesis. $q^f_t(3,2)$ denotes the Stock and Watson test statistic of the null hypothesis of 3 common trends against the alternative of 2 common trends, where $t$ denotes linear detrending. $C$ denotes log(private consumption expenditure), $I^d$ log(private dwelling investment expenditure), $I^n$ log(private investment expenditure on non-dwelling construction), $I^e$ log(private investment expenditure on equipment and plant), $E$ log(exports) and GNE log(gross national expenditure).

movements also leads to consistent conclusions. Consequently, we accept these test results and characterise these three national account components as stationary, either in levels or around a linear trend.

To test for the presence of co-integrating relations, the procedure introduced by Stock and Watson (1988) was applied to the three national account components which are integrated of order 1. The Stock and Watson procedure assumes the null hypothesis that the data series under test are all integrated but not co-integrated, so that there is a total of three unit roots under the null hypothesis. The statistic presented in the lower part of Table 4.2 tests for this hypothesis against the alternative of at most two unit roots. The results of the Stock and Watson test suggest that there are at most only two unit roots and, therefore, there is one co-integrating relation between these integrated series. In Table 4.2, we present the three eigenvectors obtained from the principal component analysis in the test. Following the suggestion of Stock and Watson, the associated co-integrating vector for this co-integrating relation can be estimated by the
eigenvector with the smallest principal component; that is the last eigenvector presented in Table 4.2. This co-integrating vector can then be used to generate the error correction term for the estimation of the associated ECM.

*The Specification of the ECM*

The specification of this national account system is determined using the procedure developed in Chapter 3 for time series systems which contain both stationary and co-integrated series. If the lagged dwelling investment expenditure is found to enter the equations for other national account aggregates, especially GNE, then this investment expenditure can be regarded as containing leading information on general economic activity. Three order selection criteria - Akaike (1973), Schwarz (1978) and Hannan and Quinn (1979) - were used to determine the specification. The linear combination of the series (in levels) generated by the eigenvector with the smallest principal component presented in Table 4.2 was used to create the error correction term. To begin the selection, a maximum order of 8, ie eight quarters or two years, was assigned to the VAR part of the ECM. Since the series, I^d, is stationary in levels and could contain a linear trend and both I^e and GNE are stationary around a linear trend, we also included a linear trend as an exogenous variable in the selection process. Given that the Schwarz criterion is superior in order-identification to the other two alternatives, we will emphasise the specification determined by the Schwarz criterion and use it as the benchmark model for analysing the lead-lag relations. This specification was estimated using the generalised least squares (GLS) technique and is presented in Table 4.3.
Table 4.3: Specification of the Error Correction Model Determined by the Schwarz Criterion

<table>
<thead>
<tr>
<th></th>
<th>$dC_t$</th>
<th>$I^d_t$</th>
<th>$dI^n_t$</th>
<th>$I^e_t$</th>
<th>$dE_t$</th>
<th>$GNE_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$dC_{t-1}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I^d_{t-1}$</td>
<td>0.9264</td>
<td>0.1122</td>
<td>0.1206</td>
<td>0.0535</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(24.87)</td>
<td>(2.13)</td>
<td>(1.88)</td>
<td></td>
<td>(2.33)</td>
<td></td>
</tr>
<tr>
<td>$dI^n_{t-1}$</td>
<td></td>
<td></td>
<td>-0.2861</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(2.92)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I^e_{t-1}$</td>
<td></td>
<td></td>
<td>0.6823</td>
<td></td>
<td></td>
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<td>(7.02)</td>
</tr>
<tr>
<td>$Z_{t-1}$</td>
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<td></td>
<td></td>
<td>-0.1091</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1.53)</td>
</tr>
<tr>
<td>Trend</td>
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<td></td>
<td>0.0028</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.56)</td>
<td></td>
<td>(4.67)</td>
<td></td>
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</tr>
</tbody>
</table>

$t$-statistic in parenthesis. $Z_{t-1}$ is the error correction term. $dC_t$ denotes the first difference of log(private consumption expenditure), $I^d_t$ log(private dwelling investment expenditure), $dI^n_t$ the first difference of log(private investment expenditure on non-dwelling construction), $I^e_t$ log(private investment expenditure on equipment and plant), $dE_t$ the first difference of log(exports) and $GNE_t$ log(gross national expenditure).
The relationships identified by the three order selection criteria are markedly similar in this case. The linear trend is included, for all three criteria, to explain GNE and $I^e$, with the associated coefficients highly significant. All of the determined specifications consistently indicate that dwelling investment is the major variable which provides leading information for other expenditure aggregates. In these specifications, the lagged dwelling investment enters not only its own equation but also those for $I^m$, $I^e$ and GNE\textsuperscript{4.1}. In all of the determined specifications, the lagged level of exports does not enter any of the expenditure equations, indicating that variations in exports provide little leading information for domestic economic conditions. Also, no lagged national account components enter the equation for consumption expenditure, not even its own lags, indicating that this national account system contains little leading information for consumption expenditure.

### 4.3 The Role of Housing Activity in the Business Cycle

Although the specifications determined for the above national account system consistently indicate that dwelling investment contains leading information for general economic activity, little economic reasoning has been obtained to explain how this process occurs. This absence could be related to the lack of important

\textsuperscript{4.1} An experiment was undertaken in which a VAR in first differences was used for the national account system. In agreement with the findings of Edey and Pleban (1991), none of the national account components used in the analysis can be regarded as a leading indicator of general economic activity in such a specification.
economic variables which are subject to control and which influence the level of general economic activity. For example, exports should be related to conditions in the international economies or markets and domestic expenditures would be influenced by domestic control variables such as the money supply and interest rates. Consequently, the picture of the business cycle presented in this national account system is incomplete. To better investigate, as well to understand, this leading relationship, we re-examine the leading indicator characteristics of housing activity using a system which has been commonly utilised for detecting the interrelation between money and output. We analyse a system which consists of five variables - a measure of economic activity, housing activity, money, prices and a short term interest rate - to examine the role of housing activity in the business cycle and the interaction between housing activity and important economic variables such as money and interest rates. This system will also allow us to re-examine the issue of whether money "Granger causes" output for Australia: a relation which was not supported by econometric testing in previous studies.

Whether movements in money or financial variables help to predict movements in output or economic activity has been an enduring topic in empirical time series analysis. Conflicting conclusions have been reported for different countries. For example, while consistent results showing that money "Granger causes" output have been obtained for the U.S., see Sims (1972) and Stock and Watson (1989b), the empirical results for other countries, such as Canada, cast serious doubts on such a relationship, see Krol and Ohanian (1990). As indicated by Cuddington (1981), it is possible that the causal relation between money and
output may depend on each government’s monetary policy management.

Trends and Unit Roots

In the following, we re-address the issue of the lead-lag relations between economic activity variables and financial variables including money. The data used in this system are monthly observations obtained from the ABS and the Reserve Bank. We use the monthly unemployment rate, $U_t$, to measure general economic activity. An increase in the unemployment rate reflects a weakening in economic activity and vice versa. The monthly series of private dwelling approvals, $A_t$, is used to approximate housing activity. The measure of money supply, $M_t$, used is M3 (currency plus bank deposits of the private non-bank sector), and the interest rate is the 90 day bank bill rate, $R_t$. Difficulty was encountered when selecting a measure for the price level because the ABS does not publish a monthly series for the consumer price index or price deflator for GDP. The most appropriate approximation we could use is the price index for materials used in the manufacturing industry, $P_t$. Although there was a change in the weights used to construct this index in late 1985, no adjustment was undertaken because the change in weights seems not to have been significant. Apart from the unemployment rate and the interest rate, the other series are in logarithms in this study. These series cover the period February 1978 to April 1991.

Univariate testing using the Dickey et al. (1984) test indicates that the hypothesis of seasonal unit roots can be rejected at the 5 per cent level in a specification
including seasonal dummies for the unemployment rate and dwelling approvals and without seasonal dummies for the remaining series. Seasonal dummies were found to be significant in the series for the unemployment rate and dwelling approvals and would influence the test results for seasonal unit roots if not properly allowed for. As a result, seasonal dummies were removed from these two series.

The testing for positive unit roots using the Dickey and Pantula test is presented in Table 4.4. The test results indicate that the unemployment rate and money supply are integrated of order 1, dwelling approvals and the 90 day bank bill rate are stationary in levels and the price index of materials used in the manufacturing industry is stationary in levels and could contain a linear trend. Again, these test results indicate that taking first differences of every component in this system would not be an appropriate procedure as some of these series are already stationary in their levels. For the unemployment rate series, we were suspicious about the test result as in some studies, such as Blanchard and Quah (1989), the US unemployment rate was assumed to be stationary. To make certain about this result, we re-applied the Stock and Watson test to this series to test for the presence of a unit root. The test statistic obtained is again well above the critical value at the 5 per cent level, accepting the hypothesis of a unit root in the series for the unemployment rate.

In a study on the interrelation between money and output, Stock and Watson (1989b) emphasise the importance of testing for a linear trend in the differenced money supply series. They showed that the presence of such a trend can affect
testing for causal relations in the money-output system. In this study, such testing was also undertaken by regressing the log-differenced money supply against a constant, a linear trend and four of its own lags. Krol and Ohanian (1990) indicate that the power of such a test is reasonably high. The test result rejects the hypothesis of the presence of a linear trend in the differenced money supply.

To test for co-integration between the two integrated series in the system, namely $U_t$ and $M_t$, we adopted a testing procedure suggested by Engle and Granger (1987). Engle and Granger proposed a number of procedures for testing the existence of co-integration between two series. Their major recommendation was to apply the augmented Dickey - Fuller (ADF) test to the residuals of the co-integrating regression. In this procedure, the ordinary least squares (OLS) technique is utilised first to regress one variable against the other (the co-integrating regression). The test for co-integration is then based on the residuals of this regression. If the residual series is found to contain a unit root, then the null hypothesis of no co-integration cannot be rejected. Unlike the Stock and Watson test, the Engle and Granger procedure is computationally simpler but depends on a particular normalisation for the co-integrating regression. However, Engle and Yoo (1987) indicate that the test statistics have the same distribution for all normalisations. They also suggest that, empirically, the test statistics should be insensitive to the choice of normalisation.
Table 4.4 Tests for Integration and Co-integration in the Five Variable System

(A) Dickey and Pantula Test Results for Unit Roots

<table>
<thead>
<tr>
<th>Variable</th>
<th>Two unit roots</th>
<th>One unit root</th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td>-3.46*</td>
<td>-1.90</td>
</tr>
<tr>
<td>R</td>
<td>-</td>
<td>-2.92*</td>
</tr>
<tr>
<td>A</td>
<td>-</td>
<td>-3.62*</td>
</tr>
<tr>
<td>P</td>
<td>-</td>
<td>-3.69* (-4.10*)</td>
</tr>
<tr>
<td>M</td>
<td>-4.39*</td>
<td>-1.86</td>
</tr>
</tbody>
</table>

(B) Engle and Granger Test for Co-integration

Co-integration regression

\[ M_t = a_0 + a_1 U_t \]

ADF test

-1.25

\[ U_t = a_0 + a_1 M_t \]

-1.84

* denotes that the test statistic is significant at the 5 per cent level according to Fuller (1976). The presented results for unit root testing are based on an AR(6). The test results are not sensitive to the assumed order of the AR process. For \( P_t \), the test statistic including a linear trend is in parenthesis. The ADF test results are based on regressions including four lagged variables. U denotes the unemployment rate, R the 90 day bank bill rate, A log(dwelling approvals), P log(price index of materials used in the manufacturing industry) and M log(M3).
In the lower part of Table 4.4, the test results for the two possible normalisations are presented. Both of the test statistics are much higher than the critical value of -3.17 at the 5 per cent level reported by Engle and Granger (1987), indicating that the null hypothesis of no co-integration cannot be rejected. Similar results were also obtained when a linear trend was included in the testing.

Money-Output Interrelation

Given that no co-integration was detected in this five-variable system, the order selection procedure for VAR systems introduced by Penm and Terrell (1984a) was used to identify the specification of this VAR. To begin the selection, the maximum order of this VAR was set at 12. Since $P_t$ could be stationary either in levels or around a linear trend, we also included a linear trend as an exogenous variable in the selection process. However, none of the three criteria included the linear trend in the specifications. It is interesting that the Schwarz and Hannan criteria both selected the same specification for this system, although that determined by the Akaike criterion is slightly different. For brevity, only the specification determined by the Hannan and Schwarz criteria is presented in Table 4.5. This specification was estimated using GLS.

The major difference between the two selected specifications appears to be in the equations for the unemployment rate and the money supply. In the specification determined by the Akaike criterion, the two-period-lagged interest rate enters the equation for the unemployment rate and the three-period-lagged unemployment rate influences the growth in money supply. No such influences are seen in Table
4.5. In both specifications, the growth in money supply enters the equation for the unemployment rate with a negative sign, a result which seems to be consistent with the notion that money "Granger causes" output. The change in the unemployment rate is also negatively related to the previous level of approvals, indicating that housing activity appears to be a forerunner to changes in the level of economic activity. Economic activity, as measured by the unemployment rate, also feeds back on housing activity. Noting that there is a difference in timing in these specifications regarding the interrelationship between housing and economic activity. While \( dU_t \) is related to \( A_{t-1} \), \( A_t \) is influenced by \( dU_{t-2} \).

In contrast to previous testing, the short term interest rate appears to be important in influencing general economic activity, although its effect is indirect in this system. In both specifications, the lagged interest rate is included in the equations.

---

4.2 In a quarterly money-output system in which GNE was used as a measure of general economic activity, consistent results which indicate that both money and housing activity “Granger cause” general economic activity were also obtained. However, the interactions in the determined specification are less informative than those presented in the monthly model.

4.3 Similar results were also obtained in an alternative specification using an index of industrial production to approximate general economic activity.
Table 4.5: VAR Specification Selected by the Hannan and Schwarz Criteria

<table>
<thead>
<tr>
<th></th>
<th>dU_t</th>
<th>R_t</th>
<th>A_t</th>
<th>P_t</th>
<th>dM_t</th>
</tr>
</thead>
<tbody>
<tr>
<td>dU_{t-1}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R_{t-1}</td>
<td></td>
<td>0.8972</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A_{t-1}</td>
<td>-0.0032</td>
<td></td>
<td>0.1640</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P_{t-1}</td>
<td></td>
<td>0.0848</td>
<td>0.9667</td>
<td>0.0228</td>
<td></td>
</tr>
<tr>
<td>dM_{t-1}</td>
<td>-0.0499</td>
<td></td>
<td>0.2837</td>
<td>0.2023</td>
<td></td>
</tr>
<tr>
<td>dU_{t-2}</td>
<td>0.1989</td>
<td></td>
<td>-4.7762</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R_{t-2}</td>
<td></td>
<td>-1.5954</td>
<td></td>
<td>-0.1755</td>
<td></td>
</tr>
<tr>
<td>A_{t-2}</td>
<td></td>
<td>0.2099</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P_{t-2}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dM_{t-2}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dU_{t-3}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R_{t-3}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.1892</td>
</tr>
<tr>
<td>A_{t-3}</td>
<td>0.0184</td>
<td></td>
<td>0.5318</td>
<td>0.0151</td>
<td></td>
</tr>
<tr>
<td>P_{t-3}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.0238</td>
</tr>
<tr>
<td>dM_{t-3}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
t-statistics in parenthesis. \( dU_t \) denotes the first difference of the unemployment rate, \( R_t \) the 90 day bank bill rate, \( A_t \) log(dwelling approvals), \( P_t \) log(price index of materials used in the manufacturing industry) and \( dM_t \) the first difference of log(M3).

for the money supply and approvals, both enter the equation for general economic activity with expected signs. These results seem to place significant importance on the effect of the short term interest rates on general economic activity. In both specifications, the only variable, besides its own lag, which enters the equation for the interest rate is \( A_{t-3} \). While \( A_t \) is related to \( dU_{t-2} \), this seems to suggest that the level of general economic activity also influences the short term interest rate through its effect on housing activity. Although the lagged growth in money supply does not enter the equation for approvals, \( dM_t \) is also related to \( A_{t-3} \). Like the short term interest rate, the effect of changes in the price level on general economic activity is also indirect. In both specifications, \( P_{t-1} \) enters the equations for the money supply and approvals with positive signs. Although the lagged growth in money supply also enters the price equation, no lagged approvals enter the equation for \( P_t \). 4.4

4.4 Discussions of the contemporaneous causality in this system are presented in Chapter 5.
The lead-lag relationships in the specification determined by the Hannan and Schwarz criteria are summarised in Table 4.6. It is obvious that, in this specification, both the money supply and housing activity provide the linkages
between economic activity and the rest of the system. However, the importance of housing activity appears to be more significant in this system as any feedback from general economic activity to the rest of the system will have to occur via housing activity. These results suggest that housing activity plays an important role in the money-output relationship and can be regarded as a leading indicator of general economic activity. As for the direct interrelation between money and economic activity, the lead-lag pattern indicates that money directly influences economic activity, however, only an indirect feedback is found from general economic activity to money.

The linear dependence and feedback in this money-output system have been measured using the approach proposed by Geweke (1982). For brevity, we only present, in Table 4.7, two cases of interest for the specification presented in Table 4.5. Testing at the 5 per cent level, 95 per cent confidence intervals are shown parenthetically. In the first case, the interaction between housing activity and the rest of the system is measured. It is found that the feedback from housing activity to the rest of the system is significant, although this measure is understandably less than that from the rest of the system to housing activity. In the second case, the measure of linear dependence between the financial variables and the variables of economic and housing activity is computed. The results indicate that the financial variables govern the movements of the activity variables with weak feedback from the latter to the former.
Table 4.7: Measures of Linear Dependence and Feedback in the Money-Output Interrelations

<table>
<thead>
<tr>
<th>Case 1: X = [dU R P dM] and Y = [A]</th>
<th>Case 2: X = [R P dM] and Y = [dU A]</th>
</tr>
</thead>
<tbody>
<tr>
<td>F_y \rightarrow x = 0.21 (0.03, 0.30)</td>
<td>F_y \rightarrow x = 0.18 (-0.03, 0.20)</td>
</tr>
<tr>
<td>F_x \rightarrow y = 0.38 (0.14, 0.52)</td>
<td>F_x \rightarrow y = 0.39 (0.11, 0.49)</td>
</tr>
<tr>
<td>F_{x,y} = 0.64 (0.34, 0.84)</td>
<td>F_{x,y} = 0.63 (0.30, 0.78)</td>
</tr>
</tbody>
</table>

F_y \rightarrow x$ the measure of linear feedback from Y to X, $F_x \rightarrow y$ the measure of linear feedback from X to Y and $F_{x,y}$ the measure of linear dependence. 95% confidence intervals are shown parenthetically. For the definitions of linear dependence and feedback, see Geweke (1982). dU denotes the first difference of the unemployment rate, R the 90 day bank bill rate, A log(dwelling approvals), P log(price index of materials used in the manufacturing industry) and dM the first difference of log(M3).

4.4 Concluding Remarks

In this chapter, two economic systems have been utilised to examine the place of housing activity as a leading indicator of general economic activity. While previous econometric testing provided little empirical support for this
relationship, the results in this study consistently indicate that housing activity contains leading information which will be helpful in forecasting general economic activity.

Some enlightening lead-lag relations are obtained in this study. In the national account system, dwelling investment is found to contain leading information for other investment and gross national expenditure. While investment expenditures are generally related to their own lags, the national account aggregates used in this study contain little leading information for consumption and exports and the value of exports do not contain leading information for domestic economic conditions. In the five-variable system addressing the money-output interrelationships, we found that housing activity plays an important role in linking economic activity and the financial variables. As for the direct relationship between money and general economic activity, the results support the notion that money "Granger causes" output. In this system, the short term interest rate is also found to be important in influencing the level of housing activity and the growth in money supply. Through these two variables, the movements in the interest rate affect the level of economic activity.

The conclusions drawn from this study are significantly different from those of previous testing for Australia. One of the major reasons for these differences must be related to the treatment of the trend and unit root properties in the data series. Unlike most previous studies, which use VARs in first differences, this study adopts a strategy of testing for the presence of trends and unit roots in individual series and in the system they form before proceeding with the
analysis. Based on these test results, appropriate specifications and procedures to detrend data are then decided. In this study, the results of unit root testing indicate that many of the macroeconomic variables used in the systems are stationary, in levels or around a linear trend. Consequently, taking first-differences of these series is likely to result in over-differencing. In the testing for co-integration, the results suggest the existence of a co-integrating relation in the national account system. As a result, a VAR in levels or first differences would be mis-specified for analysis of this system.
Chapter 5

The Effect of Changes in Macroeconomic Variables on Housing Activity

In this chapter, the responses of housing activity to innovations in important macroeconomic variables, namely a short term interest rate, money growth, prices and general economic growth, are examined using the impulse response approach. The results indicate clearly how housing activity responds differently to innovations from different sources. While the effect of an interest rate shock is relatively significant with a maximum response at 8-11 months, the effects of innovations in money and general economic growth become insignificant after a short time. The responses of general economic growth to these innovations demonstrate similar patterns, although the most significant impact, ie single-period effect, is due to an innovation of one-standard-deviation in money growth.

5.1 Introduction

The significant fluctuations in housing activity in recent years have attracted much research effort to identify economic factors which influence the housing market, see Filmer and Silberberg (1980), Yates (1981), Williams (1984) and Bassanese, Horn and Simes (1989). One major source of such influences may be
innovations in important macroeconomic variables resulting from changes in the government's macroeconomic policy. For example, an increase in the domestic interest rate structure due to a tightening of monetary policy will increase the borrowing costs to builders and reduce affordability for consumers, leading to an adverse effect on housing activity.

Recent studies on housing activity indicate that such influences exist and may be significant. In Chapter 4, a system commonly utilised by researchers to examine the interrelationships between economic activity, including housing activity, and financial variables was identified. The determined specification suggests that important macroeconomic variables, such as short term interest rates, influence housing activity directly, while indirect effects on housing activity can be found from other macroeconomic variables such as money. The results also indicate that changes in housing activity precede changes in the level of general economic activity and that there is feedback from general economic activity to housing activity.

Some important questions left unanswered in this context relates to the extent and timing of these effects on housing activity. How responsive is housing activity to innovations in important macroeconomic variables and the timing and pattern of such responses are of course most important for policy formulation. In this chapter, we investigate these questions by examining the dynamic interactions between macroeconomic variables and housing activity using the impulse response approach. Using the VAR system identified in Chapter 4, the associated moving average (MA) representation is derived to facilitate such an analysis.
Impulse responses are calculated, which show how housing activity responds to innovations of one-standard-deviation in size for included important macroeconomic variables, namely a short term interest rate, money growth, general economic growth and prices. The major findings which emerge from this study indicate that the dynamic responses of housing activity depend on the source of the initial shock. While a shock to the short term interest rate generates a relatively significant and prolonged effect on housing activity, the effects of innovations in money and general economic growth become insignificant after a short period of time. The responses of general economic growth, approximated by the unemployment rate, demonstrate similar patterns to shocks to these financial variables, although the most significant impact appears to come from a one-standard-deviation shock in money growth.

5.2 Data and the Underlying VAR System

In examining the lead-lag relationships between housing activity and important macroeconomic variables, a five-variable VAR system was utilised in Chapter 4 which involves a short term interest rate, money, a housing activity variable, prices and a measure of general economic activity. The data used to identify this system are monthly observations obtained from the Australian Bureau of Statistics and the Reserve Bank over the period February 1978 to April 1991. In this system, the short term interest rate used is the 90 day bank bill rate, \( R_t \), and the money supply used is \( M_3 \) (currency plus bank deposits of the private non-bank sector), \( M_t \). The series used to approximate housing activity is private residential dwelling approvals, \( A_t \), and that used to approximate the price level is
the price index for materials used in the manufacturing industry, $P_t$. The unemployment rate is used as a measure of general economic activity, $U_t$. An increase in the unemployment rate reflects a weakening in general economic activity and vice versa. Apart from the unemployment rate and the interest rate, the other series are in logarithms in this system.

One important aspect in the study presented in Chapter 4 relates to the treatment of the trend and unit root properties in the data series. Ignoring a common practice of using the VAR in either first differences or levels, a strategy of testing for the presence of trends and unit roots was adopted for both individual series and the system they form, before proceeding with the modelling analysis and causal links. Based on these testing results, an appropriate specification and procedures to detrend data are decided. This pre-testing strategy aims to eliminate the problem of either "over-differencing" or "under-differencing" in the system, both of which could distort the test distribution and, consequently, result in misleading conclusions on causal relations (see Stock and Watson 1989b and Ohanian 1986). In the testing for unit roots, the results indicate that, over the sample period investigated, the unemployment rate and money supply are integrated of order one, dwelling approvals and the 90 day bank bill rate are stationary in levels and the price index for materials used in the manufacturing industry could be either stationary in levels or around a linear trend. Seasonal dummies were removed from the series, the unemployment rate and dwelling approvals. The hypothesis of no co-integration between the two integrated series, namely the unemployment rate and money supply, was not rejected by the Engle and Granger (1987) test. Based on these results, a conclusion was drawn that
this system can be specified as a VAR, \([R_t \ dM_t \ A_t \ dU_t \ Pt]\), where \(d\) denotes the first difference. The lead-lag relationships determined by this specification, which is based on the results of the pre-testing strategy, are very different from those reported in previous studies (see Bullock, Stevens and Thorp 1988 and Edey and Pleban 1991). For details of this system, interested readers are referred to Chapter 4.

5.3 Methodology

To carry out a precise examination on the extent of the dynamic interrelationships between these macroeconomic variables, a direct investigation using the VAR specification may not be the best vehicle for the exercise. As argued by Sims (1980), the associated MA representation may offer a more comprehensible picture. Using this MA framework, dynamic interrelations between the variables can be analysed by "shocking" the system by an innovation, and then the impulse response of each variable in the system to this shock can be traced in the time domain. There are also advantages from applying this technique to examine the "indirect causality" in the system. Two variables can be related in an indirect Granger causal sense even if the direct effect is not significant. When one variable affects another, which in turn influences a third variable in the system, the first variable is said to indirectly Granger cause the third variable. Although the direction of such influence can be easily identified by examining the lead-lag relationships, the timing and extent of this effect are best investigated using the impulse response functions.
To generate the impulse response functions for a time series system, researchers usually begin with an m-dimensional VAR process with the lag length, p, which can be expressed as follows:

\[ X_t = A_1 X_{t-1} + \ldots + A_p X_{t-p} + U_t \quad (5.1) \]

where \( X_t = (x^1_t, \ldots, x^m_t) \), \( A_i, i=1, \ldots, p \), are \( m \times m \) coefficient matrices and \( U_t \) is an \( m \)-dimensional white noise vector with \( E(U_t) = 0 \) and \( E(U_t U_t') = \Omega_u \).

Conventionally, researchers propose procedures to identify the order of this VAR model, i.e., p. After p is identified, every element in the coefficient matrices, \( A_i \)'s, is assumed to be non-zero before a procedure, usually ordinary least square (OLS), is utilised for estimation. However, this non-zero-coefficient assumption neglects the possibility of zero entries in the coefficient matrices of this VAR(p). In economic time series analysis, it is impracticable to neglect possible zero coefficients. For example, in (5.1), there are \( mp^2 \) possible parameters which implies the existence of \( 2^{mp^2} \) possible VAR models in the form of (5.1) with or without zero entries in its coefficient matrices. Of course, it is difficult to find the optimum VAR with zero coefficients without an effective approach. To overcome this difficulty, Penm and Terrell (1984a, b) proposed a search algorithm using a block Choleski decomposition in conjunction with model selection criteria to select the optimum VAR without evaluating all possible candidate models. In the case of the presence of zero entries in the coefficient matrices, the technique of generalised least squares (GLS) is used to ensure efficient estimation. The so-determined VAR specification can be used to detect the causal and feedback
relations in the system. In Chapter 4, the Penm and Terrell procedure was
applied to the above system and a VAR(3) with zero coefficients was determined.
This so-determined VAR system is used in this chapter as the basis of the
impulse response analysis.

Bearing in mind the possible zero entries in the coefficient matrices of (5.1) and
assuming (5.1) is stationary, there exists an equivalent MA representation, ie.

\[ X_t = \sum_{i=0}^{\infty} \beta_i U_{t-i} \]  \hspace{1cm} (5.2)

where \( \beta_0 = I_m \), the mxm identity matrix and \( \beta_i = \sum_{j=1}^{i} \beta_{i-j} A_j \), \( i = 1, 2, 3, \ldots \),
with \( A_j = 0 \) for \( j > p \). Given the zero entries in the \( A_j \)'s, there can also be some
zero entries in the \( \beta_i \)'s.

For ease of analysis, a common practice used by researchers is to first
orthogonalise the \( U_t \) before interpreting the coefficients of the resulting MA
representation (for example, Sims 1980 and Burbidge and Harrison 1984). In
other words, a (usually) lower triangular matrix \( H, \Omega_U = HH' \), is chosen and let
\( V_t = H^{-1} U_t \), so that \( E(V_t V_t') = I_m \). To do this orthogonalisation, it is
necessary to choose an ordering for the variables involved in the system. In the
chosen ordering, the first variable is assumed to be contemporaneously
exogenous and is allowed to influence other variables listed below it. Each
subsequent variable in this ordering is then assumed to depend
contemporaneously on those variables listed above it. As one might expect, the
ordering of variables can sometimes significantly influence the results. The degree of such influence is governed by the extent of contemporaneous causality (correlation) among the variables.

Taking this orthogonalisation, (5.2) becomes

\[ X_t = \sum_{i=0}^{\infty} C_i V_{t-i} \] (5.3)

where \( C_i = \beta_i H \).

Using (5.3), the impulse responses of the system to an independent innovation in one of the variables can be obtained. Consider a temporary shock to the k-th component of \( V_t \), \( V^k_t \), which equals unity. Since \( \text{COV}(V^k_t, V^h_t) = 0, k \neq h \), the response of \( X_t \) to this shock is given by the k-th column of \( C_0 \) and that of \( X_{t+i} \) is the k-th column of \( C_i \) for \( i = 1, 2, 3, \ldots \). Thus, each column of \( C_i \) represents the impulse response of the system at time \( t+i \) to a shock of unit size administered at time \( t \). The total effects of this shock on the system is the sum of the k-th column of each \( C_i \).

5.4 The Impulse Response Analysis

In this study, the impulse response of this money-output system was analysed. Besides the VAR specification identified in Chapter 4, this procedure also requires a particular ordering of the variables involved, and this ordering may influence the impulse response calculation depending on the extent of the contemporaneous causality in the system. To examine the extent of such influence, the contemporaneous causality is examined (Table 5.1). To determine
the pattern of contemporaneous causality, the procedure introduced by Penm and Terrell (1984a) was utilised, together with the order selection criteria developed by Schwarz (1978) and Hannan and Quinn (1979). Interestingly, both the criteria selected the same pattern of contemporaneous causality for this system. The change in the unemployment rate, which is used to approximate general economic growth, was found to be negatively related to money growth: a result which contemporaneously links general economic growth to the growth in money supply. The price level was found to be contemporaneously correlated with most of the other variables except money. According to these results, it seems sensible to order these variables as \([R_t \ dM_t \ A_t \ dU_t \ P_t]\) as the short term interest rate and money growth are generally subject to government control and changes in these financial variables are more likely to influence the activity variables than the other way around. Since the price level is contemporaneously correlated with most of the other variables, this variable is placed on the bottom of this ordering.

One approach which may be useful in determining the ordering of the variables is to examine the causal relations using data published on a more frequent basis. For example, if both quarterly and monthly data are available for a system under investigation, then the ordering of the impulse response analysis of the quarterly system may be chosen according to the causal relations determined using the monthly data. Unfortunately, this approach is not feasible in this study as the monthly observations are the most frequently published data. However, given the small extent of contemporaneous correlation in this system, the influence of a particular ordering on the calculation of the impulse response functions is not
expected to be significant. To examine this hypothesis more carefully, we recalculated the impulse response functions based on an ordering in which the positions of $R_t$ and $dM_t$ and $A_t$ and $dU_t$ were exchanged. No significant changes to the results were found.

Table 5.1: Contemporaneous Correlation Determined by the Schwarz and Hannan Criteria

<table>
<thead>
<tr>
<th>Variables</th>
<th>$R_t$</th>
<th>$dM_t$</th>
<th>$A_t$</th>
<th>$dU_t$</th>
<th>$P_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_t$</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$dM_t$</td>
<td>0.00</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$A_t$</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$dU_t$</td>
<td>0.00</td>
<td>-0.17</td>
<td>0.00</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>$P_t$</td>
<td>0.09</td>
<td>0.00</td>
<td>0.16</td>
<td>-0.01</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Standard deviation of innovation

|                     | 0.010 | 0.008 | 0.061 | 0.002 | 0.018 |

$R_t$ denotes the 90 day bank bill rate, $dM_t$ the first difference of log(M3), $A_t$ log(dwelling approvals), $dU_t$ the first difference of the unemployment rate and $P_t$ log(prices).
In this system, there are in total 25 impulse response functions which can be obtained from the associated MA representation. Since the main interest of this study is the dynamic impact of the financial variables, namely the short term interest rate, money growth and prices, on the activity variables, especially housing activity. we therefore concentrate the following analysis on this objective.

**Figure 5.1 Profiles of Innovations**

(A) An Innovation in the Interest Rate

(B) An Innovation in Money Growth
(C) An Innovation in Housing Activity

(D) An Innovation in Economic Growth

(E) An Innovation in Prices
As the first step of the analysis, we begin with an examination of the response of each of the variables involved to an independent and temporary innovation of unit size. Figure 5.1 exhibits such profiles for a period of 20 months, together with the 95 per cent confidence intervals generated by 200 Monte Carlo experiments. Each profile and the confidence intervals are presented as percentages of the associated unit size. Interestingly, these profiles demonstrate significant differences in the pattern of movements. Innovations in the short term interest rate, housing activity and the price level appear to have relatively long memories, but those in money and general economic growth become insignificant after a short time. As will be demonstrated later, these differences in the patterns of movement appear to dominate the system's response to each innovation.

The impulse responses of the activity variables to one-standard-deviation shocks to the financial variables are presented in Figures 5.2-5.5. For ease of presentation, the signs of the responses of $dU_t$ were reversed to approximate the effects on general economic growth. The responses of housing activity to these innovations are re-scaled by the standard deviation of the housing activity innovation to facilitate a comparison of relative effects. And those of $dU_t$ are re-scaled by that of its own innovation. Among these effects, the response of housing activity to an innovation in the short term interest rate (of the size of its standard deviation) is most significant (Figure 5.2). Housing activity responds negatively to a positive shock to the short term interest rate with the effect peaking at the 8 to 11 month period. The maximum of this effect is equal to about 60 per cent of the standard deviation of the housing activity innovation, compared with an initial effect of around 30 per cent in period 2. This significant
response of housing activity to this innovation is evidence of the relative importance of interest rate movements for housing activity. The response of housing activity to a temporary interest rates shock dies out completely after 24 periods.

Figure 5.2 The Effects of an Innovation in the Interest Rate

(A) Response of Housing Activity

(B) Response of Economic Activity

The effect of such an innovation on general economic growth demonstrates a similar movement to that on housing activity, although the impact is less significant. Approximated by the change in the unemployment rate, general
economic growth responds negatively to a positive innovation in the short term interest rate with a maximum effect at around one year. Interestingly, compared with that of housing activity, there appears to be a lag in the response of general economic growth to this innovation. For example, the effect of this innovation on housing activity begins at period 1 and becomes significant at period 2, while the response of general economic growth only begins at period 2 and becomes significant at period 3. This lag in the response of general economic growth can also be observed over the medium term. According to these results, a shock to the short term interest rate will impact on housing activity before affecting general economic growth. Because of this lag, these results suggest that housing activity can be used as a leading indicator of the impact on general economic growth resulting from changes in the short term interest rate.

Unlike the response to an interest rate shock, the effect on housing activity of an innovation of one-standard-deviation in money growth is relatively insignificant (Figure 5.3). The maximum of this effect on housing activity is in the first few periods which is only equal to around 5 per cent of the associated standard deviation. However, this innovation generates the most significant and speedy impact on general economic growth: a result which is consistent with the notion that money Granger causes output. The contemporaneous interaction between money and general economic growth is reflected in this impulse response function and the maximum effect is at period 1, which is equal to about 20 per cent of the associated standard deviation. Interestingly, this effect becomes insignificant after a relatively short period, demonstrating a movement which is very different from that for an interest rate shock. The timing of the responses of
the activity variables to this shock is also different from that for an interest rate shock. While the response of housing activity suggests a lagged accommodation to the increase in money growth, there is a contemporaneous effect of this innovation on general economic growth. These results suggest that, for an innovation in money growth, the effect will impact on general economic growth before affecting housing activity, although such an effect on housing activity is relatively insignificant.

**Figure 5.3 The Effects of an Innovation in Money Growth**

(A) Response of Housing Activity

(B) Response of Economic Activity
Consistent with the movement in a general economic growth innovation, the response of housing activity to such a shock fluctuates markedly in the beginning (Figure 5.4a). The maximum of this effect is at period 2, which is equal to around 20 per cent of the associated standard deviation. Note that this impact on housing activity is more significant than those generated by innovations in money growth or prices. A positive one-standard-deviation shock to housing activity induces a positive effect on general economic growth (Figure 5.4b). This effect also fluctuates in the first several periods with a maximum effect of around 10
per cent at period 1. These results indicate that, while housing activity provides leading information on changes in general economic activity, general economic growth also influences housing activity. The extent of this influence is understandably more significant than that arising in the opposite direction in terms of the associated standard deviations.

**Figure 5.5 The Effects of an Innovation in Prices**

(A) Response of Housing Activity

(B) Response of Economic Activity
Figure 5.6 The Feedback and Other Effects

(A) The Effect of an Innovation in Housing Activity on the Interest Rate

(B) The Effect of an Innovation in Economic Growth on Prices

(C) The Effect of an Innovation in the Interest Rate on Money Growth

(D) The Effect of an Innovation in Money Growth on Prices
Housing activity responds positively to a price innovation with the effect peaking at around one year (Figure 5.5). Since each innovation in this analysis is generated separately, a positive innovation in the price level is in fact equivalent to a decrease in the real interest rate as well as a decrease in real money balances. A decrease in real money balances would adversely affect housing activity, but a decrease in the real interest rate would stimulate activity in the housing market. As demonstrated, the net effect on housing activity is positive, indicating that the effect of the decrease in the real interest rate outweighs that of the fall in real money balances. General economic growth also responds positively to such an innovation. However, the extent of this effect is negligible, indicating that the effects of changes in the real interest rate and money balances offset each other in this case.

The extent of feedback from the activity variables to the financial variables are presented in Figure 5.6. For brevity, only selected effects are presented. Consistent with the findings presented in Chapter 4, these effects, measured by the associated standard deviations, are generally less significant than the responses arising in the opposite directions. This may be due to the fact that the financial variables, such as the short term interest rate and money growth, are more subject to government control. Interestingly, the effect on the short term interest rate of a shock to housing activity appears to be very significant, indicating that housing activity may be an important variable in the decision-making processes associated with monetary control. Consistent with a priori expectations, an innovation in general economic growth produces a significant response in prices. Significant effects are also evident, with an interest rate shock
affecting money growth and a money growth shock influencing prices.

5.5 Summaries

In this study, the impulse response approach has been utilised to examine the responsiveness of housing and general economic activity to innovations in important macroeconomic variables. While an interest rate innovation of one-standard-deviation in size produces the most significant and prolonged response in housing activity, general economic growth is found to be more responsive to an innovation in the growth in money supply.

Housing activity has been commonly used by economic commentators as an indicator which provides leading information on general economic conditions. Such a useful relationship is again supported by the results of this impulse response analysis. Housing activity is found to be useful in detecting the effect on general economic growth resulting from changes in the short term interest rate, as such a change will impact on housing activity before affecting growth in general economic activity. However, this useful relationship is not obtained for a money growth shock which is contemporaneously correlated with general economic growth. Compared with the other effects, the response of housing activity to a money growth shock is relatively insignificant.

Substantial interactions are found between housing and general economic activity. Housing activity responds more significantly to an innovation in general economic growth than to those in money growth or prices. Consistent with a
priori expectation, this response is more significant than that arising in the opposite direction in terms of the associated standard deviations. The effect of innovations in the activity variables on the financial variables appear to be less significant, compared with the impact from the latter to the former. It is also noteworthy that an innovation in housing activity generates a significant effect on the short term interest rate, indicating that housing activity may be an important variable in the control processes of monetary authorities.
Chapter 6

The Effects of Demographic Changes on Australian Housing Activity

Demographic changes have been commonly regarded as important factors in influencing housing activity. In this study, the effects on housing activity of changes in net migration and domestic population are separately assessed in a dynamic time series framework, together with the influence of important economic variables, namely real per capita income and a short term interest rate. An interesting co-integrating relation is found between real per capita income and domestic population. Dynamic simulations of this model consistently point to changes in the level of net migration being a factor in fluctuations in housing activity.

6.1 Introduction

Housing activity can be influenced by many factors. Clearly, changes in economic variables such as income and domestic interest rates can have significant effects on housing activity by affecting consumers' affordability and the costs of construction for new dwellings. On the other hand, housing activity can be influenced by changes in demographic factors such as increases in population or changes in household formation. An increase (or a decrease) in the
number of households due to these demographic changes will increase (or decrease) the housing demand and, hence, affect housing activity.

Demographic influences are important to housing activity. As acknowledged by many researchers, income and demographic factors are the two major elements which determine the nation's housing demand in the long term. The influences of demographic changes on housing activity can be attributed to two main components. One is the change in household formation which includes the effects of changes in age/sex/marital structure and the other is increase in population. However, the effect on housing activity of changes in household formation appears to have weakened significantly since early 1970 and, as indicated by Hawkins, Ferris and Edquist (1987), this effect can be explained, at least partly, by changes in the important economic variables such as real income and interest rates as the rate of household formation has been closely related to movements in these variables. In a study undertaken by the Indicative Planning Council for the Housing Industry (IPC 1989), the contribution from the increase in the number of households due to changes in the rate of household formation was estimated to be only around 13 per cent in 1981-86, while the rest can be attributed to the increase in population over that sample period. There are two sources which generate increases in population, one is natural increase in domestic population and the other is net migration. In Australia, net migration has been an important factor contributing to increases in population.

While both net migration and domestic population changes have been used as the major factors in determining the long-term "underlying requirements" for
housing (IPC 1989), the dynamic impacts of these demographic changes on the "real" housing cycle have not been examined or estimated empirically. As indicated by Williams (1984), in the short to medium term, changes in economic variables should be superimposed on the long-term demographic effects and such changes could drive housing activity significantly away from those "underlying requirements". This is evident from the significant differences between the level of dwelling commencements and the "underlying requirements" estimated by IPC (see Figure 2.5). Taken together, there seems to be uncertainty regarding the usefulness of population increase in modelling "real" housing activity, especially in the context of the short-term dynamics. That is, does information on population increase help in explaining or forecasting the short-term cyclical behaviour of housing activity? If so, which component contributes more to this influence, the level of net migration or change in domestic population? Although the level of net migration has often been used by economic commentators to explain surges in housing activity, as far as we are aware, such a useful relationship has not been supported by econometric research.

In this chapter, these questions are investigated in a dynamic time series framework using real data. An analytical model is constructed which includes five economic, housing and demographic variables - real per capita income, a short term interest rate, dwelling commencements, net migration and domestic population. Subject to data availability, interrelationships are examined for these variables at the aggregate level. In this modelling, two-quarter-lagged net migration is found to enter the equation for commencements together with lagged real per capita income and the short term interest rate. However, no such short-
term influence can be identified for domestic population, which affects housing activity indirectly through an interesting long-term relationship with real per capita income. An impulse response analysis of this model indicates that a temporary one-standard-deviation shock to the level of net migration produces a more responsive impact on housing activity than that generated by a similar shock to domestic population. Dynamic simulations are also undertaken to examine the effects on housing activity arising from permanent shocks to net migration. The results consistently indicate that the level of net migration is a major demographic factor which contributes significantly to fluctuations in housing activity.

6.2. Integration Properties

Model Specification and Data

To analyse the impact of population increases on housing activity, a time series model was constructed based on the framework adopted in Chapter 4, which examines the influences on housing activity from a macroeconomic perspective. Five variables were included in the analysis presented in Chapter 4 - general economic activity, housing activity, money, general price level and a short term interest rate. Some modifications were made to this system to incorporate the effect of population increases. We introduce two demographic variables - net migration and domestic population, which allows the model to examine the responses of housing activity to different sources of population increase. Consequently, the measure of general economic activity used in the system is real
per capita income. Initial examination using this model indicates that the responses of housing activity to changes in the money supply and general price level are relatively insignificant and testing for co-integration did not support any additional co-integrating relations between these two variables and the rest of the system. These results are consistent with those obtained in Chapter 5. Consequently, these two variables are omitted from the model. Although some linkages between these and the other economic variables may be missing as a result, this will reduce the system under consideration to a more manageable size so that emphasis can be placed on the factors which are more important to housing activity.

In this study, original quarterly time series over the period 1972(1) to 1990(2) are analysed. These series were obtained from the Australian Bureau of Statistics and the Reserve Bank. In this study, real per capita income, $I_t$, was approximated by dividing real gross domestic product (GDP) by domestic population. Domestic population, $N_t$, was obtained by subtracting the level of net migration, $M_t$, from total population. The short term interest rate used is the 90 day bank bill rate, $R_t$. Given that people aged under 15 are unlikely to form their own households and hence influence the demand for dwelling units, the number

6.1 An attempt was made to use the real short term interest rate to replace the nominal rate. However, this real variable does not exhibit different trend and unit root properties than its nominal counterpart, nor does it result in significant differences or improvements in the short-term specification of the model.
of people under 15 were removed from both the demographic series\textsuperscript{6.2}. Since net migration and domestic population by age are only available for the June quarter of each year, data for the remaining quarters are approximated using the ratios of quarterly population as weights. These data series are presented in Figure 6.1. Since it is unlikely that the effect of changes in real per capita income on housing activity can be best approximated by a linear specification on the original levels, we transformed real per capita income into logarithms in this study. A different specification in which all the variables are in logarithms was also investigated. The results are discussed in section 6.3.

**Figure 6.1 Data Movements**

(A) Population Above 15

6.2 Similar conclusions were also obtained for the co-integrating relations and interactions in the system when the total numbers of net migration and domestic population were used.
(B) Net Migration Above 15

(C) Real Per Capita Income / Seasonal Dummies Removed
(D) The 90 Day Bank Bill Rate

![Chart of 90 Day Bank Bill Rate over time from 1972 to 1988](chart)

(E) Private Dwelling Commencements

![Chart of Private Dwelling Commencements over time from 1972 to 1988](chart)
The Presence of Unit Roots

As the first step of the analysis, the trend and unit root properties of individual series were tested. This was undertaken using two procedures, Hylleberg, Engle, Granger and Yoo (1990) and Dickey and Pantula (1987), and the results are presented in Table 6.1. While the presence of seasonal unit roots can be rejected for each series according to the results of the Hylleberg et al. test, the hypothesis of a unit root at zero frequency is acceptable for real per capita income and domestic population. Interestingly, for the remaining series, the test results consistently reject the hypothesis of the presence of unit roots. While the level of commencements can be accepted as integrated of order zero, both the 90 day bank bill rate and net migration are characterised as stationary around a linear trend. Note that seasonal dummies are significant in the series, real per capita income, and their presence significantly influences the test results for seasonal unit roots. To account for this influence, seasonal dummies were removed from this series.

Testing for co-integration between these two integrated series, namely $I_t$ and $N_t$, was undertaken using the Engle and Granger (1987) procedure. Engle and Granger recommend using the augmented Dickey and Fuller (ADF) test on the residuals of the co-integration regression. In this testing, there are two possible normalisations which can be used to obtain the co-integrating relationship. Both the associated test statistics were found to be more negative than the critical value at the 5 per cent level reported by Engle and Granger, indicating that a co-integrating relation exists between these two series (Table 6.2 and Figure 6.2).
To make certain about this result, we also applied the Stock and Watson (1988) test for common trend to these residual series. The test statistics are more negative than the critical value at the 5 per cent level, which reject the hypothesis of no co-integration. Similar conclusions for a co-integrating relation were also obtained when domestic population is transformed into logarithms. Taken together, these results suggest that, over the sample period investigated, there is a co-integrating relation between the observed behaviour of real per capita income and domestic population (aged above 15).

Table 6.1: Test Results for Unit Roots

(A) The Hylleberg et al. test

<table>
<thead>
<tr>
<th>Variable</th>
<th>Specification</th>
<th>t1</th>
<th>t2</th>
<th>F3&amp;4</th>
</tr>
</thead>
<tbody>
<tr>
<td>I_t</td>
<td>Intercept</td>
<td>-0.35</td>
<td>-0.73</td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td>Intercept+trend</td>
<td>-3.07</td>
<td>-0.69</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies</td>
<td>-0.15</td>
<td>-3.25*</td>
<td>10.67*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies+trend</td>
<td>-2.75</td>
<td>-2.99*</td>
<td>10.42*</td>
</tr>
<tr>
<td>C_t</td>
<td>Intercept</td>
<td>-6.67*</td>
<td>-2.31*</td>
<td>7.92*</td>
</tr>
<tr>
<td></td>
<td>Intercept+trend</td>
<td>-6.61*</td>
<td>-2.30*</td>
<td>7.76*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies</td>
<td>-4.04*</td>
<td>-5.59*</td>
<td>15.37*</td>
</tr>
<tr>
<td></td>
<td>Seasonal dummies+trend</td>
<td>-4.01*</td>
<td>-5.15*</td>
<td>15.67*</td>
</tr>
<tr>
<td>M_t</td>
<td>Intercept</td>
<td>-1.42</td>
<td>-2.86*</td>
<td>9.46*</td>
</tr>
</tbody>
</table>
Intercept + trend  -3.89* -3.48* 8.90*
Seasonal dummies -1.83 -3.06* 18.98*
Seasonal dummies+trend -2.61 -3.11* 17.04*

Rt
Intercept -3.27* -3.42* 8.70*
Intercept + trend -4.98* -3.06* 7.95*
Seasonal dummies -3.07 -3.91* 13.11*
Seasonal dummies+trend -4.56* -3.48* 11.45*

Nt
Intercept 1.62 -4.56* 13.76*
Intercept + trend -0.75 -4.43* 12.94*
Seasonal dummies 2.25 -5.41* 16.07*
Seasonal dummies+trend -0.56 -5.37* 15.05*

(B) The Dickey and Pantula test

<table>
<thead>
<tr>
<th></th>
<th>Two unit roots</th>
<th>One unit root</th>
</tr>
</thead>
<tbody>
<tr>
<td>I_t</td>
<td>-4.60*</td>
<td>-2.86</td>
</tr>
<tr>
<td>C_t</td>
<td>-</td>
<td>-4.78*</td>
</tr>
<tr>
<td>M_t</td>
<td>-</td>
<td>-3.95*</td>
</tr>
<tr>
<td>R_t</td>
<td>-</td>
<td>-4.99*</td>
</tr>
<tr>
<td>N_t</td>
<td>-3.43*</td>
<td>-0.81</td>
</tr>
</tbody>
</table>

t_1 tests for 1-L, t_2 for 1+L and F_{3&4} for the polynomial factor 1+L^2. * denotes that the test statistic is significant at the 5 per cent level. A linear trend was included in the Dickey and Pantula test except for C_t. I_t denotes log(per capita income), C_t commencements, R_t 90 day bank bill rate, M_t net migration and N_t domestic population.
Table 6.2 The Engle and Granger Test for Co-integration

<table>
<thead>
<tr>
<th>Co-integration regression</th>
<th>ADF test</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) $I_t = -0.61 + 5.45E^{-8} N_t$</td>
<td>$-3.57^*$</td>
</tr>
<tr>
<td>(b) $N_t = 1.13E+8 + 1.47E+8 I_t$</td>
<td>$-3.35^*$</td>
</tr>
</tbody>
</table>

* denotes that the statistic is significant at the 5 per cent level according to Engle and Granger (1987). The ADF test results are based on regression using four lagged variables. $I_t$ log(per capita income) and $N_t$ domestic population.

Figure 6.2 The Error Correction Process of Regressing $I_t$ against $N_t$
This co-integrating relation between real per capita income and domestic population appears to be interesting. If we take real income as output and domestic population as labour input, then this co-integrating relation could be reflecting the steady improvement in labour productivity resulted from increased capital investment and improved technology that Australia has experienced over the past two decades. Note that, under the assumptions of fixed capital investment and unchanged technology in production, such a co-integrating relation between real per capita income (average product) and domestic population (labour input) would imply a situation of increasing returns to scale for the labour input. However, in response to increases in capital investment and improved production technology, labour productivity and labour input can both rise over time. In this situation, a long-term relationship between rising average product and labour input can be established as a result of increases in labour productivity.

In this modelling, there was a concern regarding a possible additional co-integrating relationship between total housing stock and population, which may also have important implications for short-term fluctuations in housing activity. If such a co-integrating relation exists, deviations from this long-term relationship resulting from changes in total housing stock or population could also lead to a process of "error-correction" in housing activity. However, testing for such a co-integrating relation proved to be difficult as no quarterly series is published for total housing stock. In an attempt to investigate this relationship, we accumulated the quarterly total dwelling completions (both private and public) as an approximation to the total housing stock (Figure 6.3). Compared with the survey
data published by ABS, some consistency can be established for this generated series. For example, the net increases in total dwelling stock in the periods 1976-81 and 1981-86 were both around 600,000 according to the survey data, compared with increases of around 660,000 for the same periods in the generated series. The differences could be attributable to losses in the housing stock resulting from, say, demolitions (see IPC, 1989). Interestingly, the test results produced by both the Hylleberg et al. and Dickey and Pantula procedures for this generated series consistently reject the hypothesis of the presence of unit roots and accept the alternative that this series is stationary around a linear trend. Although the hypothesis of a unit root is acceptable in a specification without a linear trend, the results of testing for co-integration between this series and domestic population using the Engle and Granger procedure in a specification without a linear trend do not reject the hypothesis of no co-integration. Similar results were also obtained for testing for co-integration between this series, domestic population and real per capita income using the dynamic OLS procedure suggested by Stock and Watson (1989c), which give no support to the presence of an additional co-integrating relation. Note that if the specification used for unit root testing is incorrect so that the deterministic components, such as a linear trend, are not completely purged from the variable under consideration, the test statistic so-obtained will be biased towards accepting the null hypothesis of a unit root. Similar acceptance of the no co-integration hypothesis was also obtained for population and total housing stock in logarithms. This failure to find such a co-integrating relation could of course be due to the inaccurate approximation of this generated series for total housing stock, however, it also raises questions and doubts on the existence of such a long-term relationship. Given that no other
reasonable approximation could be obtained for the quarterly total housing stock, we continue our analysis based on these test results and accept that no co-integration exists between population and total housing stock.

**Figure 6.3 Data Movements of the Generated Total Housing Stock**

(A) Original

(B) Detrended

6.3 A Specification for the System

The specification for this system was determined using the procedure developed in Chapter 3 for an error correction model (ECM) involving both stationary and co-integrated series. The order selection criterion used was the Schwarz (1978) criterion. In this process, the residual series of the co-integration regression, (a) in Table 6.2, was used for the error-correction term. Since the series, $M_t$ and $R_t$, 

are stationary in levels and contain a linear trend, a linear trend was also included in the selection as an exogenous variable. This specification was estimated using the generalised least squares (GLS) technique and the results are presented in Table 6.3.

The interrelationships determined for this housing system support economically meaningful specifications. Several interesting findings are evident. In this specification, $dI_t$ is related to $C_{t-1}$, a result which indicates that housing activity may be used as a leading indicator of the fluctuation in real per capita income. The lagged error-correction term enters the equation for $dI_t$ with an expected sign on the estimated coefficient. This indicates that, if $I_{t-1}$ exceeds the long-term equilibrium relationship with $N_{t-1}$, then there will be a negative effect on $dI_t$ which adjusts $I_t$ towards the long-term equilibrium relationship and vice versa. In this specification, the level of commencements is influenced by both economic and demographic factors. $C_t$ is positively related to $dI_{t-1}$ and negatively to $R_{t-2}$, indicating that an increase in real per capita income or a fall in the short-term interest rate will both stimulate housing activity. Interestingly, while $C_t$ is related to $M_{t-2}$, lagged domestic population does not enter the equation for commencements. These relationships suggest that, in the short-term dynamics, the level of net migration is more important in influencing housing activity than increases in domestic population (excluding net migration). However, in this specification, domestic population can influence housing activity through the co-integrating relation with real per capita income, as $C_t$ is related to $dI_{t-1}$. This linkage between domestic population and housing activity accommodates the long-term effect of increases in population on housing activity.
Table 6.3 The ECM Specification Determined by the Schwarz Criterion

The system \([dI_t, C_t, M_t, R_t, dN_t]\)

\[
\begin{bmatrix}
1 & -5.95E^{-7}L \\
\frac{-3.52E^{+4}L}{(1.74)} & 1 - 0.970L + 0.284L^2 \\
\frac{1.73E^{+5}L}{(3.67)} & 1 - 0.365L \\
- & -1.141E^{-6}L \\
- & -1.115L
\end{bmatrix}
\begin{bmatrix}
dI_t \\
C_t \\
M_t \\
R_t \\
dN_t
\end{bmatrix}
\]

\[
\begin{bmatrix}
0.399 \\
\frac{-1.57E^{+5}}{(3.84)} & -191.3 \\
- & -0.001 \\
- & -
\end{bmatrix}
\begin{bmatrix}
Z_{t-1} \\
T
\end{bmatrix}
\]

\[
= U_t
\]

\(I_t\) denotes log(per capita income), \(C_t\) commencements, \(R_t\) 90 day bank bill rate,
Mt net migration, Nt domestic population and T time trend. Zt-1 is the error correction term. d denotes the first difference. L is the lag operator.

In Table 6.3, Mt is negatively related to dIt-1. This negative relationship appears to be inconsistent with *a priori* expectations. However, it should be noted that the error-correction term, Zt-1, is included in this equation with a coefficient estimate close in magnitude to that for dIt-1. An hypothesis that these two coefficient estimates are not significantly different from each other cannot be rejected using an F test in the system context. Under this hypothesis, if we re-parameterise every variable in the equation for Mt into levels and substitute the co-integrating relationship, (a) in Table 6.2, for Zt-1, then Mt becomes positively related to It-2 and negatively to Nt-1. These relationships between net migration, real per capita income and domestic population in levels appear to be meaningful. An experiment was also undertaken by omitting either dIt-1 or Zt-1 from the equation for Mt as a restriction on the selection process. The so-determined specification consistently omits the other variable from the equation for Mt, indicating that there is an important linkage between these two variables in explaining the level of net migration.

The interrelationships between the logarithms of these housing and demographic series were also examined using the same procedure. The relationships so-determined were similar to those presented in Table 6.3. While two-period-lagged net migration is again included in the equation for commencements along
with lagged real per capita income and the short term interest rate, no significant short-term influence can be identified from domestic population to dwelling commencements. To investigate further the effect of domestic population on housing activity, we experiment with this series. Domestic population aged above 15 is replaced by the number of population aged between 15 and 34, as population growth in this age category is most likely to influence the demand for dwelling units. However, similar results were obtained in which no significant influence can be identified from domestic population in this age category to housing activity.

6.4 Dynamic Simulations

Impulse Response Approach

The interrelationships presented in Table 6.3 between these demographic, economic and housing activity variables appear to be complex. In this specification, changes in the demographic variables affect housing activity via two channels. While the level of net migration influences dwelling commencements directly through the short-term structure of the model, domestic population affects housing activity indirectly through the long-term relationship with real per capita income. Economic variables also influence housing activity significantly. An increase in real per capita income induces a positive effect on housing activity and so does a fall in the short term interest rate. However, housing activity also impacts on the economic variables. As housing and general economic activity become buoyant, this will lead to an increase in the short term
interest rate, which in turn results in reduced housing activity.

To carry out a precise examination of the dynamic effects of these demographic and economic changes on housing activity, a more comprehensive picture may be obtained using the associated impulse response functions. Using this impulse response framework, dynamic interrelationships between these variables can be analysed by "shocking" the system with a temporary innovation, and the response of each variable to this shock can be traced in the time domain. The asymptotic distribution of the impulse response functions for a co-integrated system was analysed by Lütkepohl and Reimers (1992). Empirical applications can be found in Robertson and Orden (1990), King, Plosser and Stock and Watson (1991) and Lütkepohl and Reimers (1992). A recursive structure, which depends on the ordering of these variables, was imposed on the MA representation of the model presented in Table 6.3 to obtain the impulse response functions that represent the dynamic responses of the system to independent and temporary shocks to each of its component variables. In this imposed ordering, a variable is assumed to contemporaneously influence other variables if they are placed after it and be contemporaneously affected by other variables if they are placed before it. In this study, we assume a recursive structure ordered as \([M_t \ N_t \ R_t \ I_t \ C_t]\) and allow a structural interpretation based on a Choleski decomposition of the covariance matrix. The demographic variables are listed first in this ordering as it is more likely for them to contemporaneously influence the economic and housing variables than the other way around. The short term interest rate is listed before the income and housing activity variables. The level of commencements appears last. It is assumed that it is the combined result of the
interaction of all of the other variables listed before it.

The influence of this particular ordering on the impulse response functions depends on the extent of contemporaneous causality (correlation) in this system. Using the principle introduced by Penm and Terrell (1984a) on the ECM model with the Schwarz criterion indicates that the level of commencements is, contemporaneously, correlated positively with real per capita income and negatively with the short term interest rate. Real per capita income is negatively correlated with domestic population, which could be reflecting a short-term temporary reduction in labour productivity resulting from the increase in population (or labour force). While real per capita income is also negatively correlated with the short term interest rate, neither Mt nor Nt are contemporaneously correlated with the level of commencements. These contemporaneous relationships are not difficult to explain using general economic theory, which also appears to be consistent with the particular ordering used in this analysis.

In total, there are 25 impulse response functions which can be obtained from the associated MA representation of this system. Since the main interest of this study is the dynamic impacts on housing activity of independent shocks to the economic and demographic variables, we therefore concentrate the following analysis on this objective.
Figure 6.4 The Responses of Housing Activity

(A) The Response to an Innovation in Net Migration

(B) The Response to an Innovation in Domestic Population

(C) The Response to an Innovation in the Interest Rate

(D) The Response to an Innovation in Real Income
Figure 6.4 presents the impulse responses of housing activity to one-standard-deviation positive shocks to each of the economic and demographic variables for a period of 12 quarters. These responses are re-scaled by the standard deviation of the housing activity innovation to facilitate a comparison of relative effects. Also presented in Figure 6.4 are the 95 per cent confidence intervals generated by 200 Monte Carlo experiments. In general, the difference between the impulse responses of a co-integrated system and a non-co-integrated but stationary system is that the effect of a shock from one of the co-integrated variables will not die out over the longer term because of the imposed co-integrating relations. In other words, a one-time impulse may have a permanent effect in the sense that it shifts the system to a new equilibrium. In this study, however, the responses of housing activity to shocks in the co-integrated variables disappear over the long term because the error-correction term generated from the co-integrating relationship between real per capita income and domestic population is not included in the equation for housing activity.

The point estimates from the impulse response functions show that the dynamic responses of housing activity depend on the source of the initial shock. A positive shock to the level of net migration induce a positive response in housing activity with a lag of about two quarters. The maximum response to this shock is at quarter 3, which is equivalent to around 30 per cent of the standard deviation of the housing activity innovation. Two effects are involved in this response, a direct effect on the level of commencements caused by the increase in net migration through the short-term dynamic structure and an indirect effect generated by the co-integrating relation between real per capita income and
domestic population, which increases due to the increase in net migration. Close examination indicates that the effect from the former is much stronger than that from the latter.

The effect on housing activity of a positive shock to domestic population is weak and negligible according to the confidence interval approach. Because of a negative contemporaneous response of real per capita income to the increase in domestic population, the effect on housing activity of this shock is negative in the beginning, but gradually becomes positive in the latter quarters due to the positive effect on housing activity from the co-integrating relation with real per capita income. The responses of housing activity to shocks to the economic variables appear to be more substantial than those obtained for the demographic variables. A positive shock to the short term interest rate generates a negative effect on housing activity. This effect is prolonged with a maximum response at quarter 3, being equivalent to about 40 per cent of the housing activity innovation. This prolonged and significant response for housing activity demonstrates the importance of the short term interest rate for housing activity. After an increase in real per capita income, housing activity responds positively. The contemporaneous interaction between these two variables is reflected in this impulse response function. The maximum response is at quarter 1, being equivalent to around 60 per cent of the standard deviation of the housing activity innovation. Compared with that of an interest rate shock, this response in housing activity is more significant but persists for a shorter period.
Effects of Changes in Net Migration

Over the past two decades, the level of net migration has increased significantly from an average of around 65,000 in the early 1970s to a peak of around 160,000 in 1988-89. However, this increase in net migration appears to have come to an end with a substantial fall in 1989-90 to around 120,000. Further reductions in the level of net migration can be expected, at least in the short term, as the Federal Government has announced further cuts to the migrant intake for 1992-93. Given this trend, it is unlikely that the level of net migration in the future will be sustained at the level that Australia has experienced over the latter part of the 1980s. Consequently, these significant reductions in the level of net migration would result in adverse effects on housing activity.

In Table 6.4 and Figure 6.5, a simulation which examines the effects on housing activity of changes in net migration is presented. In this simulation, forecasts for housing commencements are produced for several scenarios in which different assumptions are made on the level of net migration. In the base scenario, the level of quarterly net migration is assumed to be fixed at the average of the 1989-90 level and forecasts for dwelling commencements are produced. These forecasts are then compared with those obtained from three different scenarios - a 30 per cent decrease in net migration from the 1989-90 level, a 50 per cent decrease and a 30 per cent increase. Using the base scenario as a control, the impacts on housing activity of changes in net migration can be calculated as percentage changes of the forecasts from the base scenario. Since these effects become significant only from the third forecasting quarter as $C_t$ is related to $M_{t-1}$.
To perform the forecasting under the different assumptions on the level of net migration, we first re-parameterised the ECM model to its equivalent VAR representation and then partitioned the system into two subvectors with one including only $M_t$ and the other involving the rest of the system. This system was transformed into an equivalent VARX representation of the form as follows:

$$Y_t = \sum_{i=1}^{p} \alpha_i Y_{t-i} + \sum_{j=0}^{q} \beta_j X_{t-j} + \epsilon_t^{1}$$ \hspace{1cm} (6.1a)$$

and

$$X_t = \sum_{m=1}^{r} \delta_m X_{t-m} + \sum_{n=0}^{i} \rho_n Y_{t-n} + \epsilon_t^{2}$$ \hspace{1cm} (6.1b)$$

where, in our case, $Y_t = [I_t \ C_t \ R_t \ N_t]$ and $X_t = [M_t]$. For details of the transformation see Penm, Penm and Terrell (1992a). Since both $\epsilon_t^{1}$ and $\epsilon_t^{2}$ are not correlated after the transformation, the forecasts for $Y_t$ under the assumption of a given level of net migration can be obtained using (6.1a). Noting that there is no significant contemporaneous causality between $M_t$ and the rest of the system, every element in $\beta_0$ is therefore zero.

Also presented in Table 6.4 are the normalised 95 per cent confidence intervals of the "pseudo-futures" generated by 200 bootstrap replications. These normalised
"pseudo-futures" give approximations to the variability of the "future data" in relation to the forecasts. In general, these confidence intervals appear to be satisfactory given the finite sample used in this study. For brevity, the bootstrap technique is not discussed. Interested readers are referred to Peters and Freedman (1985), Penm, Penm and Terrell (1992b) and Efron (1982) for details.

Figure 6.5 The Effects of Changes in Net Migration on Housing Activity

The percentage changes of the forecasting profile from the base scenario.
Table 6.4: The Effect of Net Migration Changes on Housing Activity

<table>
<thead>
<tr>
<th>Quarter</th>
<th>30% decrease</th>
<th>50% decrease</th>
<th>30% increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>-2.6%</td>
<td>-4.3%</td>
<td>2.5%</td>
</tr>
<tr>
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<td>(-2.9% -2.3%)</td>
<td>(-4.7% -3.8%)</td>
<td>(2.3% 2.8%)</td>
</tr>
<tr>
<td>4</td>
<td>-5.1%</td>
<td>-8.6%</td>
<td>5.1%</td>
</tr>
<tr>
<td></td>
<td>(-5.7% -4.5%)</td>
<td>(-9.5% -7.6%)</td>
<td>(4.5% 5.8%)</td>
</tr>
<tr>
<td>5</td>
<td>-7.0%</td>
<td>-12.6%</td>
<td>7.0%</td>
</tr>
<tr>
<td></td>
<td>(-8.2% -6.2%)</td>
<td>(-13.8% -10.9%)</td>
<td>(6.1% 8.0%)</td>
</tr>
<tr>
<td>6</td>
<td>-8.1%</td>
<td>-13.5%</td>
<td>8.1%</td>
</tr>
<tr>
<td></td>
<td>(-9.4% -7.2%)</td>
<td>(-15.1% -11.8%)</td>
<td>(7.2% 9.3%)</td>
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<tr>
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<td>-14.2%</td>
<td>8.6%</td>
</tr>
<tr>
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<td>(-16.0% -12.6%)</td>
<td>(7.5% 9.8%)</td>
</tr>
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<td>(-15.4% -12.1%)</td>
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</tr>
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</tr>
<tr>
<td></td>
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<td>(-13.4% -10.3%)</td>
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<td>6.5%</td>
</tr>
<tr>
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<td>(5.8% 7.4%)</td>
</tr>
<tr>
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<td>6.0%</td>
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<td>(-11.2% -8.6%)</td>
<td>(5.1% 6.7%)</td>
</tr>
<tr>
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<td>-9.0%</td>
<td>5.4%</td>
</tr>
<tr>
<td></td>
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<td>(-10.1% -7.7%)</td>
<td>(4.6% 6.1%)</td>
</tr>
<tr>
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<td>-9.9%</td>
<td>5.9%</td>
</tr>
<tr>
<td></td>
<td>(-6.7% -5.1%)</td>
<td>(-11.1% -8.4%)</td>
<td>(5.0% 6.7%)</td>
</tr>
</tbody>
</table>

The effects are presented as percentage changes of the forecasting profile from a scenario in which net migration is fixed at the 1989-90 level. The normalised 95% confidence interval of the "pseudo-future" generated by 200 bootstrap replications are in parenthesis.
The percentage changes presented in Table 6.4 demonstrate that net migration is a major demographic factor which results in fluctuation in housing activity. For example, a 30 per cent decrease in net migration from the 1989-90 level leads to an initial reduction of around 2.6 per cent in dwelling commencements. This effect, as measured by the percentage change of the forecasting profile based on the 1989-90 net migration level, peaks at quarter 7 with a maximum of -8.5 per cent before falling back gradually to around -5.4 per cent at quarter 15 and then fluctuates around that level afterwards. Close examination indicates that this dynamic variation in the effect is due mainly to the interaction between commencements, real per capita income and the short term interest rate in response to the reduction in the level of net migration. Initially, when net migration is reduced, this places adverse effects directly on dwelling commencements and indirectly on real per capita income through the cointegrating relationship with a lower domestic population relative to the base scenario. Combination of these effects results in the percentage change becoming more negative in the following quarters. However, as housing and general economic activity become weaker, this induces a gradual lowering of the short term interest rate which encourages more housing activity. This lower short term interest rate eventually means that the percentage change becomes less negative. However, as housing activity recovers, this also imposes upward pressures on the short term interest rate. At around quarter 15, another cyclical variation begins and the percentage change rises again. However, since the short term interest rate has adjusted to a new level which accommodates the effect of the reduction in net migration, this second cyclical variation is smaller compared with the initial fluctuation. This pattern of movement is evident across each scenario.
investigated.

Compared with the effect of changes in net migration in the "underlying requirements" estimated by IPC, these simulation results presented in Table 6.4 appear to be less significant (see IPC 1989 and Hawkins et al. 1987). In IPC (1989), a sensitivity analysis indicates that a reduction of around 50 per cent in net migration from the 1989-90 level results in a decrease of around 21 per cent from the long-term forecast of the "underlying requirements" (or 23 per cent from the 1989-90 level of private commencements), compared with a maximum reduction of around 14 per cent in the short term and around 10 per cent over the medium term for a similar reduction in this system. These differences are attributable to, at least, two major factors. Firstly, while the forecast number of households is equal to the "underlying requirements" defined by IPC, no long-term relationship between population and total housing stock is imposed in this system due to the reasons discussed in section 6.2. Lacking this "error-correction" effect on housing activity would weaken the response of dwelling commencements to this slowdown in increase in population resulting from a lower level of net migration. Secondly, the short term interest rate plays an important role in this system which restricts the response of housing activity to changes in net migration. For example, a reduction in housing activity resulting from a decrease in the level of net migration leads to a lower short term interest rate which in turn encourages more housing activity in the later quarters. The short term interest rate was not involved in the demographic model used by IPC.
Also, while real per capita income was assumed to be an exogenous influence in IPC (1989) which grows at a constant annual rate of 1.5 per cent, a co-integrating relationship was detected between real per capita income and domestic population and, therefore, growth in real per capita income is included in an endogenous mechanism in this system.

6.5 Concluding Remarks

In this chapter, a dynamic time series model has been utilised to examine the impact on housing activity of changes in demographic variables, namely net migration and domestic population. The results consistently indicate that the level of net migration is a major demographic factor which significantly contributes to the fluctuations in housing activity.

Significant interrelationships are identified between the housing, demographic and economic variables. In the identified specification, demographic variables influence housing activity via two channels. While the level of net migration impacts directly on housing activity through the short-term dynamics, domestic population affects housing activity indirectly through the co-integrating relationship with real per capita income. The short term interest rate proves to be a major factor which results in the cyclical behaviour of housing activity. When housing activity is buoyant, which leads to buoyant general economic activity, an increase in the short term interest rate will be induced which impacts adversely on housing activity. However, as both housing and general economic activity weaken, this will lead to a reduction in the short term interest rate which in turn
encourages more housing activity to emerge.

Information on the level of net migration is important in explaining the fluctuations in housing activity. This is supported by the simulation exercises undertaken in this study including an impulse response analysis. In the simulation of changes in net migration, the co-integrating relation between real per capita income and domestic population plays an important role in capturing fully the long-term effect of an increase in population on housing activity. Such an increase, resulting from either net migration or natural increase, will be associated with an adjustment in real per capita income and, consequently, affect housing activity. These results indicate that an important linkage exists in the long term from the income-population relationship to housing activity. If real income cannot "keep-up" with the population increase, construction activity will fall behind the potential increase in housing demand and, as a result, serious housing shortages could result in the long term.

The test for co-integration between total housing stock and population produces no support for such a co-integrating relationship. Although this failure could be due to an inaccurate approximation for the series, total housing stock, it raises serious doubts as to the existence of such a long-term relationship. Unfortunately, unless the data availability can be improved, precise testing for this long-term relationship remains difficult. Since little information is available on the composition, income levels and marital status of migrants on a quarterly basis, no attempt has been made to distinguish the effects of these components on housing activity. Thus, only conclusions based on aggregate level of net
migration can be drawn from this study.
Chapter 7

Summary and Conclusions

In this chapter, conclusions of this thesis are presented. Instead of summarising the results chapter-by-chapter, the approach is to draw out the major findings, implications or concerns relating to the issues addressed in this thesis. Reference is made to the relevant chapter(s) for elaboration. The ordering of the discussions does not follow that of the chapters, nor does it reflect the importance of these issues relative to the analysis of Australian housing activity.

This thesis examines the factors which influence housing activity from a macroeconomic perspective. Important macroeconomic variables which significantly contribute to the instability in housing activity are analysed. The methodology used involves econometric time-series techniques. Housing activity and relevant economic, financial and demographic variables are specified as a vector autoregressive process in which the short-term dynamics as well as the long-term relationships, if any, are investigated. Interestingly, while some economic and financial series can be characterised as co-integrated of order (1, 1), the commonly used indicators of housing activity, such as approvals, commencements and completions, appear to be stationary. A new procedure is therefore developed for examination of such a system which contains both co-integrated and stationary series. This procedure has proved to be useful in
analysing housing activity as the "error-correction" processes generated from the co-integrating relationships between economic and financial variables form an important part in explaining the fluctuations in housing activity. Details of this procedure are presented in Chapter 3.

There are, at least, two senses in which housing activity can be regarded as "special". One is the significant fluctuations in housing activity over time. The other is the persistent cyclical behaviour of housing activity through periods of different economic and demographic conditions. These interesting characteristics are summarised in Chapter 1. Compared with other domestic economic activity, the volatility in housing activity appears to be very significant.

Previous studies on housing activity have used approaches which range from a simple static partial-equilibrium modelling to variety of sophisticated macroeconomic systems. These studies are reviewed in Chapter 2, together with some critical comments on the modelling strategies and empirical results. One common problem encountered in housing studies appears to be data availability. This problem has placed limitations on modelling exercises as well as testing for the underlying economic reasoning. For some studies presented in this thesis, the major problem of data availability appears to be the lack of monthly observations for some important housing and economic variables. Richer results for the interactions between housing and related variables could be expected if such a limitation was overcome.

While most of the major findings in this thesis appear to be consistent with a
priori expectations, some different results were obtained which contradict the findings of previous studies. In forecasting or analysing activity of new construction, a common practice has been to use finance approvals for new dwelling as the major explanatory variable for variations in housing construction. However, in a forecasting exercise presented in Chapter 3, this is not supported by the results of modelling using the procedure proposed. Similar conclusions were also obtained in a comparison of forecasting performance using either the bootstrap technique or real data. These results consistently indicate that construction activity may be better forecast using finance approvals for established dwellings. In contrast to the results of previous studies, housing activity is found to "Granger cause", or act as a "leading indicator" of general economic activity in both a quarterly national account system and a monthly model which includes important macroeconomic variables such as money, short term interest rates, prices, a housing activity variable and the unemployment rate - a measure of general economic activity. These results give support to the use of housing activity as a leading indicator of changes in general economic conditions (Chapter 4). A similar conclusion was also obtained in the analysis of a quarterly system presented in Chapter 6. In that system, the level of commencements was found to "Granger cause" or act as a "leading indicator" of changes in real per capita income: a result which reinforces the conclusion that housing activity can be used as a leading indicator of general economic activity.

The background reason for these different conclusions could be attributed to a pre-testing strategy adopted in this thesis. That is, before analysing the casual relationships in a time series system, the trend and seasonal effects and unit root
properties are properly tested in each individual series and in the system they form. This pre-testing strategy was adopted as we cannot accept a presumption that there is some underlying law which ensures that the variables that make up any system we need to analyse will all be of the same order of integration. This pre-testing strategy eliminates the possibilities of "over-differencing" or "under-differencing" in the system under investigation, as both would result in distortions in the test distribution and lead to misleading conclusions for the lead-lag relationships. In contrast to the common use of a VAR in first differences or levels, a suitable specification and appropriate procedures to detrend the data are determined from the results of this testing.

In this thesis, the effects on housing activity of changes in important macroeconomic variables has been examined. The causal relationships between these variables are discussed in Chapter 4 and an impulse response analysis is presented in Chapter 5. These results indicate that housing activity responds significantly to changes in short term interest rates and general economic activity, or real income, although the effects resulting from changes in money growth and prices appear to be much less substantial. While the response of housing activity to a change in short term interest rates appear to be prolonged, the effect of real income or general economic conditions on housing activity only persists for a shorter period. Interestingly, housing activity also feeds back on the level of short term interest rates, which suggests that housing activity may be an important determinant in the decision-making processes of monetary authorities.

The effect of population increases on housing activity has been examined in
Chapter 6, together with some important economic variables. The level of net migration was identified as having significant short-term effects on housing activity, but the derived response of housing activity to an increase in domestic population (excluding net migration) appears to be negligible. Turning to the long-term effects on housing activity, the results of this study reject the hypothesis that there is a co-integrating relation between population and total housing stock. This conclusion could arise from a poor approximation for the series, total housing stock, however, this rejection places serious doubts on the existence of such a long-term relation. This result also raises an important issue regarding the impact of growth in real income or general economic activity on the level of housing activity in the long term. If growth in real income or general economic activity cannot "keep up" with the increase in population, serious shortages of housing supply would be likely in the long term. For the short to medium terms, the results indicate that changes in important economic variables, such as real income and short term interest rates, produce more significant effects on housing activity than that generated by a change in the level of net migration.

Taken together, the economic mechanism which generates cyclical behaviour in housing activity can be briefly described as follows. Considering initial shocks of an increase in real income, a fall in the level of short term interest rates or a rise in the level of net migration, these changes will result in a surge in the level of housing activity which will, subsequently, lead to an increase in general economic activity. As both housing and general economic activity become buoyant, this will induce a response from the monetary authorities to tighten monetary policy and increase the domestic interest rate structure. As housing
activity responds negatively to an increase in short term interest rates, the level of construction activity will ease over time, resulting in a phenomenon of cyclical fluctuation in housing activity. Such a mechanism at work is clearly demonstrated by the simulation of the effects on housing activity of changes in the level of net migration presented in Chapter 6.

The results of this thesis also present some important implications for the government's macroeconomic policies. It can be argued that provision of a stable macroeconomic environment would significantly reduce instability in housing activity, as much of the fluctuations in housing activity can be attributed to changes in government policy instruments, especially those involving monetary policy. Policy on immigration is also an important element influencing the level of housing activity. Where short-term stability is important, changes in government policy to cut back (or increase) immigration, to achieve other specific long-term benefits, should be gradually phased in, especially at times of cyclical downturn (or upturn) in the housing market. Since fluctuations in housing activity can influence general economic activity, "spill-over" effects of such a policy change may engender significant impacts on activity in the rest of the economy.


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