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Modelling the Dwelling Cycle in the Treasury Macroeconomic (TRYM) Model

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Abstract

The dwelling sector is a key part of the Australian economy and has a significant influence on the business cycle. Any model that hopes to explain the business cycle needs to have a coherent explanation of the dwelling cycle. The paper reviews the evidence on the dwelling cycle in Australia and outlines a revised approach to modelling dwelling investment and rental prices in TRYM. In particular it introduces rental vacancy data into the model's system of dwelling equations, to account for disequilibrium in the sector, and to better identify the lagged adjustment processes that are leading to the cyclical behaviour of dwelling investment. The paper looks at the relationship between movements in desired consumption of dwelling services, rental vacancies, consequent movements in house prices and the incentive to invest in dwellings, and the resulting upswings and downswings in dwelling supply. It shows how the interrelationship between these factors captured by a simple system of equations, with the additional influence of interest rate changes, can account for persistent cycles in dwelling investment such as those witnessed in Australia over the last twenty years.

The views expressed and any errors in the paper are those of the authors. The views presented in the paper should not necessarily be interpreted as representing the views of the Treasury, the Treasurer or the Government. The paper has benefited from statistical work by Penny Newman, a number of conversations with Kieran Davies and also picks up on some previous Treasury work on the rental market by Julie Smith and David Bassanese. The results reported in the paper are of work in progress. Any comments or questions on the material contained in the paper can be sent to the following email address: pdownes@treasury.gov.au.

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1. Introduction

The dwelling sector is a key part of the Australian economy and has a significant influence on the business cycle. For example, rapid growth in dwelling investment accompanied by asset price inflation played an important part in the late 1980s boom, as did the oversupply of dwellings and asset price deflation in the subsequent contraction. Dwelling related expenditure (investment and the consumption of dwelling rent) accounts for about 17 per cent of gross national expenditure (GNE). The housing stock constitutes about two thirds of private sector wealth, and movements in established house prices are the most important short term influence on movements in the market value of wealth. These in turn have a bearing on consumption decisions. In addition, rental prices are an important component of the consumer price indices, having a weight of about 18 per cent in the national accounts private consumption deflator, and around 10 per cent in the Treasury underlying rate measure of the CPI. Moreover, the dwelling sector plays a significant role in both business cycle fluctuations and the transmission of shocks through the economy. This follows from the persistent stock adjustment cycles that seem to be a feature of dwelling investment in Australia and the fact that there is little leakage out of this component of demand into imports. As a result, it plays a significant role in both forecasting and policy analysis applications of the model.

The paper outlines modifications to the dwelling sector equations in the TRYM model designed to improve its ability to forecast rental prices and inflation and to track the dwelling cycle. The main innovations have been the introduction of an equation for rental vacancies, the use of vacancies in the rental price equations, and modifications to the dwelling Q ratio to account for the effect of vacancies on the investment return. Rental vacancies introduce disequilibrium into the dwelling market. They represent the difference between supply and demand for dwelling, or in other words the degree of unemployed dwelling space. The supply of rental services is given by the dwelling stock in the short term, so it is possible to identify movements in demand from the vacancies data. As a result, the vacancies data can be used to provide an estimate of the elasticity of substitution between rental and non rental consumption.

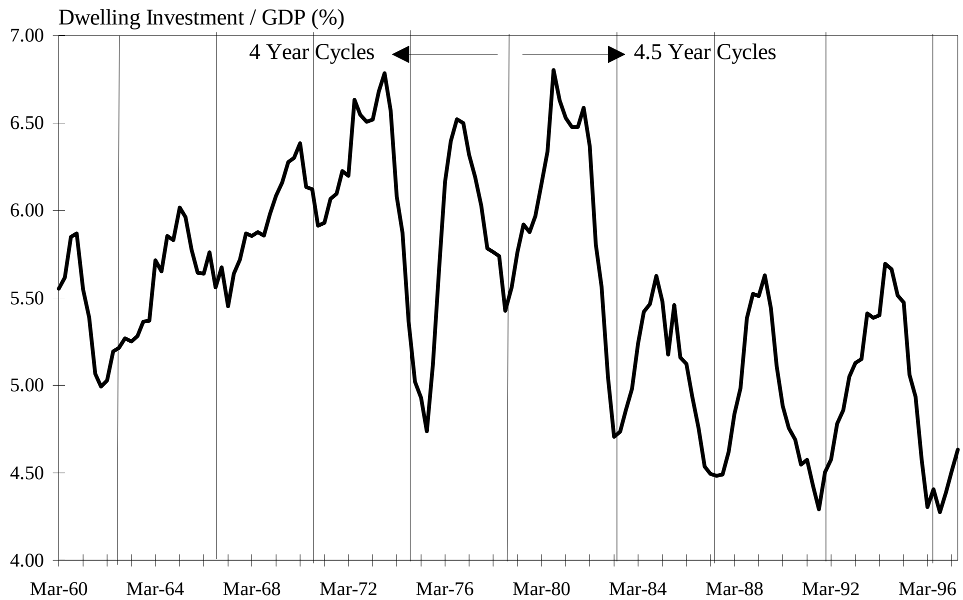
This differs from the previous TRYM specification for the sector which assumed the market cleared in the short to medium term, and used movements in non rental consumption to infer movements in rental demand relative to fixed short run supply. The implied elasticity of substitution between rental and non-rental consumption was derived from the rental price equation, but recent estimates had been implausibly high leading to instability in the dwelling stock in the steady state. The modified approach is to estimate the elasticity of substitution from the vacancy equation and to use vacancies in the price equation. When demand rises, vacancies fall below their equilibrium level leading to rising rental prices. Rising rental prices lead to higher dwelling investment and hence higher rental supply via the dwelling Q ratio. Higher rental prices also lead to substitution away from rental consumption, offsetting the initial pressure on supply represented by a low level of vacancies. Rising supply and falling demand return vacancies to their equilibrium — but with the lagged response, movements tend to overshoot. The three equations (for rental prices , rental vacancies, and dwelling investment), plus two identities (for the dwelling stock and rental supply) form a dynamic system which is estimated using full information maximum likelihood (FIML) techniques.

Section 2 below contains a preliminary look at some of the stylised facts of the dwelling cycle in Australia, some of the features of the data at the regional level, and a brief assessment of possible explanations for the cyclical behaviour of dwelling investment at the regional and national level. The argument is made that while demographic factors and supply side overshooting are important features of the regional data, behaviour at the national level is somewhat different. Section 3 contains a brief survey of specifications used in previous Australian models, including the 1993 Conference version of TRYM, addresses some data issues that influenced the previous specifications, and sets out a stylised version of the modified set up. Section 4 reports on the preliminary equation specifications, estimation results, and the simulation properties of the system as a whole.

2. The Dwelling Cycle

Chart 1 below contains the basic stylised facts to be explained. The interesting feature of the dwelling growth cycle is its high level of regularity, its symmetry, and the shortness of its frequency at around 4 to 4½ years. This contrasts with the irregularity, asymmetry and seeming longer length of growth cycles in GDP.

Chart 1: Dwelling Cycle in History



The chart suggest that the dwelling sector over history has been characterised by repetitive stock-adjustment dynamics which create growth cycles of a consistent 4-4½ years in length. Casual inspection of the data appears to indicate that both the amplitude and the length of the cycle are a little higher since the late seventies than they were in the earlier period. The average length of the cycle appears to have been in the vicinity of 4 years in length prior to 1978, and of around 4½ years duration in the period thereafter. This seems to be consistent with Grenville's (1997) speculation that financial deregulation may have increased both the amplitude and length of the cycles by "providing more rope for the cycle to swing". In the regulated world the upswing of the cycle would come up against quantitative lending controls. These served to truncate the upswing and shorten the cycle.

The continuation and even lengthening of the dwelling cycle post deregulation were, of course, against expectations at the time. Grenville, for example, takes the following quote from the Campbell Report:

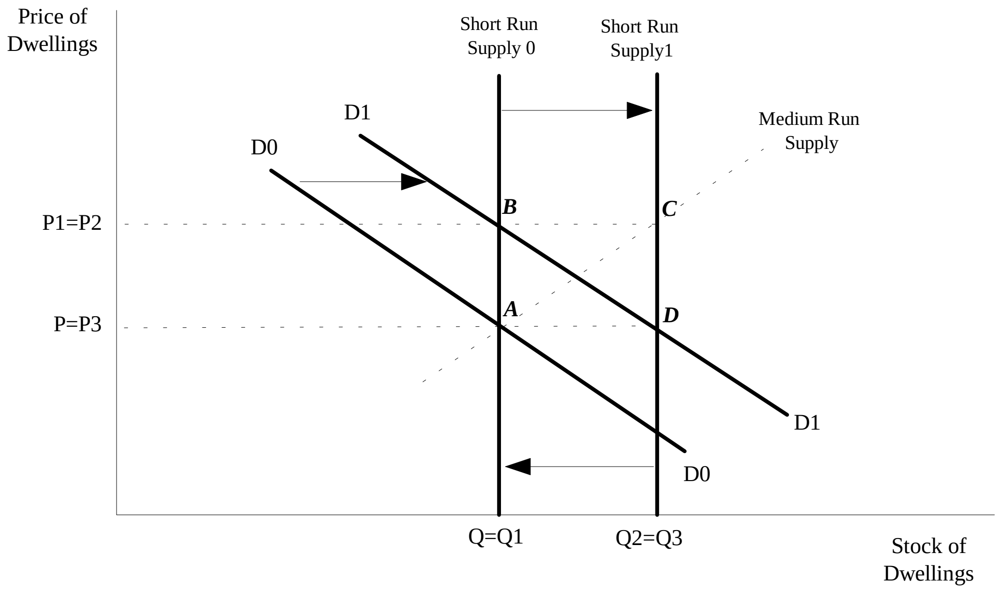
> "The Committee concludes that in the long run, housing financiers' inflows would be more stable if their interest rates were allowed to move in line with market forces. Coupled with the greater overall monetary stability, interest rate decontrol may help appreciably to stabilise housing finance flows, especially as household sector investors have become more interest sensitive. The reduced volatility in funds flows should contribute to a more stable housing sector over the long term". (Australian Financial System Inquiry 1981, P 639.)

Yet as is quite clear, the cycle did not die away with deregulation. Indeed, if anything, it seems to be in more robust health than ever before. It may be that there are certain adjustment processes leading to the cycles in the dwelling sector, and that these have remained reasonably constant over time.

2.1 Possible Explanations

But what are the factors that cause the cycle? One possible explanation is the familiar cobweb model where supply is constrained in the short run, and responds with a lag leading to overshooting. A simple representation of this is set out in Chart 2. Schematically, a positive shock to demand has the effect of shifting the demand curve to the right. The supply of dwellings is fixed in the short run, so the immediate effect is for prices to rise from P to P1. This induces an increase in investment, and dwelling supply shifts with a lag from Q to Q1. But at this point the market is over supplied. Prices fall to P3. Lower prices reduce the incentive to invest. Supply responds with a lag, the market is undersupplied, prices rise, and so on. Quantities and prices cycle around ABCD.

Chart 2: Cobweb Model



The appeal of this style of explanation is that it would produce regular symmetric cycles like those in Chart 1. Moreover, the model has many features which appear to be applicable to the dwelling sector. Supply is fixed in the short term and only responds with a lag — with delays between planning, financing, building approvals, dwelling construction, and bringing the house on to the market. If we look at the lags in construction, combined with lagged adjustment in house prices, they seem to be consistent with producing cobweb style stock adjustment cycles of about the frequency apparent in Chart 1.

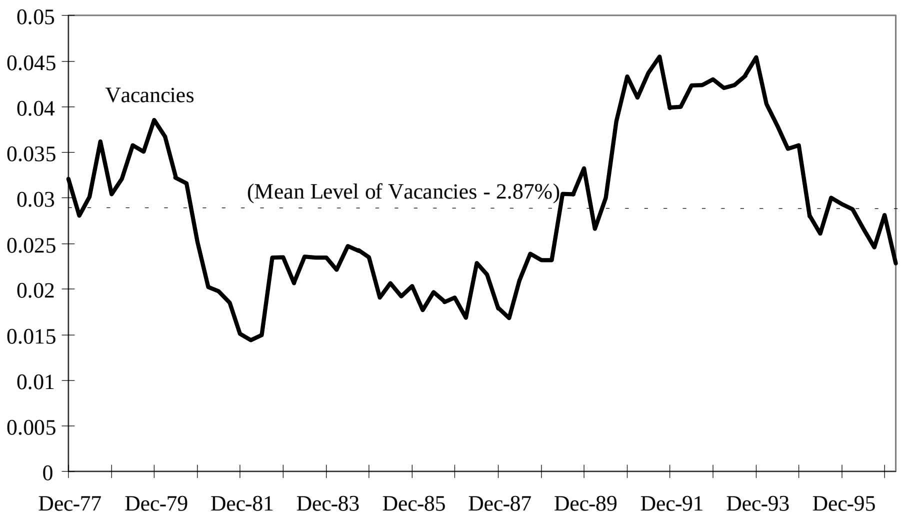
However, there are a number of practical and theoretical problems with this simple explanation, and the truth is undoubtedly much more complicated. The most obvious theoretical problem is that it seems to require agents in the market not to be particularly forward looking. If behaviour was rational, then the established house price would be relatively stable and the incentive to invest would be reasonably constant over time. The ABCD daisy wheel above would not turn. Repeated overshooting would also seem to require that agents in the market do not learn from their mistakes. Even if they were not rational the first time around, how is it that they overreact time and time again?

The first possible answer to this is that the characteristics of the building industry seem to work in favour of lagged adjustment and overshooting repeatedly taking place. In particular, the market seems likely to be subject to coordination failure with low costs of entry and large numbers of small firms. Each individual builder assumes that his addition to supply will have no effect on the market price. The supplier responds to the current price resulting in oversupply and a subsequent fall in price. Similar features result in repeated overshooting in some agricultural markets — for example, the “hog” cycle in the US.

Likewise, lags and price overshooting may also occur as a result of uncertainty. The supplier does not know whether his part of the market is rising or falling because of local demographic or other factors or a general swing in demand. If the investment, as in a dwelling, is irreversible and the returns are uncertain, then it pays the investor to wait (Dixit and Pindyck (1994). The investment has both an intrinsic value (the classical NPV) and a time value (the value of waiting). The investment therefore has the characteristic of a call option and the price will fluctuate even in the presence of rationality.

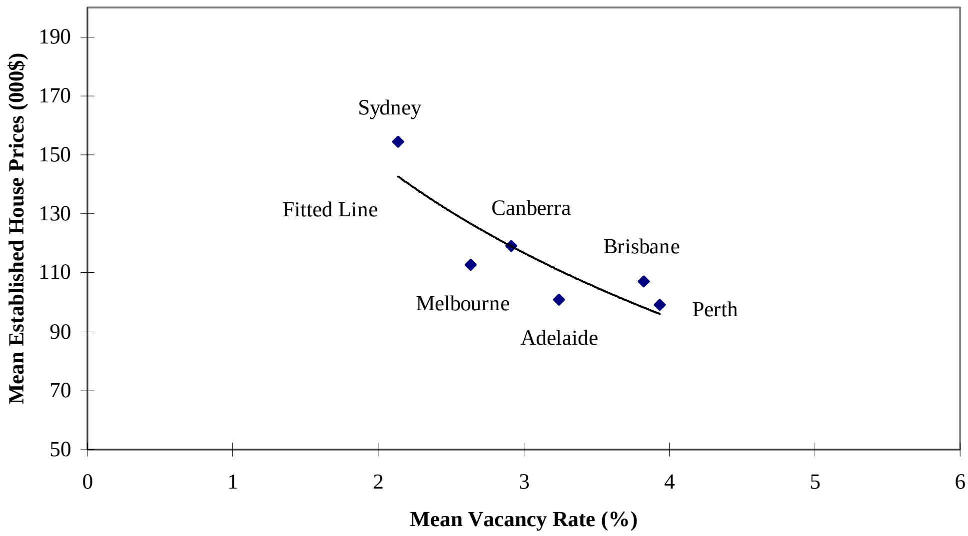
Moreover, the market is heterogenous. Each house is different and transaction costs can be large. Again it pays to wait, and unlike homogenous commodity markets where prices adjust instantly, prices are likely to adjust with a lag. The role of heterogeneity, transaction costs and overlapping contracts in leading to lagged adjustment and inertia in the market is evidenced by the fact that the market does not clear. At any one time, there is a certain level of unemployed or vacant accommodation in the market (Chart 3). Analysis of the role of vacancies appears to be playing an increasing role in the housing literature with vacancies modelled as movements around a search equilibrium — applying similar ideas to those employed in labour economics (eg Diamond 1981).

Chart 3: Rental Vacancies



For a given set of characteristics, any particular market should exhibit a given natural vacancy rate to which it will return (Rosen and Smith (1983) and Wheaton (1991)). While we do not want to go into this literature in any detail here, it is interesting to note that there does seem to be a consistent pattern to vacancies across the capital cities, with vacancies on average being the lowest where the opportunity cost of the vacant space is highest (Chart 4).

Chart 4: Average Rental Vacancies and House Prices by City
1977(4) to 1997(1)



There seem to be good reasons therefore to suspect that there will be lagged adjustment and inertia in both sides of the dwelling market. The dwelling cycle might therefore be a consequence of a number of interactions:

- Rental vacancies to rental prices with a lag.
- Rental prices to established house prices (with a lag) to the incentive to invest and dwelling investment (further lags).
- Higher investment leading to higher supply and reduced vacancies (directly).
- Falling rental vacancies reversing the initial movement in prices (with a lag).
- Higher prices reducing consumption of rents and also reversing the initial fall in vacancies (with a lag).

The interaction of either prices to vacancies and vacancies to prices or investment to supply and to prices might lead to dynamic instability in the market.

The fact that persistent lagged adjustment and the sort of interactions outlined above do occur seems to be bourn out by the Sydney market. Charts 5a, 5b and 5c show the series of linkages between rental vacancies and dwelling investment. First, movements in vacancies lead to movements in rental prices (Chart 5a). When vacancies are above normal levels, rents are falling and vice versa when the vacancy rate is low. Higher rental prices are then gradually priced into established house prices (Chart 5b) which appear to take around five to six quarters to respond (similar to the lags between rental prices and investment we find in the investment equation in Section 4 below). Finally, (Chart 5c) movements in house prices lead to changes in investment levels but this time without an apparent lag (possibly because builders respond to the direction of price movements which lead the price level). Investment then shifts the supply of dwellings and dwelling rents leading to changes in rental vacancies, and so on.

Chart 5a: Vacancies Leading Rental Prices - Sydney

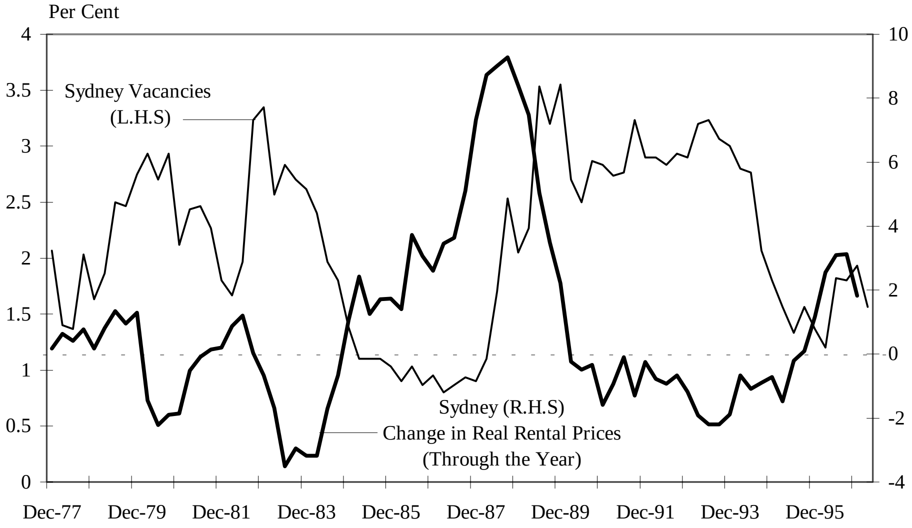


Chart 5b: Rental Prices Leading House Prices - Sydney

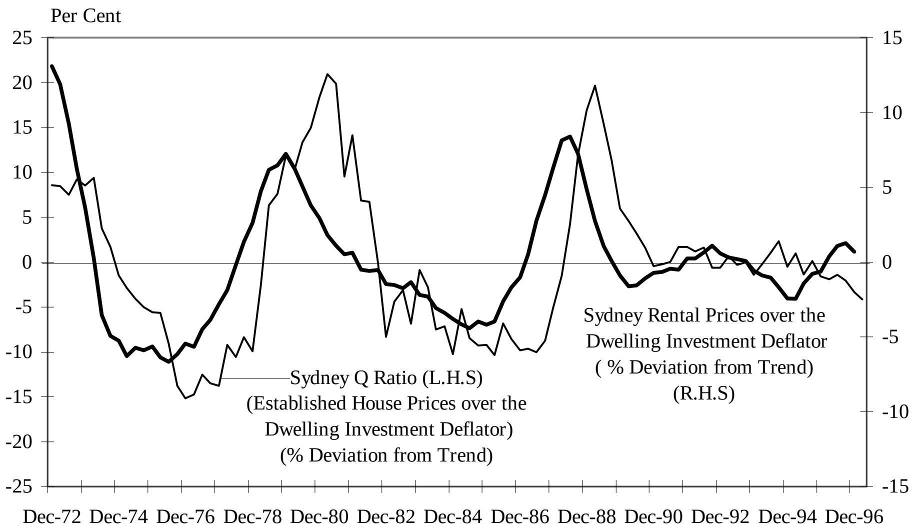
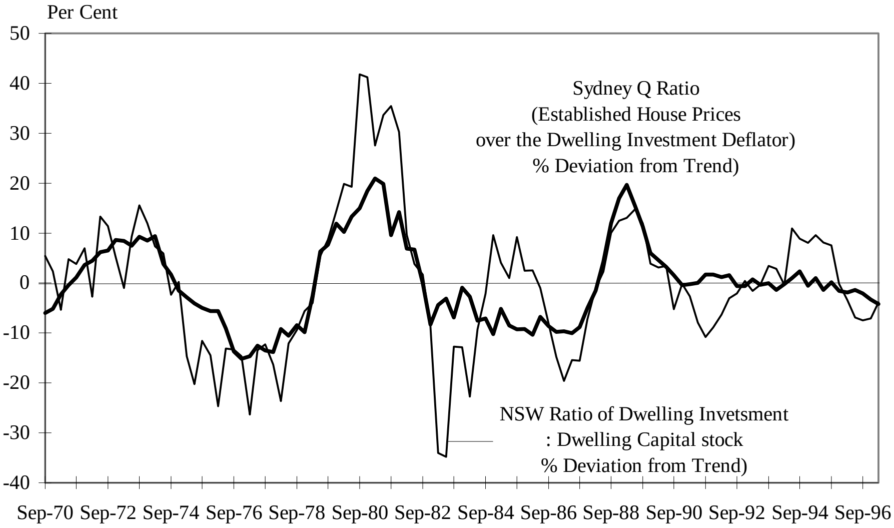
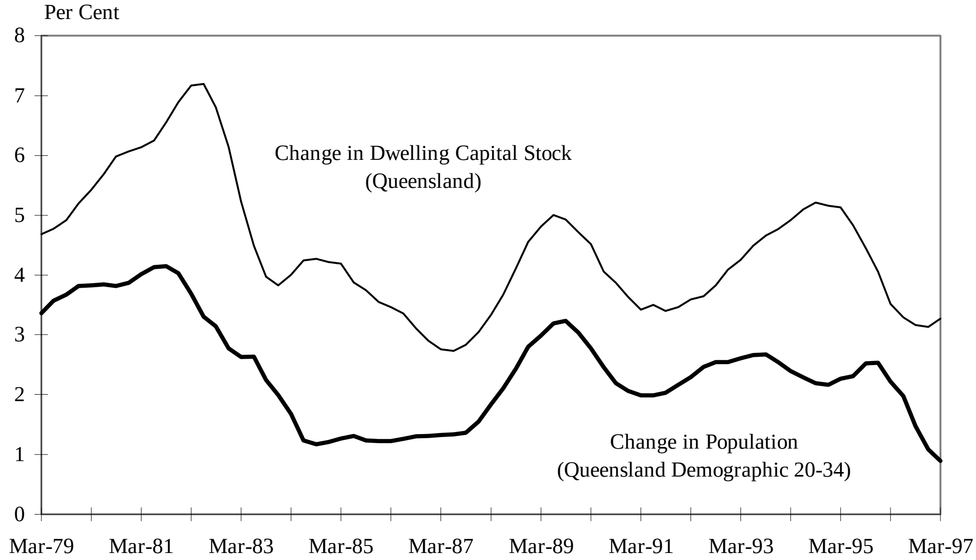


Chart 5c: House Prices Driving Investment - Sydney



However, the relationship between house prices and investment levels in Chart 5c are far from perfect and there are obviously other influences at work. Moreover, the feedback from movements in supply (the last stage above) to movements in dwelling vacancies (the first stage) is complicated with rental price movements leading to substitution away from the consumption of rents and hence also having an effect on vacancies (and also with a lag). In addition to the lagged adjustment processes, the dwelling market is continually being influenced by other factors, such as fluctuations in incomes and interest rates and changes in demographics. In individual urban and regional markets, fluctuations in population growth seem to have important effects. In particular, population growth might directly influence the level of dwelling investment via the activity of developers and speculative builders. According to Williams (1984), around two thirds of new dwelling commencements are due to developers and speculative builders and “the actions of speculative builders and investors account for much of the short term variability in building activity.” Whether this activity is stabilising or destabilising is a moot point. In so far as local developers and builders can anticipate the likely demand for dwellings, they are likely to stabilise the housing market. Whichever, fluctuations in population growth clearly have important direct effects in individual markets. For example, in Queensland there have been large movements in the household forming 20 to 34 year old cohort of the population (most interstate migration also occurs in this group) and seemingly contemporaneous changes in the dwelling supply (Chart 6). Clearly it pays in studying any regional market to keep a close eye on demographic developments.

Chart 6: Growth in the Dwelling Stock and the Population 20-34 years

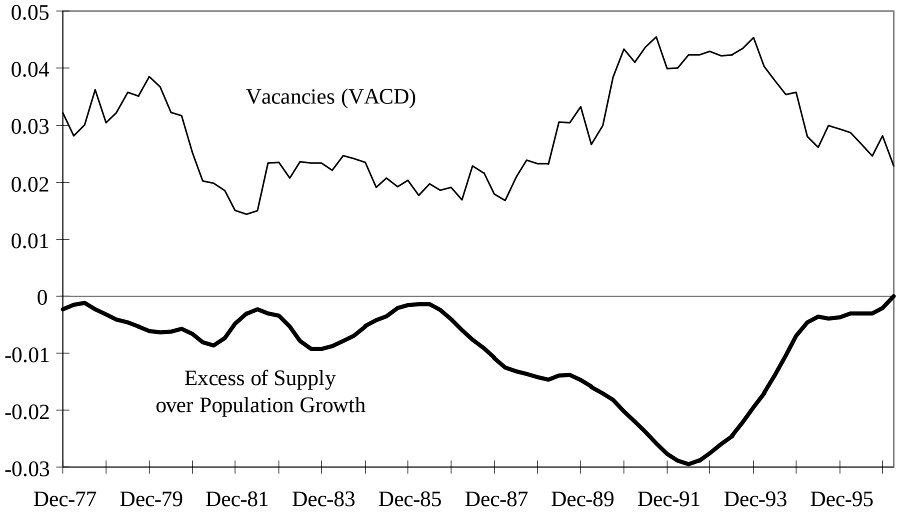


Clearly demographics and household formation play an important role in individual markets. Indeed, analysing demographic influences on underlying demand (household formation versus new dwelling commencements) seems to be a central feature to the Indicative Planning Council for the Housing Industry (IPCHI) approach to forecasting undersupply or oversupply in particular housing markets.

2.2 Aggregation

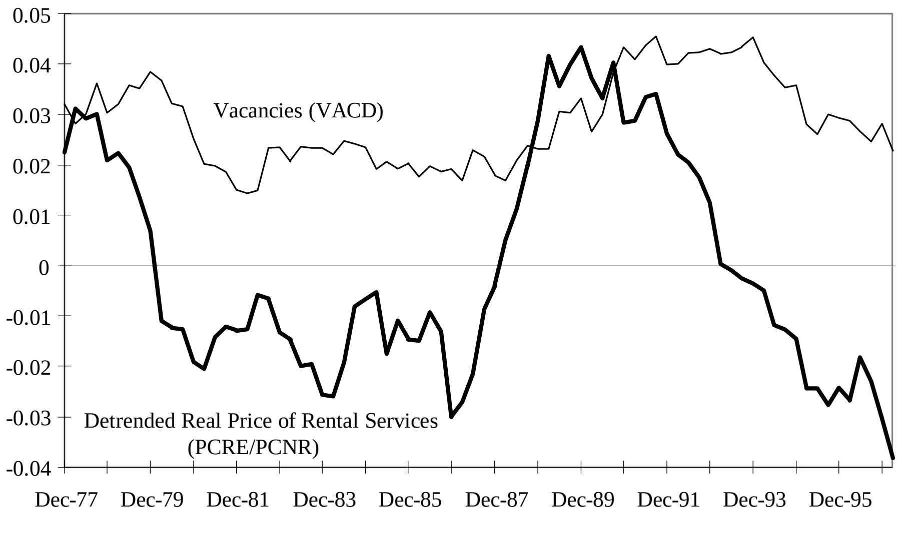
However, our interest here is in the aggregate market rather than regional markets and the above is little more than a casual inspection of the regional data to obtain a feel for how the market is responding as a whole. Clearly, individual markets do seem at times to be characterised by stock adjustment style overshooting and there is an important role for demographic factors. However, much of the demographic influence on the regional markets is driven by interstate migration. This nets out at the national level. As a consequence, dwelling investment for the aggregate market seems less volatile than it does for any individual market. Moreover, despite our best efforts, IPCHI style overshooting behaviour did not seem to work very well in explaining movements in vacancies. For example, Chart 7 below shows a simple indicator of over or undersupply in the dwelling sector estimated by cumulating the difference between the demeaned growth in the dwelling stock (supply) and the demeaned rate of household formation (demand) as given by the growth of the 20 to 34 year old cohort of the civilian population. Rather than the expected strong positive correlation with rental vacancies, almost the opposite seems to occur with rental vacancies seeming to be the highest when the dwelling stock is at its lowest relative to the household forming population. Other variants appeared equally unsuccessful, although controlling for other influences did eventually lead to some effects becoming apparent.

Chart 7: Vacancies and an Indicator of Excess Supply - Australia



Still the situation seems very different from the regional markets where demographics and overshooting behaviour appear to play such an important role. What then is driving the movement in vacancies at the national level? The main determinant appears to be the lagged effects of movement in rental prices. This can be seen in Chart 8 below. The movements in relative rental prices are much larger than those in vacancies. Even with a minimal response to the rental price (low elasticity), they must have a significant effect on the vacancy rate. More details are reported in Section 4 below.

Chart 8: Rental Prices and Vacancies - Australia



* Detrended real rental prices above are expressed as log difference from the trend.

Therefore, while the regional market may be characterised by stock adjustment style overshooting and demographics, these factors may play a slightly different role in the national market. In particular, the above highlights the possible role of dynamic adjustment between rental prices and rental vacancies at the national level.

Thus, rather than a simple story of stock adjustment dynamics and supply overshooting, we seem to have a complex story of price, vacancy, price interaction on top of the stock adjustments which are further accentuated by the swings in demand and interest rates coming from the rest of the economy. The complexity of the latter means that agents are faced with a high degree of uncertainty, and possibly explains why planners at the local level do not smooth out the cycle.

3. Previous Empirical Studies

This section outlines the approach to modelling the dwelling sector in the NIF-10 and NIF-88 models, the Murphy Model and the 1993 Conference version of TRYM. The earlier models tended to take a portfolio approach to modelling dwellings, with household's investing a given proportion of their wealth in the form of dwelling capital in accordance with standard portfolio allocation models.[1] Also, reflecting the regulated environment, there tended to be a focus on modelling finance approvals and the sequence through dwelling commencements to construction. The more recent models ignore the finance approvals and commencements data and model dwelling investment directly. Also, rather than treating investment as a portfolio allocation decision, the simplifying assumption is made that risk-adjusted returns are equalised across asset classes. The equilibrium capital stock is determined by the consumers' choice of rental against non rental consumption — in turn, driven by the relative price.

3.1 Model Review

3.1.1 NIF–10 and NIF–88

The dwelling sector in the NIF–10 and NIF–88 models was modelled as a three tiered structure, with the supply and demand for new dwelling finance forming the top layer, the value of dwelling commencements placed in the middle, and the value of work done or investment at the bottom.

The market for mortgage finance was assumed to be in a constant state of excess demand and therefore determined by the available supply of mortgage finance. The supply of mortgage finance was provided by lenders, who adjusted their stock of outstanding loans to a desired stock using a partial adjustment model. (The desired stock of outstanding loans was a

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1 See also Williams (1984).

function of the money supply and relative interest rates — that is, mortgage interest rates compared to two year government bonds.)

The proportion of total new mortgage finance that was used to finance new building construction was largely demand determined — a function of the *relative price of dwelling consumption*, *the stock of dwellings per capita* (as the stock of dwellings rose relative to the population, overall demand for new dwellings fell) and *disposable income* (discounted by the average level of new mortgage finance repayment commitments). New dwelling commencements depended on *the level of mortgage approvals for new dwellings* and *the change in private sector liquid assets* (designed to capture the effects of outside finance). Total private investment in dwellings was just a lagged response to dwelling commencements.

NIF–88 was differentiated from its predecessor by including a dwelling sector Q ratio (capturing speculative non-mortgage credit) in the housing commencements equation and also by modelling separately the commencements of other dwellings and the commencements of alterations.

Underpinning this approach was the implicit assumption that finance is never over supplied. While the model builders acknowledge the existence of counter-examples, it was argued that given the importance of credit constraints in the dwelling sector in the Australian economy, deviations from this assumption were not serious. This focus has become less relevant in a deregulated market.

3.1.2 The Murphy Model (MM2)

The household sector in MM2, following the approach taken in the earlier EPAC Australian Medium-term Policy Simulation (AMPS) model, has broadly the same structure as the 1993 Conference version of TRYM. Total consumption is allocated between expenditure categories on the basis of relative prices. In the short run, the supply of rental services is fixed by the stock of dwellings — which is slow to change — and, therefore, variations in the demand for rental services affect the market clearing price rather than the quantity consumed.

The price of rental consumption adjusts to the market clearing price in roughly three quarters. Any change in the market clearing price is passed on fully to the actual price by lagged changes in actual and market clearing prices. However, these lags in combination with an error correction term (with an *imposed* coefficient of 10 per cent) lead to some minor overshooting of the market clearing price. The equilibrium or market clearing relative price level is inversely proportional to the ratio of non-rental to rental consumption.

$$\frac{\mathrm{Ln}(\mathrm{Price}_{\text{rental consumption}})}{\mathrm{Ln}(\mathrm{Price}_{\text{non-rental consumption}})} = \alpha + \frac{\mathrm{Ln}(\mathrm{Consumption}_{\text{non rental}})}{\mathrm{Ln}(\mathrm{Consumption}_{\text{rental}})}$$

This relationship is imposed and assumes that the elasticity of substitution is 1 in the long run.

The ratio of dwelling investment to the dwelling capital stock is modelled as a function of a Q-ratio, the yield curve and its own past behaviour. The Q-ratio is modelled as the ratio of the price of the dwelling capital good to the dwelling investment deflator (the expected return) against the real 10 year bond rate (the actual return). Dwelling investment responds with a lag of two quarters to changes in the expected return from dwelling investment due to changes in rental prices. The yield curve is lagged three quarters and is equal to the difference between the long and short term interest rates and reflects the tightness of monetary policy.

The first persistence term in the equation is lagged one quarter and has a coefficient of 1.01 which sets up an accelerating investment cycle. This cycle is cut off after three quarters by the second term (lagged four quarters) which has a coefficient of minus 0.24 and feedback from the price of dwelling services.

3.1.3 Overseas Models: The Fair Model

The above structure is fairly typical of that found in many overseas models. One example is the well known Fair Model of the United States economy. Fair argues that if the consumption of housing services is proportional to the stock of housing, the variables from the theoretical model that affect consumption can be taken to affect the housing stock.

The demand for housing services is a function of wealth, non-labour income, the after-tax wage, real long term interest rate and the housing price deflator. These variables imply a desired level of housing services which, in turn, imply a desired level of housing capital stock.

The investment equation is specified in per capita terms. The desired level of housing services and the adjustment of the capital stock through investment to meet this desired level are estimated simultaneously. The model is a disequilibrium model with supply adjusting gradually to demand. The housing stock adjusts to remove 6.6 per cent of any difference between the desired and actual capital stock per quarter. The investment deflator does not respond to demand conditions in the dwelling sector directly, but is specified as a constant ratio of the general price level so that supply is assumed to be perfectly elastic in the long run.

3.2 1993 Conference Version of TRYM

The modifications to the dwelling sector outlined below followed from problems encountered when progressively updating the previous version of the model. The passage below drawn from Antioch and Taplin (1993) provides a good description of the reasoning behind the specification of rental consumption and prices in the 1993 version of the model.

> *[In TRYM] the rental price is determined by a simple consumer demand system consisting of rent and non-rent expenditures. Consumers regard rental services as an (imperfect) substitute for other consumption goods. This is captured by a constant elasticity of substitution (CES) utility function, which is defined over the consumption of rental services and other consumption goods. Once consumers have chosen the aggregate level of consumption spending based on their income and*

wealth, they then choose the utility maximising proportion of rent consumption. The solution to this maximisation problem yields the following demand curve.

log(CRE/CNR)=*c0pcr-cdwsig**log(PCRE*PCNR)

where: CRE=rent consumption;

CNR=other consumption goods;

cdwsig=the elasticity of substitution between rental and non-rent consumption;

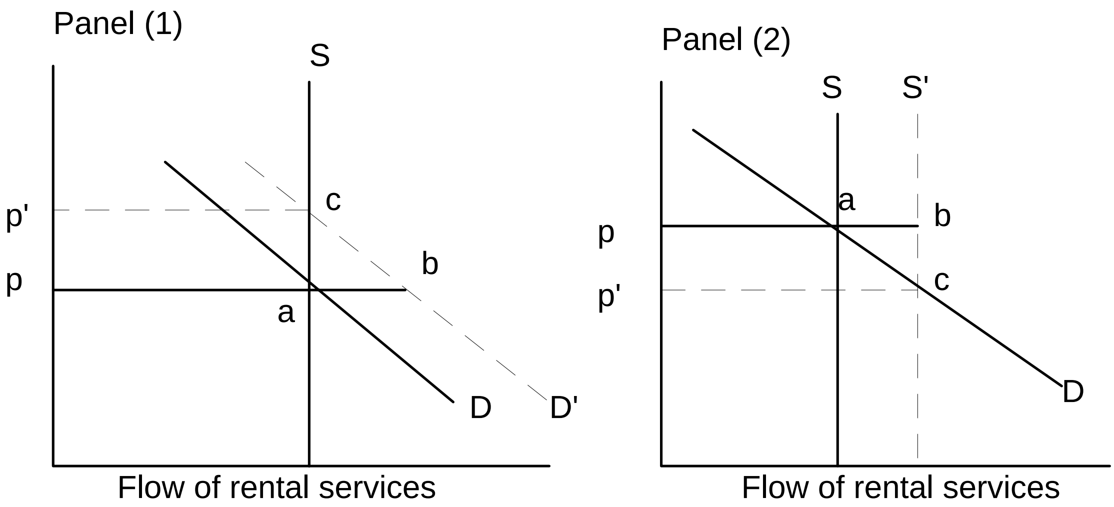
PCRE=the price of rents; and

PCNR=the price of non-rent consumption.

Because net investment is typically a small fraction of the capital stock, the stock of dwellings and therefore the supply of rental services is essentially predetermined in the short run. Thus the relative price of rents adjusts to ensure that demand equals the fixed level of supply. This suggests that the demand equation should be inverted. The resulting equation determines the relative price of rents as a function of the predetermined share of rental services. This yields an equation for the equilibrium price of rents of the form:

log(PCRE/PCNR)=*c0pcr*-1/*cdwsig**log(CRE/CNR)

The demand and supply relation in the dwelling sector is depicted in the following chart.



In the short run, the supply of dwelling services - defined as the ratio of dwelling investment to dwelling stock, is fixed. Therefore changes in demand for dwelling rents affect the price of rents in the short run as indicated by the above equation. To illustrate the comparative static effects of the dwelling market, suppose that our initial position is at point a in panel (1). Suppose also that private final consumption rises because of an increase in income or wealth. This will cause the demand for rental services to shift to the right from D to D'. If this increase in demand is not matched by an equivalent rise in supply then, at unchanged rent prices, there will be *an excess demand for dwelling services - measured by the distance between points a and b. This will cause the price of rents to rise (from p to p') until the new equilibrium is reached - which is at point c. Alternatively, if the supply of rental services rises by more than private consumption - see panel (2), at unchanged rent prices there will then be an excess supply for dwelling services - measured by the distance between points a and b. This will cause the price of rents to fall (from p to p') until a new equilibrium is reached, which is at point c.*

The dynamic specification of the above model is as follows. Because most rents are fixed by contracts for periods of a year or so, actual rents are likely to lag behind equilibrium rents as defined by the above equation. Accordingly, an error correction specification was used for the rent price equation.

$$\Delta\log(PCRE/PCNR)=a2pcr*\Delta\log(CNR/CRE)$$
$$-a0pcr*[\log(PCRE(-1)/PCNR(-1)) - c0pcr$$
$$-1/cdwsig*\log(CNR(-1)/CRE(-1))]$$

The estimated equation gave the following results:

Sample 1986:1 to 1992:4

Parameter	Estimate	t-statistic
a0pcr	0.1113	2.736
a2pcr	0.4392	4.239
c0pcr	-1.7002	-1.500
cdwsig	0.8857	1.489

R^2=0.69 SE=0.49% DW=1.83

As can be seen, the equation had a reasonable standard error and the coefficients were reasonably significant and of sensible magnitudes despite the short sample period of six years. The equation represented a theoretically consistent way of modelling dwelling prices and the system as a whole was fairly standard and similar to the set up in other macro models such as the Murphy Model and AMPS.

However, a couple of problems were apparent with the equation even at the time. The first was the short sample period. The equation did not work well when the sample was extended prior to 1986 — something that was thought to be possibly due to financial deregulation and problems with the data. The second was that the equation assumed that changes in non rental relative to rental consumption represented movements in the demand curve for rents. But non rental consumption included items such as motor vehicles and durables which are more in the nature of investment. Hence, non rental consumption was likely to be much more volatile than the underlying demand for rental services. This was likely to bias the estimated elasticity of substitution upwards and indeed, as time went on, the estimate increased to unrealistic levels with recent estimates of a modified version of the above equation reaching levels of above four. This in turn began to cause problems with the stability of the asset market equilibrium embodied in the steady state version of the model. In short, any shock that caused a movement in relative prices between dwelling investment and non rental consumption (and the revised relative price block did exactly that for anything that effected the exchange rate) would lead to a very large movement in the equilibrium dwelling capital stock. The change in equilibrium stock implied changes in equilibrium dwelling investment, implying a change in the equilibrium savings / investment imbalance which, given World commodity and import prices, fed back to the real exchange rate which, in turn, was driving a wedge between the deflators.[2] However, the high estimated elasticity posed a dilemma as the estimate is also important for inflation. A lower elasticity would lead to much higher rental price volatility than was apparent from the data. Hence, a slightly different approach to the problem seemed to be required.

The proposed solution, set out below, is to use movements in rental vacancies to identify movements in demand. However, the problem of extending the sample period back to the late seventies first needs to be addressed.

3.3 Data Considerations

The problem with the estimation of the equation for the 1993 version of the model can be seen in Chart 9 below. For the period 1986 to 1993 there does appear to be an inverse relationship between rental consumption and the rental price. However, for longer periods — either post 1993 or prior 1986 — the relationship appears to be a positive one with both consumption and prices rising.

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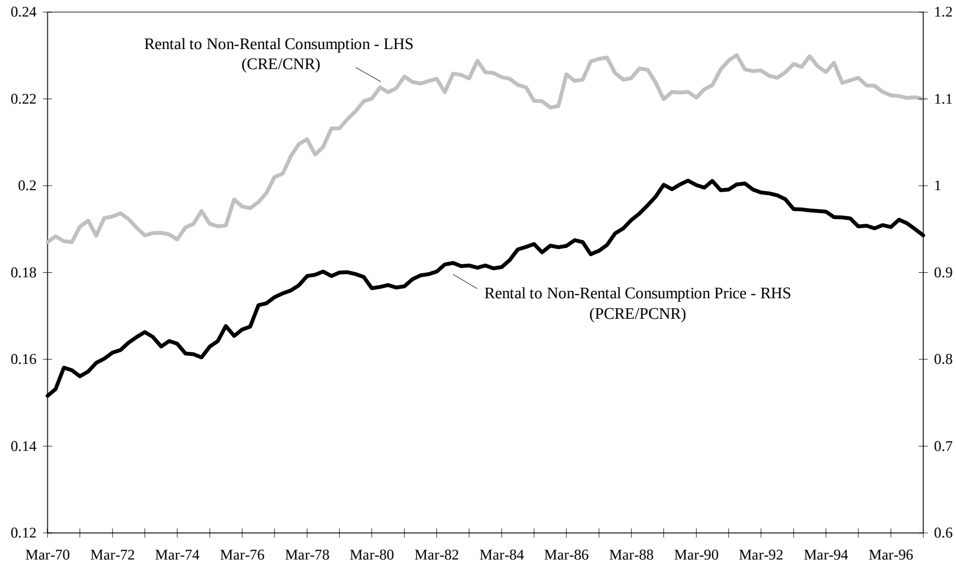
[2] This is just one of many instances over the years where the steady state version of the model has helped to identify problems in the dynamic version of the model. This highlights the value of thinking about the long run (and other) implications of any particular equation specification. The steady state or long run version of the model does not have a particularly large influence on the results of most simulations. Rather, it has its main use in providing a consistency check on the dynamic version of the model, and in imposing the useful discipline of forcing the modeller to think about the long run implications when specifying a new equations. As such it helps to safeguard against ad hocery, data mining and spurious regressions.

Chart 9: Rental / Non Rental Prices and Rental / Non-Rental Consumption



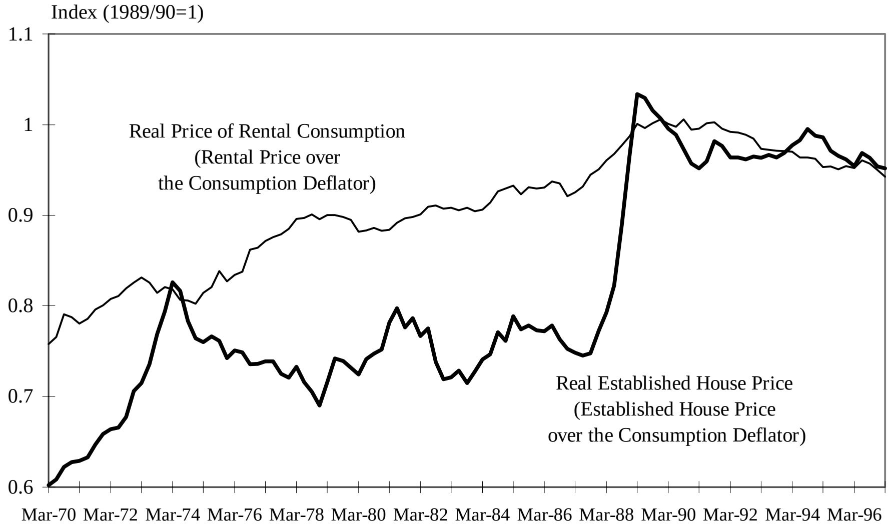
At first glance, this might appear to indicate a supply relationship. However, the dwelling investment equation implies a perfectly elastic long-run supply, with the rental price fixed by the required rate of return and the dwelling investment deflator. While there has been some upward movement in both the dwelling investment deflator (relative to other deflators) and the real rate of return, neither seems sufficient to explain the significant upward trend in the rental deflator. What then is driving the upward trend? It seems likely that, as the rental return has been reasonably stable over the long term, the trend reflects the upward movement in real established house prices over time, in turn, reflecting the fact that urban land is partly supply constrained and is rising in value over time with rising population and rising real income levels.

In the United States, trends in real established house prices, and the factors behind them, have been the subject of considerable debate since the publication of an article by Gregory Mankiw and David Weil entitled “The Baby Boom, The Baby Bust, and the Housing Market”. This argued that the rise in established house prices through the 1970s and 1980s was mainly attributable to the baby boom effect, and that the baby bust was likely to lead to falling house prices in real terms over the next two decades.[3] Our brief assessment of the implication of this argument for Australia is that the baby boom effect may have caused a change in the rate of real increase in established house prices in the 1970s and 1980s, and that this may slow in

3 And by a large margin - down 47 % by the year 2007 on one estimate although the latter was not necessarily representative - Mankiw and Weil (1992) argue that around 20% would have been representative. However, the equations they ran were based on the US National Accounts dwelling deflator which if it follows the SNA should be a measure of investment flows and hence should not include the value of land. Hamilton (1991) reruns the equation using rental prices and the predicted fall disappears. Peek and Wilcox (1992) re-examine the evidence and estimate that house prices will rise at about the same rate over the next two decades as the last two decades due to rising incomes, and different income profiles and fewer credit constraints of the younger generation.

the next 20 years as some of this effect is unwound.[4] Chart 10 below shows real established house prices against rental prices.

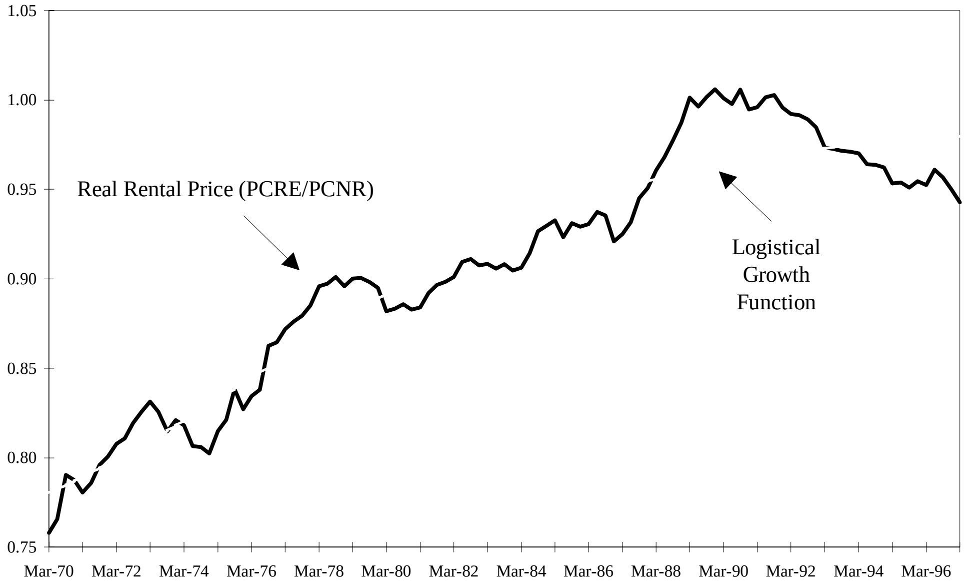
Chart 10: Upward Trends in Established House Prices and Rental Prices



The trend rise in house prices confers a capital gain on the owner of the property. The return on the investment is therefore the rental return (as measure by the ABS survey) plus the expected capital gain. Therefore, rents will trend up over time but this does not act as a disincentive to consume the services of the dwelling that sits on the land (KDW does not include land) which provides the estimate of CRE. Reflecting this, we have simply detrended the rental to non rental price ratio using a logistical trend (that is, to allow for the possibility that the trend changes over time due to demographic factors, such as the baby boom effect).

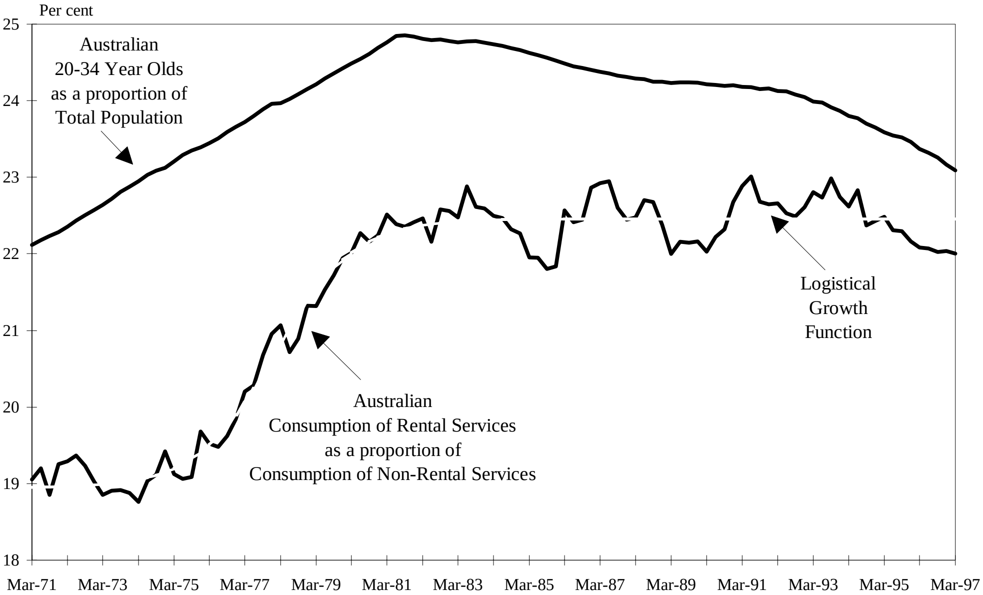
4 Population growth has been, as is likely to continue to be, higher in Australia. Moreover, low entry costs and large numbers of small businesses tend to suggest much higher elasticities of long run supply than would be required to drive a Mankiw and Weil style result.

Chart 11: Real Rental Price and Logistic Trend



This still leaves the apparent upward trend in the consumption of rents relative to total consumption. This may reflect social changes such as the break down of the extended family leading to an increase in the demand for housing, problems in the construction of the capital stock estimates and hence CRE, or it may reflect demographic changes — in particular, the so called baby boomer effect with the rise in the proportion of 20 to 34 year olds in the population in the late seventies. This rise (see Chart 12 below) coincided with the increase in CRE as a proportion of total consumption. For simplicity, and consistent with the use of demographic variables in the KDW equation, we have simply removed the trend in CRE/CNR using a logistical growth function as shown.

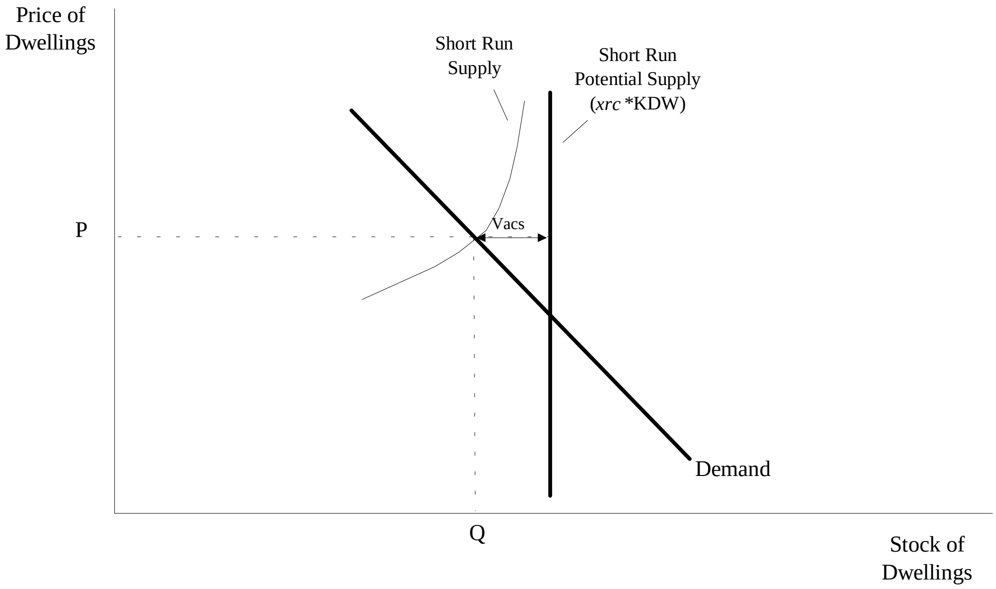
Chart 12: Demographic Factors and the Rise in Rental Consumption



3.4 Modified Structure

The following figure presents a stylised representation of the modified structure of the dwelling sector in TRYM.

Figure 1: Demand, Supply and Vacancies



As previously, the short run potential supply of dwellings is treated as inelastic and is a simple function of the dwelling capital stock in the previous quarter. However, equilibrium in this system is not given by the point where demand and potential supply cross, but rather by where the demand curve cuts the short run supply curve which is given by the vacancy relationship. As can be seen from the diagram, vacancies — like unemployment — cannot fall below zero. Consequently, a simple hyperbolic function is specified for the relationship between vacancies and rental prices.

$$\Delta \ln(PCRE) - \Delta \ln(PCNR) = a0 - a1 * \frac{(VACD - c1)}{VACD}$$

When vacancies are below their equilibrium level (c1), there is pressure for rental prices (PCRE) to rise relative to other prices (PCNR), with the pressure becoming much larger as vacancies approach zero. While the equilibrium $c1$ is likely to reflect search factors and change over time — for example, changing real house prices — no attempt has been made here to endogenise it.

As vacancies represent the difference between short run rental demand and rental supply (the position of which is known from the dwelling stock), they can be used to identify the demand function. Rental vacancies are therefore modelled (as was demand previously) as a function of the change in non rental to rental consumption, and the relative price of rental services. The derived elasticity of substitution between rental and non rental consumption determines the rental / non rental consumption split in equilibrium.

4. Equation Specifications and Estimation Results

4.1 Price of Rental Consumption

As mentioned above, the main factor driving movements in the rental price is the level of vacancies. A lagged dependant is introduced and adjusted for movement in the logistic trend (DLGF) discussed above (Section 3.3). An adjustment is also introduced for the change in relative import prices (demeaned) to allow for the effect of sharp movements in the exchange rate on non rental consumption prices and, hence, the relative price in some quarters.

$$
\begin{aligned}
\Delta \ln(PCRE) = {} & a1 \times (\Delta \ln\left(\frac{PCRE}{PCNR}\right) - DLGF) \\
& + a2 \times (\Delta \ln\left(PCNR\right) + DLGF) \\
& + (1 - a2) \times (\Delta \ln\left(PCNR(-1)\right) + DLGF) \\
& + a3 \times \Delta \ln\left(\frac{PMGS}{PD}\right) \\
& + a0 \times \left[\frac{(VACD - c1)}{VACD}\right] \\
& + s1 \times Q1 + s2 \times Q2 + s3 \times Q3 - \left(s1 + s2 + s3\right) \times Q4
\end{aligned}
$$

Results:

Sample: 1977(3) to 1997(1)

Parameter	**Interpretation**	**Estimate**	**t-Statistic**
a_1	lagged Δ (pcre/pcnr)	0.581	6.92
a_2	price of non-rents	0.297	3.82
a_3	price of imports to supply	-0.026	-2.03
a_0	error correction	-0.004	-2.63
c1	equilibrium vacancy rate	0.027	9.11
s1	seasonal dummy	-0.001	-1.59*
s2	seasonal dummy	0.002	2.11
s3	seasonal dummy	0.002	2.52

Diagnostic Statistics

R^2 = 0.86	
SE = 0.0037	
DW = 2.49*	
Box-Pierce Q (1-8th order auto correlation)	17.13*
Jarque-Bera Test for Normality	11.15*
Chow Test for Parameter Stability	0.84
Ramsey's Reset Test	0.00
Breusch-Pagan Heteroscedasticity Tests:	
Trend	0.21
Y-Hat	2.41
Joint	4.39*

* Indicates the test has failed at the 5% confidence level.

Interpretation

The diagnostics tend to suggest that the equation needs a little more work. In particular, the relative import price variable appears questionable. However, the vacancy rate is correctly signed and significant. The equilibrium vacancy rate is estimated at 2.7 per cent — close to the average value for the sample period. A 0.5 percentage point fall in the vacancy rate will cause rental prices to rise by 0.4 of percentage point relative to other prices in the first year. This seems smaller than the implied coefficient in individual markets. For example, the relationship in the Sydney market seems much closer (see Chart 5b) and is around two to three times that estimated above. It seems likely that there may be a problem in the aggregation of vacancies across markets given the non-linearity of the relationship between vacancies and prices. Given the non linearity, aggregation, strictly speaking, requires estimation in each individual market, and further work will be done on this issue. It is interesting to note that the significance and size of the coefficient on vacancies rises in the FIML estimates reported in the attachment, while that on the other variables, particularly the relative price of imports, falls.

4.2 Rental Vacancies

The vacancy equation is specified in simple partial adjustment format with the detrended relative price of rents (PCREd/PCNRd) and movements in non rental consumption (CNR) relative to the consumption of rent (which is fixed by the dwelling stock in the short term) being the main determinants, as discussed above. As vacancies increase when demand is falling, the elasticity of substitution between rental and non-rental consumption can be read directly from the equation. As the rental market is characterised by overlapping contracts and high transaction costs, the relative rental price is lagged three quarters in the equilibrium component. A term for the relative price of imports (RPMGST), detrended and demeaned, is also included to control for the effect of short term movements in the exchange rate on the relative price ratio.

$$
\begin{aligned}
VACD &= (1-b0)\times VACD(-1) \\
&+ b2\times\left(\frac{CNRd}{CREd}-\frac{CNRd(-1)}{CREd(-1)}\right) \\
&+ b0\times\left[c2 - cdwsig\times\left(\frac{PCREd(-3)}{PCNRd(-3)}\right) + c3\times RPMGST(-3) + c4\times\left(\frac{CNRd(-1)}{CREd(-1)}\right)\right] \\
&+ s1\times Q1 + s2\times Q2 + s3\times Q3 - (s1+s2+s3)\times Q4
\end{aligned}
$$

Results:

Sample: 1979(4) to 1997(1)

Parameter	Interpretation	Estimate	t-Statistic
b_0	partial adjustment	0.283	5.32
b_2	shift in demand (ΔCNR)	-0.081	-2.29
cdwsig	elasticity of demand	-0.291	-4.77
c_2	long run constant	0.030	-29.33
c3	relative import price	-0.035	-2.72
c4	demand shift (CNR/CRE)	-0.214	-2.32
s1	seasonal dummy	-0.002	-4.91
s2	seasonal dummy	0.001	1.90*
s3	seasonal dummy	0.001	2.63

Diagnostic Statistics:

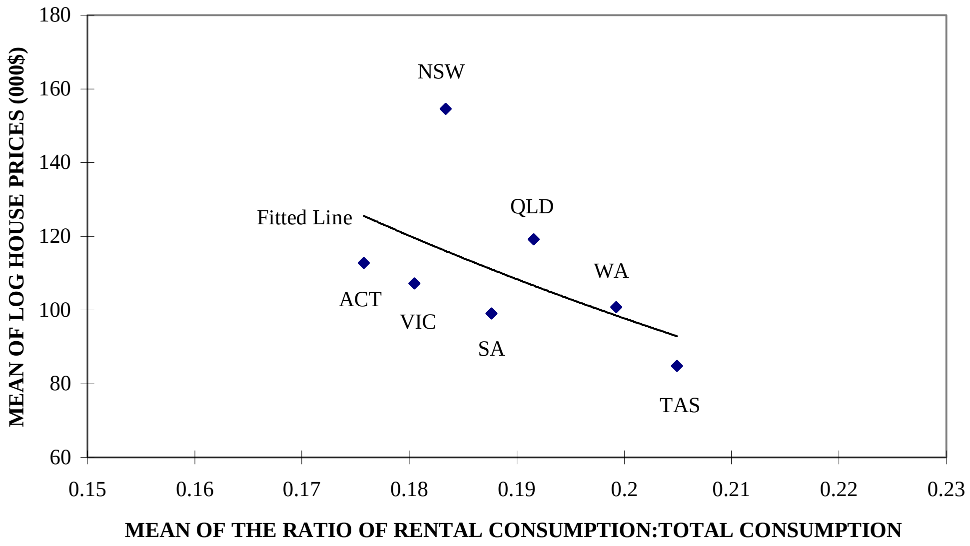
$R^2 = 0.917$		
SE = 0.0025		
DW = 2.17*		
Box-Pierce Q (1-8th order auto correlation)		3.80
Jarque-Bera Test for Normality		0.55
Chow Test for Parameter Stability		1.24
Ramsey's Reset Test		0.00
Breusch-Pagan Heteroscedasticity Tests:		
	Trend	0.22
	Y-Hat	1.40
	Joint	2.10

* Indicates the test has failed at the 5% confidence level.

Interpretation

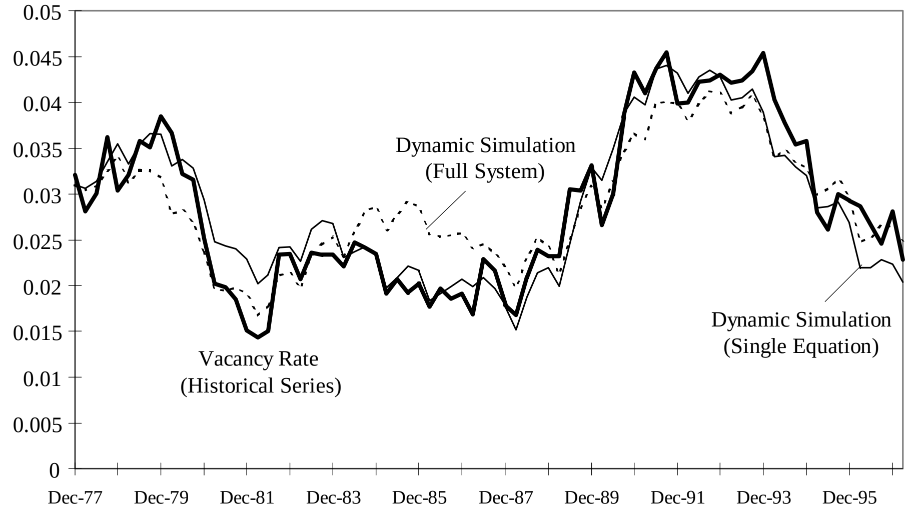
The equation seems to perform reasonably well in comparison to the PCRE equation, perhaps reflecting the fact that this time we are aggregating a set of linear rather than non-linear relationships. The elasticity of substitution is estimated at around minus 0.3. This seems a little lower than previous estimates. Yates (1981), for example, estimated demand elasticities of between minus 0.7 and minus 1.2. In contrast, the above estimate implies that demand for shelter is relatively inelastic. It may be that in the short to medium run, transaction costs and other considerations mean that the elasticity of substitution for many people is zero and the true elasticity only becomes apparent as time goes by. The above specification would therefore lead to an underestimation of the long run elasticity. The question is by how much? Chart 13 below uses data on relative house prices (which for a given return should reflect relative rental prices) against the proportion of rents in total consumption. The estimated line implies an elasticity of around minus 0.41, although the inclusion of non-metropolitan consumption data (in comparison with the price data which is for capital cities) would tend to reduce the variance along the horizontal axis and bias the estimate downwards.

Chart 13: House Prices and Rental Consumption
1984(1) to 1997(1)



Reflecting the reasonably low standard error and an absence of problems, as indicated by the diagnostics, the equation seems to perform well when simulated by itself or as part of the system. The FIML estimates reported in the attachment are little different to those reported above.

Chart 14: Vacancies - Actual and Simulated



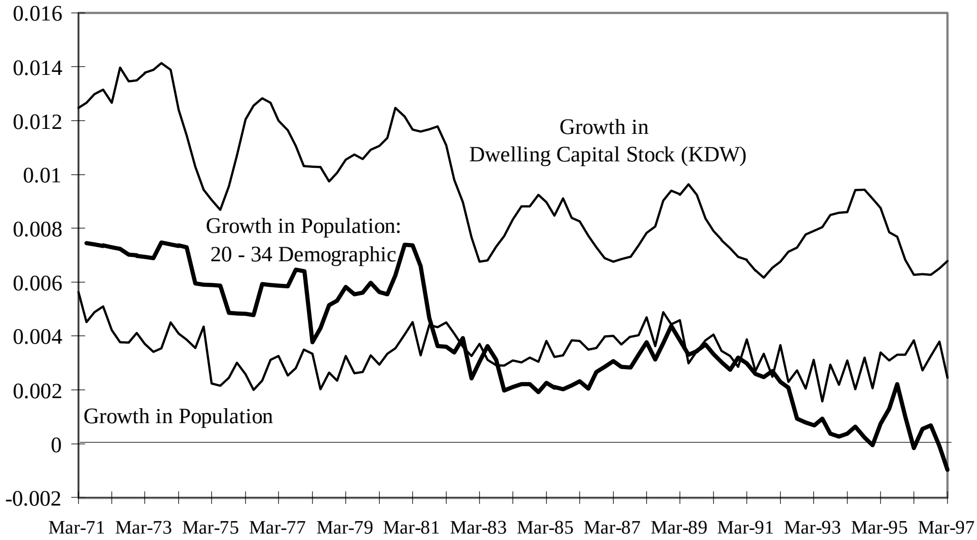
4.3 Dwelling Investment

The dwelling investment equation is similar in structure to the 1993 specification, with movements in the dwelling stock being modelled as a function of lagged dependants to capture the inertia in dwelling investment, and lagged values of the dwelling Q-ratio, which is defined as the expected rental rate of return over the required rate of return (borrowing and depreciation costs). Four modifications have been made to the previous specification. These are:

- The introduction of the vacancy rate into the calculation of the rental rate of return. When the vacancy rate rises, the return to investors falls.
- The introduction of demographic effects.
- The use of the detrended rental price deflator (removing the logistic trend in the ratio described in Section 3 from the deflator level).
- The freeing up of the lag structure on the Q-ratio reflecting the observation in Section 2 above that rental prices take five to six quarters to feed through to the established house price, and the estimation of the equation over a much longer sample period.

We experimented with dummies for financial deregulation on the parameters for both the Q-ratio and the lagged dependants but, to our surprise, were not able to find any significant effect. The choice of the demographic variable is based on Mankiw and Weil (1989) who provide data on estimated housing demand by age (P240). These show that additional housing demand is minimal for children and teenagers, but rises rapidly between the age of 20 and 30, peaking at around 40. Mankiw and Weil use weights from census data to derive a demographic housing demand variable. Similar profiles are apparent for Canada.

Chart 15: Demographics and Growth in the Dwelling Stock



$$
\begin{aligned}
\frac{IDW}{KDW(-1)} &= \left(EXP(GR) - 1 + RKDDW\right) \times \left(1 - a_1 - a_2 - a_3 - a_4\right) \\
&+ ad \times \left(DDEM(-2) - DNPAD(-2)\right) \\
&+ a_1 \times \left[\frac{IDW(-1)}{KDW(-2)}\right] + a_2 \times \left[\frac{IDW(-2)}{KDW(-3)}\right] \\
&+ a_3 \times \left[\frac{IDW(-3)}{KDW(-4)}\right] + a_4 \times \left[\frac{IDW(-4)}{KDW(-5)}\right] \\
&+ aq0 \times \left(QDW - 1\right) + aq1 \times \left(QDW(-1) - 1\right) + aq2 \times \left(QDW(-2) - 1\right) \\
&+ aq3 \times \left(QDW(-3) - 1\right) + aq4 \times \left(QDW(-4) - 1\right) + aq5 \times \left(QDW(-5) - 1\right) \\
&+ s1 \times Q1 + s2 \times Q2 + s3 \times Q3 - (s1 + s2 + s3) \times Q4
\end{aligned}
$$

where:

QDW=PCREt*(1-RTCRE)*XRCRE*(1-VACD)/PIDW

/{[(a6*RIGL+(1-a6)*RI90-FIE)/(1+FIE/100)]/400+RKDDW*(1+FIE/400)}

Results

Sample: 1978(1) to 1997(1)

Parameter	Interpretation	Estimate	t-Statistic
a_1	past investment	0.853	7.48
a_2	past investment	-0.067	-0.43*
a_3	past investment	0.144	0.87*
a_4	past investment	-0.155	-1.58*
a6	interest rate split	0.771	18.92
ad	demographic effect	0.09	3.43
aq0	Q-ratio	0.001	1.73*
aq1	Q-ratio	-5.9 (-04)	-0.08*
aq2	Q-ratio	1.0 (-03)	1.36*
aq3	Q-ratio	4.2 (-04)	0.57*
aq4	Q-ratio	1.0 (-02)	1.39*
aq5	Q-ratio	-4.0 (-04)	-0.65*
s1	seasonal dummy	-5.0 (-05)	-0.75*
s2	seasonal dummy	2.1 (-06)	0.03*
s3	seasonal dummy	7.7 (-05)	1.13*

Diagnostic Statistics

R^2 = 0.966		
SE = 0.003		
DW = 1.90		
Box-Pierce Q (1-8th order auto correlation)		6.58
Jarque-Bera Test for Normality		7.50*
Chow Test for Parameter Stability		0.35
Ramsey's Reset Test		0.00
Breusch-Pagan Heteroscedasticity Tests:		
	Trend	4.23*
	Y-Hat	6.86*
	Joint	7.06*

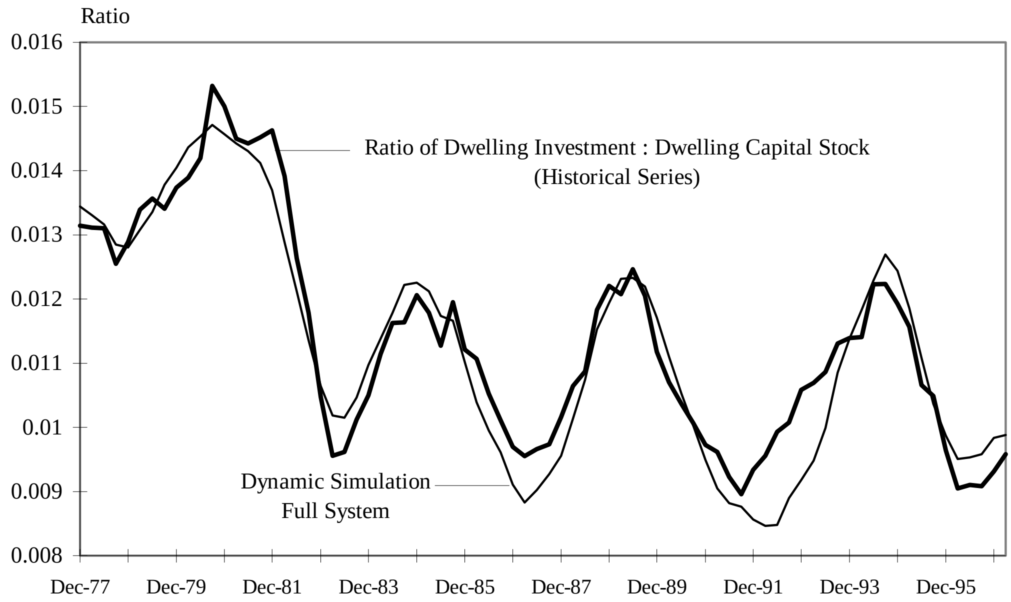
* Indicates the test has failed at the 5% confidence level.

Interpretation:

As in the previous equation, the lagged dependants dominate the short term movements, reflecting the high degree of inertia in dwelling investment. The coefficient on the demographic variable is significant, but not as high as expected, with a one per cent increase in the growth of the 20 to 34 year old cohort leading to a 0.1 percentage point increase in the growth rate of the capital stock. It is interesting to note that the first and the fourth lag are largest, the latter being consistent with the speculation in Section 2, and the former possibly reflecting a credit constraint effect from changes in interest rates (which tend to dominate short term movements in the Q-ratio). The dynamic simulation (Chart 16 below) and out of sample forecasting properties of the equation seem sound despite the tests for heteroskedasticity and normality, although these indicate the equation may need more work. The FIML estimates reported in the attachment are little different from those reported above.

Finally, the system as a whole seems to simulate well over history, which is encouraging, especially if the PCRE equation can be further improved. One interesting feature of the dynamic simulations of the system as a whole is the relative absence of large feedbacks between dwellings (which appears to be dominated by lagged dynamics and the effects of interest rates) and vacancies and rental prices (which seem to mainly feed back between each other).

Chart 16: Dwelling Investment - Actual and Simulated



5. Summary and Conclusions

In summary, the results turn out to be much more complicated than simple cobweb style overshooting as speculated in Section 2. Movements in interest rates, supply side lags and dynamic adjustment seem to dominate the movements in dwelling investment, while rental prices and vacancies appear to have most effect on each other. The equations seem to work well as a system, and further work will be done to check the consistency of the aggregate equations (particularly the rental price equation) with relationships at the regional level. Surprisingly, testing for effects from financial deregulation seemed to produce little return, although it may be a case of offsetting effects, for deregulation clearly has had significant effects on lending practices, interest margins and the gearing of the household sector over time. It seems likely that behaviour has changed over the sample period of the estimated equations, and will continue to change (for example, as a result of the entry of mortgage managers into the retail lending market) in ways not captured by the equations. It therefore pays to be cautious in interpreting the estimation and simulation results above. Developments in dwelling investment at any point in time might be affected by compositional factors, developments in regional markets or other influences not included in the above specifications.

The equations above, reflecting the requirements of the model, represent a simple system that attempts to capture the salient features of behaviour in the sector. The preliminary specifications seem to be able to explain the dwelling cycle in history, have improved the model's ability to track inflation, asset prices and wealth, and, we hope, have incorporated information from dwelling vacancies in an internally consistent way. Further work will be done cross checking the above equations, and the properties of the system as a whole, before final specifications are incorporated into the model.

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Appendix A: Full Information Maximum Likelihood Estimates

The following results were via FIML estimation of the system of equations - consisting of equations for PCRE, rental vacancies (VACD), dwelling investment (IDW), and two identities for the dwelling capital stock (KDW) and rental consumption (CRE).

Price of Rental Consumption

$$
\begin{aligned}
\Delta \ln(PCRE) = a1 \times \Delta \ln\left(\frac{PCRE}{PCNR}\right) \\
+ a2 \times \Delta \ln(PCNR) \\
+ (1 - a2) \times \Delta \ln\big(PCNR(-1)\big) \\
+ a3 \times \Delta \ln\left(\frac{PMGS}{PD}\right) \\
+ a0 \times \left[\frac{(VACD - c1)}{VACD}\right] \\
+ s1 \times Q1 + s2 \times Q2 + s3 \times Q3 - (s1 + s2 + s3) \times Q4
\end{aligned}
$$

Results

Sample: 1977(3) to 1997(1)

Parameter	**Interpretation**	**Estimate**	**t-Statistic**
a_1	price of rents to non-rents	0.591	5.66
a_2	price of non-rents	0.192	2.04
a_3	price of imports to supply	-0.011	-0.57*
a_0	error correction	-0.004	-2.89
c_1	equilibrium vacancy rate	0.030	24.0
s_1	seasonal dummy	-0.001	-1.31*
s_2	seasonal dummy	0.001	1.37*
s_3	seasonal dummy	0.001	1.56*

Diagnostic Statistics

$R^2 = 0.99$
SE = 0.0028%
DW = 2.43*

* Indicates the test has failed at the 5% confidence level.

Rental Vacancies

$$
\begin{aligned}
VACD = {} & (1-b0)\times VACD(-1) \\
& + b2\times\left(\frac{CNRd}{CREd}-\frac{CNRd(-1)}{CREd(-1)}\right) \\
& + b0\times\left[c2+c0\times\left(\frac{PCNRd(-3)}{PCREd(-3)}\right)+c3\times RPMGST(-3)+c4\times\left(\frac{CNRd(-1)}{CREd(-1)}\right)\right] \\
& + s1\times Q1+s2\times Q2+s3\times Q3-(s1+s2+s3)\times Q4
\end{aligned}
$$

Results

Sample: 1979(4) to 1997(1)

Parameter	Interpretation	Estimate	t-Statistic
b_0	partial adjustment	0.277	3.63
b_2	shift in demand (ΔCNR)	-0.095	-1.83*
cdwsig	elasticity of demand	-0.295	-3.57
c_2	long run constant	0.030	24.0
c_3	relative import price	-0.034	-1.86*
c_4	demand shift	-0.207	-1.64*
s_1	seasonal dummy	-0.002	-4.15
s_2	seasonal dummy	0.001	1.29*
s_3	seasonal dummy	0.001	1.89*

Diagnostic Statistics

$R^2 = 0.92$
SE = 0.0024
DW = 2.17

* Indicates the test has failed at the 5% confidence level.

Dwelling Investment

$$\frac{IDW}{KDW(-1)} = \left(EXP(GR) - 1 + RKDDW\right) \times \left(1 - a_1 - a_2 - a_3 - a_4\right)$$
$$+ a_1 \times \left[\frac{IDW(-1)}{KDW(-2)}\right] + a_2 \times \left[\frac{IDW(-2)}{KDW(-3)}\right]$$
$$+ a_3 \times \left[\frac{IDW(-3)}{KDW(-4)}\right] + a_4 \times \left[\frac{IDW(-4)}{KDW(-5)}\right]$$
$$+ a_5 \times \begin{Bmatrix} aq0 \times \left(QDW - 1\right) + aq1 \times \left(QDW(-1) - 1\right) + aq2 \times \left(QDW(-2) - 1\right) \\ + aq3 \times \left(QDW(-3) - 1\right) + aq4 \times \left(QDW(-4) - 1\right) + aq5 \times \left(QDW(-5) - 1\right) \end{Bmatrix}$$
$$+ ad \times \left(DDEM(-2) - DNPAD(-2)\right)$$
$$+ s1 \times Q1 + s2 \times Q2 + s3 \times Q3 - (s1 + s2 + s3) \times Q4$$

where:

QDW=PCREt*(1-RTCRE)*XRCRE*(1-VACD)/PIDW

/{[(a6*RIGL+(1-a6)*RI90-FIE)/(1+FIE/100)]/400+RKDDW*(1+FIE/400)}

Results

Sample: 1978(1) to 1997(1)

Parameter	**Interpretation**	**Estimate**	**t-Statistic**
a_1	past investment	0.880	6.23
a_2	past investment	-0.035	-0.20*
a_3	past investment	0.086	0.36*
a_4	past investment	-0.141	-0.98*
a6	interest rate split	0.758	10.87
ad	demographic	0.097	2.90
aq0	Q-ratio	0.001	1.50*
aq1	Q-ratio	-2.13 -04	-0.21*
aq2	Q-ratio	9.18 -04	0.90*
aq3	Q-ratio	3.60-04	0.33*
aq4	Q-ratio	0.001	1.09*
aq5	Q-ratio	-6.44 -04	-0.69*
s1	seasonal dummy	-3.13 -05	-0.31*
s2	seasonal dummy	-7.69 -06	-0.06*
s3	seasonal dummy	7.62 -05	0.88*

Diagnostic Statistics

R^2 =0.97

SE = 0.0003

DW = 1.95

* Indicates the test has failed at the 5% confidence level.