The Indicator Role of Asset Prices

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Summary

Asset prices are included in the Bank’s ‘checklist’ of monetary indicators, which the Bank uses to assess the appropriate stance of monetary policy. The main reasons for including asset prices are twofold. First, theory suggests that asset prices contain useful information about market expectations of future real economic growth and interest rates (the asset’s ‘fundamentals’). However, price movements based on speculative market dynamics rather than on economic ‘fundamentals’ may well make it difficult to extract this information.

Second, asset price movements are also likely to have direct effects on consumption and investment expenditure via wealth and, possibly, liquidity, effects. The response of consumption and investment spending, however, will be sensitive to perceptions of the permanence of asset price movements.

This article concludes by investigating, by way of simple indicator models, statistical linkages between real equity and house price indices, and measures of real economic activity and inflation. Although the asset price variables are generally significant in explaining real activity and inflation, there are wide error margins associated with these indicator models. These results suggest that while asset prices may have some value as indicators, they are insufficiently precise or reliable to place great weight on for monetary policy purposes.

1. Introduction

In assessing the appropriate stance of monetary policy, the Bank monitors a broad range of indicators of inflation and economic activity. These include the exchange rate, interest rates, money and credit aggregates, inflation expectations, real economic activity variables, and asset prices.

This article focuses on the role and value of asset prices as indicators for monetary policy.

There are many reasons for including asset prices in the Reserve Bank’s ‘checklist’ of monetary indicators. First, as discussed in Section 2, standard asset pricing theory suggests that asset prices may contain information relevant to monetary policy formation. According to this theory, the price of an asset should reflect forward-looking assessments of economic growth and interest rates. Unfortunately, this information on key macroeconomic variables, or ‘fundamentals’, may be obscured by movements in asset prices which are based on speculative market dynamics (‘bubbles’).

The usefulness of asset prices as a policy indicator depends on distinguishing the two sources of movements in asset prices.

Second, macroeconomic theory suggests that asset price movements are also likely to influence current consumption and investment via wealth, and possibly liquidity, effects. These effects are discussed in Section 3. Wealth and liquidity effects will depend importantly on perceptions regarding the permanence of asset price movements, and this may relate to the ‘fundamentals’ ideas discussed in Section 2. For instance, strong sharemarket increases and subsequent falls in numerous Western countries during the second half of the 1980s, may have been perceived as impermanent ‘bubble’ behaviour. This may explain why consumption expenditure was affected less than might otherwise have been expected.

Third, asset prices can affect consumer price indices in a very direct manner. This was the case for the price of existing houses until the last quarter of 1993. However, existing house prices are no longer in the CPI regimen, although it is still important to assess the way in which existing house prices might affect the current housing component of the CPI, e.g., the purchase and construction costs of new homes, and private sector rentals.

Finally, asset prices in the form of equity prices, like the exchange rate and interest rates, are financial market prices. Such prices, unlike most other indicators, are observable on a virtually continuous basis. This timeliness enhances the ability of equity prices to provide leading information on other variables - including the case where

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1 For practical purposes, the Bank monitors asset prices in the form of equity (stock market) and house price indices. However, much of the discussion in this article is applicable to other forms of wealth, including physical and human capital.

2 Moreover, there may also be a tendency for asset prices to ‘overshoot’ in a manner similar to exchange rate overshooting. See Blanchard (1981).

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equity prices may have more of a contemporaneous association with other variables.

The discussion in Sections 2 and 3 suggests that (real) asset prices will be more useful in providing information about real economic activity, rather than inflation directly. Section 4 describes investigations into simple indicator models which seek to explain real activity and inflation using asset price information. Asset price links to inflation are likely to be mainly through effects on real expenditure in conjunction with capacity constraints.

2. Asset prices and ‘fundamentals’

(a) Fundamentals and asset pricing theory

The idea that asset prices should reflect important forward-looking information, especially about future economic growth, springs from standard asset pricing theory. One proposition of this theory is that the price of an asset should equal the present discounted value of expected future returns from the asset. Returns depend on the type of asset, but usually take the form of profit/dividends, interest receipts, rental income, redemption/terminal value, and capital gains. The rate at which future returns are discounted to the present, is known as the discount rate, or the required rate of return on the asset. This rate usually incorporates any risk associated with the asset’s returns, and different rates are likely to apply at different distances into the future. Expected future returns and discount rates are described as the asset’s ‘fundamentals’.

The second proposition of asset pricing theory suggests that the rate of return (yield) on all substitutable assets should be equal, after adjusting for risk. This explains why riskier assets such as shares, typically have a higher expected yield than do relatively risk-free assets such as government bonds. A higher expected yield is necessary to compensate for the greater risk of the asset.

According to standard asset pricing theory, higher growth expectations should raise asset prices. This arises from the tendency for higher growth to be reflected in higher profits and dividends (in the case of equity), raising the present value of claims on those profits.

Conversely, higher expected interest rates will tend to lower asset prices. This is because discount rates are closely associated with interest rates on competing, low risk financial assets (e.g., government securities). Therefore, higher expected interest rates are likely to increase expected discount rates, which lowers the present discounted value of future returns. Equivalently, if the return on risk-free government bonds rises, then there is likely to be a purchasing shift in favour of risk-free assets. This increases the price of risk-free assets and decreases the price of other assets (which were initially overpriced compared to government bonds). This process will continue until the prices of risk-free and all other assets adjust so that risk-adjusted yields are equal across all assets. Changing interest rates may also affect asset prices indirectly, via their effects on the outlook for growth and therefore the outlook for returns.

As discussed in Appendix 1, there are likely to be events which influence ‘fundamentals’ without necessarily affecting expectations about economic growth and interest rates. For example, a change in taxation policy may change expected returns but not expected economic growth. Increased risk aversion and/or a greater expected variability in returns (with expected returns unchanged), may increase expected discount rates without affecting expected risk-free interest rates.

(b) Fundamentals versus bubbles

In line with asset pricing theory, it seems possible to deduce information about expected real returns and economic growth, using information on real asset prices and discount rates. For instance, if the real price of assets rises, and expected real discount rates are unchanged, then it may be inferred that higher real returns are expected. This may well reflect higher expected real economic growth.

As indicated earlier, however, asset prices are likely to be driven not just by ‘fundamentals’ but also by speculative market forces. The existence of ‘bubbles’ complicates the task of distilling information that real asset prices may contain about expected growth rates of real activity/re-

3 Appendix 1 provides standard formulae for both nominal and real (inflation-adjusted) asset prices. Equation [1] suggests that it is a yield curve, rather than a single discount rate, which is more appropriate for discounting purposes. See Chapple (1994) for a discussion of yield curves.

4 Expected capital gains should be based on fundamentals, otherwise ‘bubble’ behaviour is present. See Stiglitz (1990).

5 Risk is usually some measure of expected variability of the asset’s returns.

6 Bubbles have many interpretations, but generally describe movements in asset prices which are not based on underlying fundamentals.

7 Flood and Hodrick (1990) highlight the (econometric) problem of separating bubble movements from the possibility that the underlying fundamental model is misspecified.

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Figure 1 shows recent movements in real equity and house price indices. After a period of negative and then negligible growth over much of 1990-92, these asset prices have shown relatively strong growth over 1993 and the early part of 1994. More recently, growth in asset prices has shown signs of moderating. Figure 1 also highlights the significantly greater volatility in equity prices compared to the volatility in house prices (note that the left-hand scale, for equity prices, covers five times the range of the right-hand scale for house prices). Consistent with standard asset pricing theory, this probably reflects relatively more volatility in the expected returns to equity.

A typical approach to distinguishing movements based on fundamentals from movements which are bubbles, is to attempt to justify asset price movements in terms of fundamentals. Figure 2 displays a simple illustrative attempt to explain New Zealand real equity price movements in terms of fundamentals. A ‘fundamental asset price’ is generated by equation [4] which is described in Appendix 1, and requires data on expected real return growth and discount rates. Real growth expectations are approximated by a 12-quarter moving average of past annual GDP growth rates. The real discount (interest) rate is derived from the 5-year government bond rate, and average expected inflation for the five year horizon which is represented by a 4-quarter moving average of past inflation. This then allows a comparison of actual to (an approximation of) a ‘fundamental’ real equity price. Both the actual and fundamental asset prices are normalised at the second quarter of 1992, although this point is arbitrary and does not much affect the general movement of the ratio of the prices.

A tentative conclusion from Figure 2 is that there appears to be a strong cycle causing actual equity prices to swing up and down in relation to a rough approximation of a fundamental price - although the ratio has displayed relatively less volatility in the last few years.

There are two interpretations of the cyclical behaviour shown in Figure 2, and these highlight the difficulty of separating asset price movements based on fundamentals and movements that are bubbles. The first interpretation is that, although asset prices are likely to revert to fundamentals in the long run, bubble behaviour causes deviations from fundamentals in the short run. This interpretation is consistent with the findings of Cutler, Poterba, and Summers (1990) who conclude that ‘bubble-like’ movements in asset prices seem inherent and due to a speculative feedback effect (‘speculative dynamics’). Likewise, Blundell-Wignall and Bullock (1992) test for a long-term (co-integrating) relationship between share prices, profits, and the return on bonds. The hypothesis of long-run reversion to fundamentals could not be rejected, and tests also revealed the presence of ‘speculative dynamics’. Finally, French and Poterba (1991), were unable to isolate changes in fundamentals which could explain the run-up and decline of Japanese equity value and price-earnings ratios. Bubble behaviour is often assigned to the component of asset price movements which cannot be explained by movements in fundamentals.
The other interpretation of the cyclical movements shown in Figure 2, is that the approximations of the ‘true’ fundamentals are inaccurate. That is, the proxies for expected real return growth and discount rates, which were described earlier, do not track closely enough the actual, but unobservable, market perceptions of the fundamentals which are determining asset prices. There are also likely to be problems in finding a robust formula for calculating an asset price based on fundamentals. Along these lines there are many studies which have focused on the specification or interpretation of fundamentals, in order to explain purported bubble behaviour. Garber (1991), for example, proposes market fundamental explanations for three famous episodes of ‘bubbles’.

In summary, according to asset pricing theory, real asset prices contain potentially useful information about expected future real returns, which are likely to be highly correlated with expected real economic growth. However, real asset prices also reflect real discount (interest) rates, and probably bubble behaviour as well, both of which are difficult to isolate. The existence, let alone the calculation, of bubble movements, and the appropriate definition of real discount rates, are contentious issues which severely complicate extraction of information about expected real growth and real interest rates from asset prices.

3. Wealth and liquidity effects

Whereas Section 2 discussed the possible information content of asset prices, this section looks at the channels through which asset prices—whether driven by fundamentals or by speculative activity—might have direct effects on the economy.

(a) Wealth effects

Wealth effects have traditionally been considered the most important link from asset markets to the real economy and inflation. When (real) asset prices change, there is likely to be a change in the asset holder’s evaluation of (real) wealth holdings. Increases in wealth can be a source of increased future income, both through increased future real returns, and through an increased ‘liquidation’ value of the asset. However, the extent to which current expenditure will change as a result, will depend on how permanent the new wealth level is perceived to be. If wealth changes are perceived as temporary there is likely to be a negligible effect on expenditure. By contrast, wealth changes which are seen by the asset holder as long-lasting, will probably induce greater expenditure responses. This relates quite strongly to ideas of ‘fundamentals’ versus bubble behaviour. The more that asset price movements are perceived to be based on fundamentals, the bigger the wealth effect is likely to be. Consumption and investment spending are the typical categories of expenditure which respond to changed perceptions of real wealth.

As described in the Section 1, consumption responses to equity price movements during the mid 1980s may well

8 These were the Dutch tulipmania (1634-37), and the Mississippi and South Sea bubbles (1719-20).
suggest that the movements were, to some extent, seen as impermanent and/or not based on fundamentals. The extent to which asset price movements affect consumption is potentially very important for monetary policy, particularly since consumption comprises the majority of expenditure in the economy. Steindel (1992) suggests that in the United States, the wealth effect on consumer spending has weakened. This is thought to be a reason why consumption models, which include a wealth variable, over-predicted consumer spending in the United States for the early 1990s.

Consumption responses to changes in wealth, reflect the permanent income theory of consumption. This theory suggests that consumers spend a stable proportion of average expected income, rather than current income. Increases in ‘permanent’ real wealth adds to future average income, and should therefore increase current consumption - even though current income may not have changed. This suggests that increases in wealth are likely to be associated with a lower personal savings rate. Fisher (1992) finds evidence of such a relationship for the United Kingdom. He claims that most of the fall in the private savings rate between 1985-87, can be explained by increased wealth/permanent income.

The permanent income concept is also applicable to investment spending. For example, a firm which experiences an increase in the value of its assets, may be inclined to invest more of its retained earnings in new capital equipment. Again, the response depends on how transitory the asset price change is expected to be.

There are some asset price effects which are specific to investment spending. In particular, increases in equity prices will lower the cost of raising equity finance. Higher equity prices will also make it more costly to obtain physical capital by purchasing claims on existing capital. This increases the incentive to obtain real capital assets through new real investment. These mechanisms reflect the standard ‘Q’ theory of investment, which suggests that new investment is spurred when the (marginal) stockmarket value of a capital asset is greater than the (replacement) cost of the capital asset in the goods market.

(b) Liquidity effects

An additional channel through which changes in asset prices may influence consumer spending is through liquidity effects on the demand for, and supply of, credit.

On the demand side, the basic argument for liquidity effects is that, regardless of their expected permanent incomes, many consumers may be constrained in their ability to borrow and spend by lack of collateral to back borrowing. Changes in asset prices, by affecting the value of collateral, may affect access to credit and, ultimately, spending behaviour. Figure 3 shows the relationship between a nominal house price index and nominal private sector credit in New Zealand. There is evidence of an association between the general trends in house price growth and credit growth. The relationship appears generally contemporaneous, especially over the last few years. However, there are occasions where changes in house price growth have led changes in credit growth, e.g. 88Q2-Q3, 90Q1-Q2, 93Q2-Q3.

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Financial liberalisation in many industrial countries, including New Zealand, during the 1980s is often viewed as a period of private balance-sheet adjustments. Private borrowing surged in order to adjust debt to income ratios to desired levels. The spending associated with increased rates of credit growth, fuelled economic growth, which was soon reflected in higher asset prices. Higher asset prices provided the collateral against which further borrowing and spending could occur. This self-reinforcing process was thought to have created high levels of indebtedness, and to have pushed asset prices beyond levels justified by fundamentals.\footnote{Wealth effects, and borrowing to take advantage of expected capital gains in asset prices, were likely to have exacerbated this self-reinforcing process.}

After strong increases, numerous asset prices, in many industrial countries, displayed substantial declines. For example, significant boom/bust cycles in commercial and residential property prices, and equity values, were seen in many industrial countries during the late 1980s and early 1990s.\footnote{BIS (1993) emphasise these boom/bust cycles, and discuss their relation to the economic performance of many countries.} Falling asset (collateral) values are likely to increase the net liabilities of the private sector. For example, in the early 1990s, house prices fell substantially in many areas of the United Kingdom. This left many homeowners with mortgages in excess of the market value of the house - a situation which was termed 'negative equity'. Increases in net liabilities may affect expenditure because of periods of balance-sheet restructuring in the private sector. This involves higher rates of debt repayment in order to reduce net liabilities. 'Negative equity', for instance, was considered by Fisher (1992) to be a factor in the adverse performance of the U.K. economy, particularly consumption, during the early 1990s. Others consider increased net liabilities not to have had much effect on expenditure. For example, Longworth and Poloz (1992) find that Canadian consumption was not much affected by households trying to repay debt.

The rise and then fall of many asset prices across many countries, may also have had effects on the supply-side aspects of credit. When asset prices were increasing, lending may have been based on 'inflated' asset values. Blundell-Wignall and Bullock (1992) suggest that there was excessive lending related to asset prices in Australia during the late 1980s. Decreasing asset prices have the effect of lowering the capital reserves of lending institutions. Hence, asset price falls were thought to have created financial fragility with the effect of slowing credit growth. This point is emphasised by Blundell-Wignall and Bullock (1992), who note the marked slowing of credit growth in Australia following asset price declines at the end of the 1980s. Supply-side 'credit crunches' were argued to have occurred in the United States, as financial intermediaries became much more cautious in their lending in order to restore their own balance sheets.

Because of wealth and liquidity effects, asset prices may play an important role in the transmission of monetary policy to economic activity and inflation. This is because monetary policy has the ability to influence interest rates and the outlook for economic growth, in the short-term at least, both of which are closely associated with asset price fundamentals. The ability to influence asset prices by influencing 'fundamentals', gives monetary policy the potential to affect expenditure growth through the wealth and liquidity channels which were described in this section.

Of course, asset price fundamentals are affected by many things apart from monetary policy. For example, real interest rates, especially long-term, are heavily influenced by international interest rate developments. The outlook for returns/profit growth is likely to be affected by fiscal policy (government spending and taxation), the wage bargaining regime, management changes, technological and productivity changes, competition policy, terms of trade shifts, and so on.

4. Indicator models

Sections 2 and 3 outlined theory as to why asset prices might be useful for monitoring and forecasting purposes. Whether reflecting forward-looking fundamentals, or exerting direct effects on expenditure through wealth and liquidity channels, asset prices appear to have potential use as indicators of real economic activity. Links between asset prices and inflation are likely to be indirect, depending on the relationship between activity and inflation.

This section outlines investigations into statistical linkages between asset prices and real activity/inflation\footnote{Technical details are contained in Appendix 2.}. Such associations may be useful in forming simple 'indicator models', which can then be used to help monitor and forecast real economic activity, and perhaps inflation.

(a) An indicator model for real activity

Many studies have emphasised the usefulness of asset price variables in explaining real economic activity. For
example, Fisher and Merton (1984) find real stock market growth to be highly significant in predicting growth in real GNP and its components, at least for the United States. Doan et al (1983) also find equity information to be good at forecasting GNP movements.

The development of a simple indicator model for real activity is as follows. The first step tries to explain a real activity variable solely in terms of its recent history. Then real asset prices in the form of a real equity (stockmarket) index and a real house price index, are added to determine whether they provide additional explanation of real economic activity. Finally, the importance of other variables in explaining real activity is considered, as well as the effects that these other variables have on the relative importance of the asset price variables.

The variable used to represent real economic activity is the broad (quarterly) measure of seasonally-adjusted real Gross Domestic Product (GDP). Production-based GDP was chosen, rather than expenditure-based GDP, since the former is less volatile and generally considered to be more accurate for New Zealand.

Although models for annual GDP growth were tried, the emphasis was on a model explaining quarterly GDP growth. Annual growth rates will usually have new (implicit) information only about the latest quarter, since the growth rates for the previous three quarters is typically already known. A quarterly growth rate model directly models extra (marginal) information about real activity.

The model is estimated over the period 1985Q1 to 1994Q1. This reflects the probable, and actual, difficulty of finding robust statistical relationships over longer sample periods, given the various credit and interest rate controls prior to 1985. The theory outlined in sections 2 and 3 emphasises the link between (flexible) interest rates and wealth, especially in the sense of monetary policy having the ability to influence interest rates. Models estimated over longer sample periods sometimes indicated a ‘structural break’ around 1984/5, and invariably broke down when the sample period started in 1985. For these reasons it was decided to model ‘post-1984’, a period with a flexible interest rate regime.

Initial results showed that GDP growth is not well explained by previous rates of GDP growth. This underscores the difficulty in modelling quarterly, as opposed to annual, GDP growth, but is consistent with the fact that a quarterly growth model isolates only the ‘extra’ information about GDP.

Equity and house price indices were found to be significant in explaining quarterly GDP growth when added as explanatory variables. GDP growth is positively associated with (quarterly) equity and house price growth in the preceding quarter, and also with equity price growth in the quarter before that. In other words, asset price movements are associated with expenditure movements over the following few months. This is consistent with both the ‘information value’ and wealth/liquidity theories about asset price links with expenditure.

The coefficients for the asset price variables in the indicator model, suggest that house price growth has a greater ‘weight’ than equity price growth in terms of its association with GDP growth. That is, if equity and house price growth each changed by one percentage point, the latter would have a greater impact on GDP growth. According to the theory, this suggests that wealth and/or liquidity effects are stronger than the information content asset prices might have about GDP growth. This is because, although both equity and house prices should be affected by interest rate changes, the equity index is likely to be more sensitive to the growth outlook. This seems to be corroborated by the higher volatility of the equity price index. Therefore, the higher coefficient on house price growth is more likely to be due to its wealth/liquidity effects on expenditure. This is consistent with the fact that the total value of the housing stock is much greater than that of the stockmarket, and that people are more likely, and able, to borrow against housing value.

Section 2 suggests that asset prices should reflect information about expected returns and discount rates. Separate tests confirmed a general negative association of real interest rates and asset prices, although more for equity prices than for house prices. Various proxies for the ‘fundamentals were added to the model but were not very significant, and did not much affect the significance of the asset price variables. This may highlight the fact that asset prices are reflecting useful information about fundamentals - information for which it is hard to find accurate proxies.

International integration of goods and capital markets is likely to have increased the sensitivity of the New Zealand stock market movements to movements in certain overseas stock markets. Since 1985, about two thirds of the variation in the New Zealand stock market price index can be explained by movements in United States and Australian equity prices. Associations are probably due to the tendency for international real interest rates to move in similar ways, coupled with the link between interest rates and asset prices. When substituted for the New Zealand equity index, an Australian stock market series showed some significance in explaining New Zealand GDP growth. However, this caused on overall deteriora-

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12 This is consistent with the findings of Griffiths (1993).
tion in the indicator model. In particular, the New Zealand house price index lost a significant amount of explanatory power. When the Australian equity index was included with the New Zealand equity and house price indices, it showed no significance.\(^{13}\)

The final form of the simple indicator model is given in Appendix 2. Although the equity and house price variables are statistically significant in explaining GDP growth, the overall indicator model has a high standard error. This means that predictions of GDP have big margins for error, such that the model, at this stage, is unlikely to alter the importance of asset prices within the 'checklist' of monetary indicators. However, further research may well lead to improved indicator models for real activity.

Further variables could be added, such as a real exchange rate, overseas growth rates, the terms of trade, and fiscal variables. This develops the model into a more general aggregate demand equation, which is based on structural relationships suggested by standard macroeconomic theory. This is different to simple indicator models, which exploit close correlations but do not purport to infer causal relationships. Section 3 indicates that asset prices might well be useful as indicators of the consumption and investment components of real expenditure. Also, the significance of asset prices may indicate that these variables will be useful as 'wealth variables' in standard consumption and investment equations.

(c) An indicator model for inflation?

Sections 2 and 3 do not provide any theoretical justification for a direct link between real asset prices and inflation. As an empirical matter, Shiller and Beltratti (1992) find that changes in stock prices show little correlation with changes in inflation rates in the United States or United Kingdom, a result which they see as consistent with asset pricing theory. Lee (1992) also finds stock returns of little use in explaining variations in inflation, using post-war United States data. Despite this theory and evidence, and for whatever reasons, real asset price variables are usually significant, albeit marginally, in explaining various measures of inflation for New Zealand.

An inflation indicator model, essentially similar to the previously described activity indicator model was tested. The sample period was from 1985 onwards, and measures of inflation were based on the CPI (excluding GST effects). These measures were: annual inflation; quarterly inflation; and the absolute change in quarterly inflation (all in percentage terms). All inflation measures were partly able to be explained by past values of inflation. Lagged values of quarterly growth in real equity prices were generally significant\(^{14}\), and had positive associations with inflation. Lagged values of quarterly real house price growth were typically significant, but contemporaneous house price growth showed a significant negative association with inflation in all three variants on the model.

Despite some significance of real asset price variables in explaining various measures of inflation, the simple inflation indicator model suffers the same problem as the real activity indicator model - high margins for error. This compromises the precision of any predictions that the model makes. Thus, further research is necessary before these rudimentary indicator models for inflation become of much importance for policy purposes. One possibility, for example, would be to estimate models explaining measures of underlying inflation. This is in the spirit of using seasonally-adjusted GDP, in that it provides a better indication of ongoing rather than 'one-off' episodes of inflation.

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13 Similar results were obtained when a United States equity index was used as either a substitute for, or a supplement to, the New Zealand equity price index.

14 Although this usually required a high (>10%) level of significance. However, these variables improve the overall quality of the model.
Appendix 1

This appendix supplements the discussion of Section 2 by providing standard asset pricing formulae (and includes the treatment of agents’ risk preferences).

Nominal asset price

\[
A_t = E_t \left\{ \frac{D_t}{(1+R_t)} + \frac{D_{t+1}}{(1+R_t)(1+R_{t+1})} + \ldots \right. \\
\left. + \frac{D_{t+n}}{(1+R_t)(1+R_{t+1})\ldots(1+R_{t+n})} \right\} [1]
\]

\[
= E_t \left\{ \sum_{j=0}^{n} \frac{D_{t+j}}{\prod_{k=0}^{j} (1+R_{t+k})} \right\} [2]
\]

where;
- \(A_t\) = the asset’s nominal price at the start of period \(t\).
- \(D_t\) = the nominal return at the end of period \(t\).
- \(R_t\) = the nominal discount rate applicable during period \(t\).
- \(n\) = the life (or term) of the asset.
- \(E_t\) = the expectations operator

Real asset price

\[
a_t = E_t \left\{ \sum_{j=0}^{n} \frac{d_{t+j}}{\prod_{k=0}^{j} (1+r_{t+k})} \right\} [3]
\]

where lower case letters denote the real (inflation-adjusted) values of the corresponding upper case letters.

Risk preferences

The discount rates in the above formulae can be interpreted as the required rate of return for the asset. These rates will therefore reflect both the uncertainty/risk surrounding expected returns, and agents’ risk preferences. The required rate of return will equal the ‘risk-free’ rate of interest if there is complete certainty regarding the asset’s returns, and/or if an agent is risk neutral. Risk neutral agents are concerned only with expected returns, no matter what the anticipated variance of the returns might be.

It is more usual to assume that agents are risk averse, i.e., they require a risk premium to compensate for the variance (risk) of returns. Greater uncertainty about asset returns, and/or greater aversion to any level of risk, can therefore increase the discount rate, independent of the risk-free interest rate. If general uncertainty of asset returns and overall degrees of risk aversion are stable, then there is likely to be a strong relationship between movements in risk-free rates of interest and movements in discount rates.

Real asset pricing formula for Figure 2

\[
a_t = d_t \frac{(1+g_t)/(r_t-g_t)} [4]
\]

[4] is the result of making the following simplifying assumptions about [1]:
- real returns, \(d_t\), are perpetual (\(n = \infty\)), and grow at rate \(g_t\).
- the ratio of \(r_t\) and \(g_t\) is constant, and \(r_t > g_t\) (stability condition).
Appendix 2

This appendix supplements the discussion of Section 4 by providing technical/statistical details of the econometric investigations.

Econometric estimation was primarily by OLS using PCGive version 8.0, although recursive least squares estimation was used to analyse parameter stability.

All variables appearing in the models are assumed to be stationary - tests for unit roots were not performed. As most of the variables are in terms of real growth rates, it was assumed that these variables were integrated of order zero.

The use of quarterly growth variables helped avoid any multicollinearity problems with using annual growth rates when the data are quarterly.

Real equity and house price indices were a result of deflating nominal indices by the CPI (excluding the one-off effects of GST)

Seasonal adjustment was applied to 'raw' production-based GDP using STAMP software.

YZ = quarterly percentage growth rate in seasonally-adjusted (production-based) New Zealand GDP.

EQ = quarterly percentage growth rate in real New Zealand equity index.

HP = quarterly percentage growth rate in real New Zealand house price index.

INF = quarterly percentage growth rate in the CPI (excluding GST effects).

Indicator model for quarterly GDP growth:

Dependent Variable: YZ

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<th>Explanatory Variable</th>
<th>Coefficient</th>
<th>t-Statistic</th>
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<tr>
<td>EQ [-1]</td>
<td>0.0339</td>
<td>3.579</td>
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<tr>
<td>EQ [-2]</td>
<td>0.0191</td>
<td>2.071</td>
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<tr>
<td>HP [-1]</td>
<td>0.1635</td>
<td>2.075</td>
</tr>
<tr>
<td>Constant</td>
<td>0.0030</td>
<td>2.627</td>
</tr>
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</table>

R-squared = 0.411
n = 37
F(3,33) = 7.6908 [0.0005]
d.o.f. = 33
S.E.R. = 0.67%
DW = 2.23

Normality of residuals: Chi-squared (2) = 0.88025 [0.6440]
Sample Period: 1985Q1 to 1994Q4.

[-n] denotes that the variable is lagged n periods.
Indicator model for quarterly inflation:

Dependent Variable: INF

<table>
<thead>
<tr>
<th>Explanatory Variable</th>
<th>Coefficient</th>
<th>t-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>INF [-1]</td>
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<td>11.652</td>
</tr>
<tr>
<td>EQ [-1]</td>
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<td>EQ [-2]</td>
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<td>Constant</td>
<td>0.0018</td>
<td>1.236</td>
</tr>
</tbody>
</table>

R-squared = 0.841  \quad F(5,31) = 32.866 [0.0000]  \quad \text{S.E.R.} = 0.53%  
\quad n = 37  \quad \text{d.o.f.} = 31

AR(1): Chi-squared (1) = 3.2874 [0.0698]  
Normality of residuals: Chi-squared (2) = 1.1334 [0.5674]  
Sample Period: 1985Q1 to 1994Q4.

{-n} denotes that the variable is lagged n periods.


