FUNDAMENTAL SHARE PRICES AND AGGREGATE REAL OUTPUT

by

Nicolaas Groenewold*

Department of Economics
The University of Western Australia

DISCUSSION PAPER 00.05

* I would like to thank Pat Fraser for helpful comments on a previous draft.
Abstract
This paper analyses the interrelationships between the share market and the macroeconomy within the framework of a structural vector autoregressive (SVAR) model. The model has just two variables - share prices and real output - and uses a distinction between temporary and permanent shocks to identify macroeconomic and share market-shocks. The identification scheme is similar to that used in macroeconomics by Blanchard and Quah (1989). We use the estimated model to examine the dynamic interaction between the two variables. We go on to use it to compute a fundamental share-price series based on the assumption that fundamentals are driven by real macroeconomic forces.
INTRODUCTION

Both economists and finance specialists are giving increasing attention to the relationship between the share market and the rest of the economy. There can be little doubt about the growing importance of the share market from the point of view of the aggregate economy. In Australia the ratio of share-market capitalisation to GDP has approximately tripled in the last 25 years – from less than 30% in the mid-1970s to over 80% in the late 1990s. Not only has the share market increased relative to the real economy, but it appears that the inter-relationship between them has strengthened. It has always been recognised that the share market reflects to some extent the goings on in the rest of the economy but recently there has been widespread recognition that the influence is also in the opposite direction – dramatic events in the share market are likely to have an impact upon the real economy.

There are various ways in which the share market and the macroeconomy have been related in the literature. One approach has been from a asset-pricing perspective in which the Arbitrage Pricing Theory (APT) was used as a framework to address the question of whether risk associated with particular macro variables is reflected in expected asset returns; examples include the original work by Chen, Roll and Ross (1986) who applied the model to the US as did Chen and Jordan (1993), Beenstock and Chan (1988), Clare and Thomas (1994) and Cheng (1996) all of whom analysed UK data, Ariff and Johnson (1990) using data for Singapore, Martikainen (1991) for Finland and Groenewold and Fraser (1997) for Australia. A closely-related analysis is that of the consumption-CAPM which concentrates on a single macro influence, the growth of aggregate consumption; see, e.g., Breeden (1979) and Grossman and Shiller (1981).

The direction of influence underlying the asset-pricing literature is the traditional one – from the economy to the share market. A similar focus is found in the literature which explores the response of aggregate share prices to the (expected) inflation rate; early work carried out in this area is by Bodie (1976), Fama and Schwert (1977), Jaffe and Mandelker (1976) and Nelson (1976) whereas more recent applications include those by Balduzzi (1995), Graham (1996) and Groenewold, O’Rourke and Thomas (1997). Similar studies assess the response of the share market (often, but not always, at an aggregate level) to other macro variables such as those governed by monetary policy and fiscal policy.
An alternative to this direction of influence from the economy to the share market is to analyse the effects of share prices on the macroeconomy or selected macroeconomic variables. A relationship of this nature which has received considerable attention is that between share prices and investment (in the sense of capital formation). Studies of this type start with Tobin’s q-theory of investment (Tobin, 1969) and also include Fischer and Merton (1984), Morck, Shleifer and Vishny (1990), Blanchard, Rhee and Summers (1993) and Chirinko and Schaller (1996). The question in that literature is whether firms, in making investment decisions should or do pay any heed to share prices or whether share prices are simply a veil which can be dispensed with when making decisions about real variables such as investment.

More recently, empirical models without any specific theoretical structure have been applied in a more pragmatic fashion to the two-way relationship between share prices and macroeconomic variables. The vector auto-regressive (VAR) model has been particularly popular in this area given that it can be used as a framework for formal examination of inter-relationships within a given data set without the need to specify a theoretical framework a priori. Once estimated, the model can be used to simulate the effects of shocks in a way that is consistent with the data by the use of impulse response functions and forecast-error-variance decomposition.

A relatively early application of the VAR model to the analysis of the relationship between share prices and the macroeconomy is by Lee (1992) and more recent ones can be found in Cheung and Ng (1998) and Gjerde and Saettem (1999). Both the Lee and Gjerde and Saettem papers are specified in terms of variables which have been transformed so that they are stationary. It is well known that this involves a potential loss of information if the variables are cointegrated. The paper by Cheung and Ng finds cointegration in the levels of the variables and takes this into account by estimating a closely related model, the vector error-correction model (VECM).

The VAR analysis is useful for the simulation of the effects on the endogenous variables of shocks to equation error terms. However, given the non-theoretical nature of such models, the interpretation of such shocks is difficult. An extension of the VAR model (the structural VAR or SVAR) imposes theory-based restriction on the VAR to enable the identification of the errors terms. Variants of the SVAR model have been extensively used in macroeconomics. We use such an extension in this paper and base our restrictions on the work of Blanchard and Quah (1989) who use their model to decompose movements in real output and the rate of unemployment into those driven by aggregate demand and supply shocks.

To formulate our restrictions, we take the view that ultimately share prices reflect the value of economic activity although they will clearly be subject to other influences as well. We therefore distinguish between two different shocks in our model. The first is a macroeconomic shock which has permanent effects on both real output and share prices. The second is a share-market shock which may affect output but not permanently and will affect share prices, possibly permanently.1

We simulate the effects on both variables of each of these two shocks. We then go on to use this identification scheme to decompose the share price variable into fundamental and non-fundamental components, identifying the former with the accumulated effects of past and present macro shocks. This decomposition allows us to compare our results to those in recent work on the decomposition of share prices into fundamental and non-fundamental components by, e.g. Lee et al. – see Lee (1995, 1998), Chung and Lee (1998) and Hess and Lee (1999). Lee’s work is also carried out using a VAR framework but he uses share prices and dividends rather than share prices and macroeconomic variables and he bases his restrictions on the log-linearised dividend-discount model of Campbell et al. – see Campbell and Shiller (1987, 1988) and Campbell and Ammer (1993).

The structure of the paper is as follows. In section II we briefly set out the Blanchard and Quah version of the SVAR model. In the following section we present our data, paying particular attention to the questions of stationarity and cointegration since these properties will determine the form of the model. In section IV we discuss the specification of the VAR and present some model diagnostics. Results are reported in section V and conclusions are drawn in the final section.
II THE SVAR MODEL

We will consider a model in two variables, a real share-price index, \( s \), and real output, \( y \). Suppose that we can write a structural model relating the two as:

\[
B(0)\varepsilon_t = b_0 + B(L)\varepsilon_{t-1} + \varepsilon_t,
\]

where \( L \) is the lag operator, \( L, = L_{t-1} \) and

\[
B(0) = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}, \quad b_0 = \begin{bmatrix} 0 \\ 0 \end{bmatrix}, \quad \varepsilon_t = \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix}
\]

\[
B(L) = B(1) + B(2)L + B(3)L^2 + \ldots + B(p)L^{p-1}
\]

We interpret \( \varepsilon_1 \) as a real share-market shock and \( \varepsilon_2 \) as a real macroeconomic shock and we wish to use (1) to compute a decomposition of \( s \) into two components, the first associated with shocks to the real economy and the other with shocks to the share market. As explained in section II, we call the share price component driven by the macro shock the fundamental share price. We can therefore compute the fundamental share price index by simulating the model with the first shock set at zero while the second takes its historical value.

The simulation uses the vector moving-average (VMA) form of the model:

\[
\varepsilon_t = \varepsilon_0 + C(L)\varepsilon_{t-1}
\]

where \( C(L) = (B(0) - B(L)L)^{-1} \) and \( \varepsilon_0 = C(L)\varepsilon_0 \).

To compute the simulations we need estimated versions of the \( C \) matrices in (2). These cannot be derived from (1) since this system is not identified, the two equations being observationally equivalent. Instead we estimate the standard reduced-form VAR:

\[
\varepsilon_t = \varepsilon_0 + A(L)\varepsilon_{t-1} + \varepsilon_t
\]

A comparison of (1) and (3) shows that the coefficients of the two systems are related by \( A_0 = B(0)^{-1}b_0 \) and that the errors are related by \( \varepsilon_t = B(0)^{-1}\varepsilon_t \).

Clearly, once we know \( B(0) \) or \( C(0) = B(0)^{-1} \) we can move from the estimated reduced-form VAR to an estimated version of the structural MA which we need for simulation.
III DATA

The two variables in our model are real GDP and a real share price index. The share price index used is the All Ordinaries Index for the Australian Stock Exchange (ASX). The ASX also publishes an accumulation index which accounts for dividends as well as price changes and we would have preferred to use this but it is available for only a relatively short period. Experimentation with both series over a common sample period indicates that their time-series properties are very similar which is consistent with findings elsewhere that the intertemporal behaviour of the accumulation index is almost completely determined by its price component.

The price index was converted to a real series by dividing by the implicit deflator for GDP. Data for GDP and the deflator are available only at a quarterly frequency so that the share price index was also converted to quarterly form by averaging monthly figures which were themselves averages of daily closing figures. Real GDP is seasonally adjusted and the sample period is 1959Q4-1999Q1. The data were taken from the Reserve Bank of Australia Bulletin section of the dX EconData database.

Both variables were used in log form. First differences of the logs of the variables are displayed in Figure 1. Clearly real output is considerably less volatile than real share prices. This is reflected in the summary statistics for the two variables reported in Table 1. Even though real share-price growth has a mean which is about a third of real GDP growth, its variance is over 30 times as large. The skewness and kurtosis statistics indicate that there are deviations from normality in both variables so that tests based on the normal distribution will not be strictly valid. This is not likely to be a serious problem in this paper since the focus on model simulation and the decomposition of share prices rather than on hypothesis-testing per se. The final statistic in the table shows that there is evidence of autocorrelation in the growth of real output but not in real share price changes (as the Efficient Markets Hypothesis would predict).

Before specifying the model, we examined both variables for stationarity. The results are reported in Table 2. We first examined the variables in the (log) levels. The ADF and PP tests are t-type tests of the significance of $y_{t-1}$ in the regression of the first difference of $y$ on a constant, a trend term (in the case where a trend is indicated), $y_{t-1}$ and lagged first difference terms in the ADF case. The number of lagged first difference terms in the case of the ADF tests are chosen to remove the autocorrelation in the error process while the PP test makes an alternative adjustment for autocorrelation. Both tests indicate clearly that the non-stationary null hypothesis cannot be rejected for either variable. In both cases the results are insensitive to the number of lags used. These outcomes are confirmed by the KPSS test which tests the null hypothesis of stationarity against the alternative of non-stationarity. In this case, too, the results are insensitive to lag length. The graphs of the data indicate that the real share price index in particular may have been the subject of one-time shifts during the sample period. The shifts are particularly noticeable in the early 1970s and in 1987, the former probably associated with the rapid and unexpected rise in inflation starting in about 1973 and the latter associated with the stock market crash of October 1987. Since Perron (1989) has shown that the presence of breaks in the data may lead one to erroneously fail to reject non-stationarity, we used the test of Zivot and Andrews (1992) which tests for stationarity allowing for a break but without the break needing to be specified in advance. The tests showed weak evidence of a level shift in the early 1970 but the results were not significant. We therefore conclude that both variables are non-stationary in the logs. Tests for stationarity in the first differences (of the logs) provided clear evidence that the variables are stationary once differenced so that we conclude that they are both I(1).

We then proceed to test for cointegration and the results are reported in Table 3. The Engle-Granger procedure tests for stationarity in the residuals from the cointegrating regression of the log of the real share price index on the log of real GDP. Both ADF and PP versions of the test clearly fail to reject the null hypothesis of non-stationary residuals and therefore point to an absence of cointegration. These results are confirmed by the outcome of the Johansen test -- both the trace and the maximum-eigenvalue versions of the test do not allow the rejection of the null of zero cointegrating vectors.

We therefore conclude that both the variables of interest are I(1) and that they are not cointegrated and we proceed to model them accordingly.
IV THE EMPIRICAL MODEL

We were able to conclude in the preceding section that the log of the real share price index and the log of real GDP (share prices and output) are non-stationary and not cointegrated. There are therefore two independent stochastic trends in the system of two variables and we implement the theoretical restrictions discussed in section II by assuming that one of the trends affects both the variables (i.e., the macro shock has permanent effects on both output and share prices) and that the stock market shock affects share prices in the long run but has only a temporary effect on output. We estimate the VAR in first-difference form and impose the restriction that the sum of the MA coefficients of the stock market shock in the output equation is zero (see equation (2)).

Before using the model for simulation, we need to set the lag length. Since we are using quarterly data, we entertained a maximum lag length of 6. We estimated the model for lag lengths of 1 to 6 and computed the Akaike and Schwartz Criteria as well as test statistics for autocorrelation and ARCH in the residuals of the equations. The results are reported in Table 4. The two traditional criteria used in the choice of lag length, AIC and SIC, are not very useful in the present case since they move (almost) monotonically in opposite directions. Hence we resort to the use of adjusted $R^2$ and tests for autocorrelation and ARCH in the residuals. We use the Box-Pierce-Ljung joint test for autocorrelation at lags 1 to 4 and Engle’s test of fourth-order ARCH. The explanatory power of each equation is low but recall that the dependent variable in each case is the proportional change. Adjusted $R^2$ is maximised at lag 4 for the output equation and at lag 3 for the share price equation. Looking at the residuals, we find that there is some evidence of autocorrelation and ARCH in the output equation at low lags but none in the share price equation at any lag. Both equations are free of autocorrelation and ARCH at lag 4 but there is evidence of ARCH in the output equation at lag 3. Hence we choose a lag length of 4 while recognising that a shorter lag length would not do much violence to the data. We recognise that four lags may result in over-parameterisation and report some experimentation with fewer lags.

It is interesting to consider the implications of the estimated model with four lags for the question of Granger-causality. The $F$-statistic for the hypothesis that output Granger-causes share prices cannot be rejected at the 5% but can be rejected at the 1% significance level while share prices are found to Grange-cause output at 1%.

V MODEL SIMULATIONS

In this section we use the estimated model to calculate the values of the impulse response functions (IRFs) and the historical decomposition of the share price index into its fundamental and non-fundamental components. We begin with the IRFs which are reported in Figures 2 and 3.

In Figure 2 we show the effects of a unit macro shock on the two variables of interest – real output and real share prices. The results indicate that the effects on share prices are larger than those on real output, but this undoubtedly reflects the fact that historically share prices have fluctuated a great deal more than output has. The effect on both variables is positive. This is not surprising in the case of output. The positive effect on share prices is consistent with a supply interpretation of the macro shock. In a standard aggregate-demand/aggregate-supply interpretation of macroeconomic fluctuations, a supply shock shifts the aggregate supply curve to the right, depressing prices and increasing output. This is reflected in the ISLM model underlying aggregate demand by a rightward shift in the LM curve which increases output and reduces the interest rate. If we take interest rates in this simple framework to be the channel of transmission from real to financial markets, the reduced interest rate encourages substitution of shares for bonds in agents’ portfolios, thus raising share prices. An aggregate demand shock, on the other hand, would tend to raise interest rates, thus depressing share prices.

The values of the cumulative IRFs for $t = 1$ and $t = \infty$ are reported in Table 5. Since the model is specified in first differences, the cumulative effects on the first differences are the effects on the levels of the corresponding variables.

In Figure 3 we show the effects on output and share prices of a stock market shock. This has a positive effect on share prices but an effect of the opposite sign on output. Again the effect on share prices is larger in absolute value than that on output. The negative effect on output is also consistent with the theoretical structure outlined above. A favourable stock market shock (say, an improvement in expectations not reflecting current real output) encourages wealth holders to shift funds into the stock market from the bond market. The consequence is that bond yields rise as bond prices fall which, in an ISLM framework, has an adverse effect on investment and hence on output via aggregate demand. This is only a temporary effect since eventually prices adjust and real output is restored to its original value. This is reflected in Figure 3(a).
in that the output change is reversed so that initial fall is offset. It appears that the effect substantially works itself out by the end of six quarters. The cumulative effects are given in the second line of Table 5.

Our final application of the estimated SVAR model is to use it to calculate the fundamental component of the share price index. We do this by first calculating the structural MA coefficients and the structural residuals based on the restrictions set out in section II. We then simulate the model by setting the stock market shock at zero for the entire sample period and allowing the macro shock to take on its historical values. The resulting series for the first difference in the log of the real share price index is what would have been observed if only macro shocks had hit the market over the sample period. For ease of interpretation, we converted this series to nominal terms by adding the actual values of the log first difference of the implicit deflator and then converted to a series for the level of the index by integrating the series forward and converting from logs to levels.

To implement the forward integration we faced a starting-value problem and we linked the series to the actual level of the index at the end of 1967 which was the end of a period of relative stability in the index and could reasonably be chosen as a time when the actual and fundamental values of the index were closely aligned. This approach is preferable to that which often seems to be used in the literature, viz. simply starting the series at the beginning of the sample period; e.g. Lee (1995, 1998) and Chung and Lee (1998). The level of the resulting series is not insensitive to this assumption and it is recognised that any conclusions drawn from the level of the fundamental series are crucially dependent on the starting-value assumption.

The results of these calculations are pictured in Figure 4. The first notable feature of the graph is the volatility of the fundamental series. This is closely related to the number of lags in the SVAR. Recall from the discussion in section IV that a lag length of 3 would also have been acceptable. We re-ran the estimation and simulation with models with shorter lags and found that these alternatives produced a noticeably smoother series with the same overall characteristics. In particular, the fundamental series did not follow the actual index so closely around the time of the October 1987 Crash and shows that the market is clearly overvalued before and undervalued after the Crash.

The graph suggests that the Australia share market has gone through three distinct phases over the past 30 years. The first is a period of share-market undervaluation which runs from the early 1970s to the early 1980s and is associated with the unexpected high inflation for much of that period. Recall that the model is specified in real terms so that a share market which keeps up with the real macroeconomy needs to have prices growing at least as fast as prices in general. A graph of the real share price index shows that for this period real share prices fell dramatically in the early 1970s and did not recover until well into the 1980s.

The second phase includes most of the 1980s and early 1990s and includes the Crash of October 1987. In the early part of this phase share prices recovered from the undervaluation in the 1970s although this seems to have gone too far in the lead-up to the Crash after which there was a brief period of undervaluation. But apart from 1987, this phase represented one in which share prices were not too far from their fundamental value.

The third phase started in the early 1990s and has lasted to the end of the sample period. It is one of overvaluation and there were no signs at the end of the 1990s that this period was coming to an end. The figures for the first quarter of 1999 suggest that the share price index is overvalued by approximately 25% although such figures need to be interpreted with the starting-value problem in mind. The pattern observed for Australia is not dissimilar to that for Korea but contrasts strongly to the experience of some other Pacific-Rim countries reported in Chung and Lee (1998), although it ought to be noted that their decomposition is based on a model involving share prices, dividends and earnings rather than the two variables we use.

A final comment on the features of Figure 4 is that it suggests that actual share prices revert to fundamental share prices over a long time period. This feature casts doubt on our analysis of the data and on our model specification which imply that the difference between the two series is driven by a stochastic trend which is independent of that underlying real output and fundamental share prices. However, a test of the difference between the two series produces clear evidence that it is non-stationary, confirming our earlier analysis of the data and the specification of the model.10
VI CONCLUSIONS

This paper has used a structural vector autoregressive model to investigate the properties of the Australian aggregate share price index over the past 40 years. We used a two-variable model to distinguish between two types of shocks—the first a macroeconomic shock and the second a stock market shock. This identification was based on the macroeconomic analysis of Blanchard and Quah (1989) and was achieved by assuming that the stock market shock has only a temporary effect on real output although it may have a permanent effect on real share price whereas the macro shock has a potentially permanent effect on both real output and real share prices.

The model was estimated using quarterly data for Australia for the period 1959–1999. The estimated model was simulated to assess the effects of the two types of shocks on each of the two variables in the model. It was found that the effects of both shocks die out quite quickly—most of the action was over after about six quarters. A positive macroeconomic shock was found to have a positive effect on both real output and real share prices. We argued that this was consistent with a supply shock in an AD/AS/ISLM framework. A positive stock market shock was found to boost share prices but to depress output initially although the output effect was only temporary. This observed effect is also consistent with the workings of an ISLM model coupled with a supply-determined natural level of real output to which price changes drive the economy in the long run.

We also used the estimated model to decompose the historical behaviour of the share price index into its fundamental and non-fundamental components, where the former was assumed to be driven by the macroeconomic shock and the latter by the share market shock. The results suggest that share prices were undervalued for much of the 1970s but overvalued for most of the 1990s. The under-valuation in the 1970s is associated with the high and unexpected inflation in that period which depressed real share prices very significantly. The over-valuation in the 1990s is associated with the long macroeconomic boom of the 1990s and is similar to the relationship between share prices and macroeconomic performance observed in the US although it appears that the Australian boom was somewhat later in starting than its US counterpart.

REFERENCES


### Table 1: Summary Statistics

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Real GDP growth</th>
<th>Real share-price growth</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>0.0094</td>
<td>0.0030</td>
</tr>
<tr>
<td><strong>Variance</strong></td>
<td>0.0002</td>
<td>0.0075</td>
</tr>
<tr>
<td><strong>Skewness</strong></td>
<td>0.5263</td>
<td>-1.2662</td>
</tr>
<tr>
<td><strong>Kurtosis</strong></td>
<td>2.7666</td>
<td>4.2588</td>
</tr>
<tr>
<td><strong>Box-Pierce (Q(6))</strong></td>
<td>21.0684</td>
<td>10.3223</td>
</tr>
</tbody>
</table>

Note: significance levels in parentheses.

### Table 2: Stationarity Tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Log Real GDP</th>
<th>Log Real SPI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ADF: no trend</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>trend</td>
<td>-1.7434</td>
<td>-1.3346</td>
</tr>
<tr>
<td>trend</td>
<td>-2.7958</td>
<td>-1.3408</td>
</tr>
<tr>
<td><strong>PP: no trend</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>trend</td>
<td>-1.2599</td>
<td>-1.4777</td>
</tr>
<tr>
<td>trend</td>
<td>-2.1134</td>
<td>-1.5200</td>
</tr>
<tr>
<td><strong>KPSS: σ(μ)</strong></td>
<td>3.2070</td>
<td>0.4731</td>
</tr>
<tr>
<td><strong>KPSS: σ(ε)</strong></td>
<td>0.5344</td>
<td>0.4711</td>
</tr>
</tbody>
</table>

Notes: 5% critical value for the ADF and PP tests without trend is -2.86 and with trend is -3.41. The 5% critical value for the KPSS test is 0.463 for the σ(μ) test and 0.146 for the σ(ε) test.
### Table 3: Tests for Cointegration

<table>
<thead>
<tr>
<th>Test</th>
<th>Statistic</th>
<th>ADF</th>
<th>PP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Engle-Granger</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ADF</td>
<td>-1.3961</td>
<td>-1.7298</td>
</tr>
<tr>
<td><strong>Johansen</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r = 1</td>
<td>Trace</td>
<td>0.460</td>
<td>0.460</td>
</tr>
<tr>
<td></td>
<td>Eigenvalue</td>
<td>13.544</td>
<td>13.084</td>
</tr>
<tr>
<td>r = 0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: The 5% critical value for the ADF and PP versions of the Engle-Granger test is -3.04. The 5% critical values for the Johansen test are as follows: 8.1 for both trace and eigenvalue tests of the hypothesis that r=1 and 17.8 for the trace test and 14.6 for the eigenvalue test of the hypothesis that r=0.

### Table 4: VAR Diagnostics

<table>
<thead>
<tr>
<th>Lag</th>
<th>Output equation</th>
<th>Share price equation</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Q(4) ARCH(4) Adj R²</td>
<td>Q(4) ARCH(4) Adj R²</td>
<td>AIC</td>
</tr>
<tr>
<td>1</td>
<td>8.9151 (0.0633) 8.1257 (0.0871) 0.0147</td>
<td>5.1749 (0.2698) 2.8487 (0.5835) 0.0388</td>
<td>-13.2812</td>
</tr>
<tr>
<td>2</td>
<td>8.3195 (0.0806) 8.9868 (0.0614) 0.0388</td>
<td>4.8613 (0.0318) 2.9213 (0.5711) 0.0288</td>
<td>-13.4106</td>
</tr>
<tr>
<td>3</td>
<td>5.2952 (0.2483) 10.0791 (0.0391) 0.0683</td>
<td>0.1627 (0.9969) 1.9552 (0.7440) 0.0902</td>
<td>-13.4941</td>
</tr>
<tr>
<td>4</td>
<td>0.5095 (0.9726) 6.5992 (0.1586) 0.1444</td>
<td>0.2872 (0.9906) 2.5708 (0.6320) 0.0824</td>
<td>-13.6310</td>
</tr>
<tr>
<td>5</td>
<td>0.2607 (0.9922) 6.6519 (0.1555) 0.1406</td>
<td>0.2105 (0.9948) 2.2484 (0.6902) 0.0724</td>
<td>-13.6843</td>
</tr>
<tr>
<td>6</td>
<td>0.2342 (0.9965) 6.4117 (0.1704) 0.1284</td>
<td>0.1718 (0.9965) 2.7151 (0.6066) 0.0663</td>
<td>-13.6819</td>
</tr>
</tbody>
</table>

Note: Significance levels in parentheses.
Table 5: Cumulative IRF values

<table>
<thead>
<tr>
<th>Shock</th>
<th>Effect at  t=1</th>
<th>Effect at  t=\infty</th>
<th>Effect at  t=1</th>
<th>Effect at  t=\infty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macro</td>
<td>0.8034</td>
<td>0.8196</td>
<td>4.0174</td>
<td>2.8970</td>
</tr>
<tr>
<td>Share-market</td>
<td>-0.0995</td>
<td>0.0000</td>
<td>0.7414</td>
<td>1.0772</td>
</tr>
</tbody>
</table>

Figure 1
Real output and share price growth
Endnotes

1 Whether the two shocks both have permanent effects depends on the order of integration of the two variables and, if they are both I(1), whether they are cointegrated. To anticipate our findings in the following section, we find that both variables in our model are I(1) and not cointegrated so that there are two independent stochastic trends.

2 As noted in the previous footnote, the precise specification of the model depends on the time-series properties of the variables being modelled and we proceed here by in the anticipation of our results in Section III that the two variables of interest are I(1) and not cointegrated.

3 The restriction imposed here is only loosely theoretical. More formal derivations of the fourth restriction have been provided in other contexts; e.g. Lee (1995, 1998) derives a similar restriction for a model of share prices and dividends from the log-linear dividend-discount model of Campbell and Shiller (1988). On the other hand, Blanchard and Quah (1987), in the original paper in which they apply the procedure to a macroeconomic question, base their identifying restriction only loosely on a simple ad hoc macro model.

4 ADF statistics, estimated autocorrelations, ARCH and Q statistics are very similar for the two series and test outcomes are always the same irrespective of which series is used.

5 See Dickey and Fuller (1991) and Phillips and Perron (1988) for the ADF and PP tests respectively.

6 See Kwiatkowski, Phillips, Schmidt and Shin (1992) for details of this test.

7 See Engle and Granger (1987) for details.
8 See Johansen (1988) for details of the Johansen test.

9 See Ljung and Box (1978) and Engle (1982).

10 The ADF (PP) statistic for the difference between the two share prices series is -1.4024 (-1.0796) both of which have a 5% critical value of -3.41. This result is not sensitive to lag length used for autocorrelation correction or the presence of a trend and is consistent with the outcome of the KPSS test.

<table>
<thead>
<tr>
<th>DISCUSSION PAPERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Economics</td>
</tr>
<tr>
<td>The University of Western Australia</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Title of Paper</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian's unemployment problem</td>
<td>Lee, A.L. Miller, A.T.</td>
</tr>
<tr>
<td>A user's guide to DAP 2000</td>
<td>Yang, W. Clements, K.W. Chen, D.</td>
</tr>
<tr>
<td>Wage effects of drinking in Australia</td>
<td>Lee, Y.L.</td>
</tr>
<tr>
<td>Energy costs in the WA minerals industry</td>
<td>Clements, K.W. Ye, Q.</td>
</tr>
<tr>
<td>Report of the 1999 PhD conference in economics and business</td>
<td>Clements, K.W. Barrett, J.</td>
</tr>
<tr>
<td>Wage effects of drinking and smoking: an analysis using Australian twins data</td>
<td>Lee, Y.L.</td>
</tr>
<tr>
<td>Prices, legislation and marijuana consumption</td>
<td>Darya!, M.</td>
</tr>
<tr>
<td>The economics of marijuana consumption</td>
<td>Clements, K.W. Darya!, M.</td>
</tr>
<tr>
<td>Minerals and regional employment in Western Australia</td>
<td>Clements, K.W. Johnson, P.L.</td>
</tr>
<tr>
<td>Western Australian agriculture: structure, trends and farming systems</td>
<td>Islam, N.</td>
</tr>
<tr>
<td>A history of bimetallism: Greece, Rome, Middle Ages, Modern Times</td>
<td>Weber, E.J.</td>
</tr>
<tr>
<td>The Trade Practices Act after 25 years: mergers and the role of the ACC</td>
<td>Fels, A.</td>
</tr>
<tr>
<td>Income disparity and convergence in China's regional economies</td>
<td>Wu, Y.</td>
</tr>
<tr>
<td>Regional integration, productivity and growth: a study of the Southern China region</td>
<td>Wu, Y.</td>
</tr>
<tr>
<td>Export performance and economic growth: co-integration and causality analysis for Malaysia, 1966-96</td>
<td>Siddique, M.A.B. Selvanathan, E.A.</td>
</tr>
<tr>
<td>Violation of the IID-Normal assumption: Effects on tests of asset-pricing models using Australian data</td>
<td>Groenewold, N. Fraser, P.</td>
</tr>
<tr>
<td>Estimating the WA agricultural production system: A profit function approach</td>
<td>Ahammad H. Islam, N.</td>
</tr>
<tr>
<td>Future trends in Japanese steel consumption</td>
<td>Crompton, P.</td>
</tr>
<tr>
<td>How different is mining from mineral processing?</td>
<td>Qiang, Y.</td>
</tr>
</tbody>
</table>
98-30 Lee, Y.L. Optimal schooling investments and earnings: an analysis using Australian twin data

98-29 Magnani, L. Market volatility, adjustment of labor and earnings

98-28 Le, A.T. Self-employment and earnings among immigrants in Australia

98-27 Greig, R. The importance of the University of Western Australia to the state of Western Australia: a preliminary assessment

98-26 Gruen, D. Why does the Australian dollar move so closely with the terms of trade?

98-25 Clements, K.W. Simulating Demand Systems

98-24 Siddique, M.A.B. Export performance and economic development in Thailand

98-23 Groenewold, N. The Australian natural rate of unemployment: some estimates from a structural VAR

98-22 Macfarlane, I.J. Shann Memorial Lecture: Australian monetary policy in the last quarter of the twentieth century

98-21 Ahammad, H. Looking backward versus looking westward: a regional perspective on tariffs

98-20 Groenewold, N. Tests of asset-pricing models: how important is the IID-normal assumptions?

98-19 Yuen, W.C. Food Consumption in rich countries

98-18 Wu, Y. Redundancy and firm characteristics in Chinese state-owned enterprises

98-17 Le, A.T. The determinants of immigrant self-employment in Australia

98-16 Clements, K.W. A new input-output table for Western Australia - Part 2

98-15 Clements, K.W. A new input-output table for Western Australia - Part 1

98-14 Ghosh, R.N. The labour market in the Maldives: the case for institutional reforms

98-13 Ahammad, H. The economics of the WA minerals sector: an overview of ERC research

98-12 Weber, E.J. The IMF and Indonesia: Two equal partners

98-11 Le, A.T. Empirical studies of self-employment

98-10 Clements, K. Yang, W. The matrix approach to evaluating demand equations

98-09 Turkington, D. The Western Australian gold study Part II

98-08 Greig, R. The Western Australian gold study Part I

98-07 Greig, R. The performance of foreign direct investment in China: a preliminary analysis

98-06 Wu, Y. Forecasting steel demand in South-East Asia

98-05 Crompton, P. The inflation tax, variable time preference, and the business cycle

98-04 Lahiri, R. World metal prices: a database

98-03 Qiang, Y. An econometric study of gold production and prices


98-01 Clements, K. Madsen, P. What does minerals growth mean to WA?

97-30 Ahammad, H. Clements, K. Metal markets and East Asia: emerging trends, issues and policies Part III

97-29 Greig, R. Metal markets and East Asia: emerging trends, issues and policies Part II

97-28 Greig, R. Metal markets and East Asia: emerging trends, issues and policies Part I

97-27 Greig, R. The world real interest rate: stochastic index number perspectives

97-26 Ong, L. Clements, K. Izan, H.