



Identification of common and idiosyncratic shocks in real equity prices: Australia, 1982–2002

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Abstract

A structural vector autoregressive (SVAR) model of real equity prices in Australia is specified to contain common shocks in international equity markets and domestic shocks in Australian financial and goods markets. Common shocks are identified through the long-run comovements of international equity markets, resulting in the model being characterized as having more shocks than variables. The empirical results show that the dot-com crisis of 2000 causes Australian real equity values to depreciate significantly below a precrisis baseline forecast, while contagion from the Asian financial crisis of 1997–1998 is found to have a much smaller negative impact.

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1. Introduction

During the period 1982–2002, nominal share prices in Australia increased on average by approximately 9.5% per annum and real share prices averaged an increase of around 5% per annum. Fig. 1A highlights the movements of Australian equity and goods prices over this period. Although the Australian share market was subject to the global shocks of the 1987 equity market crash and the 1991–1992 recession, it appears to have been

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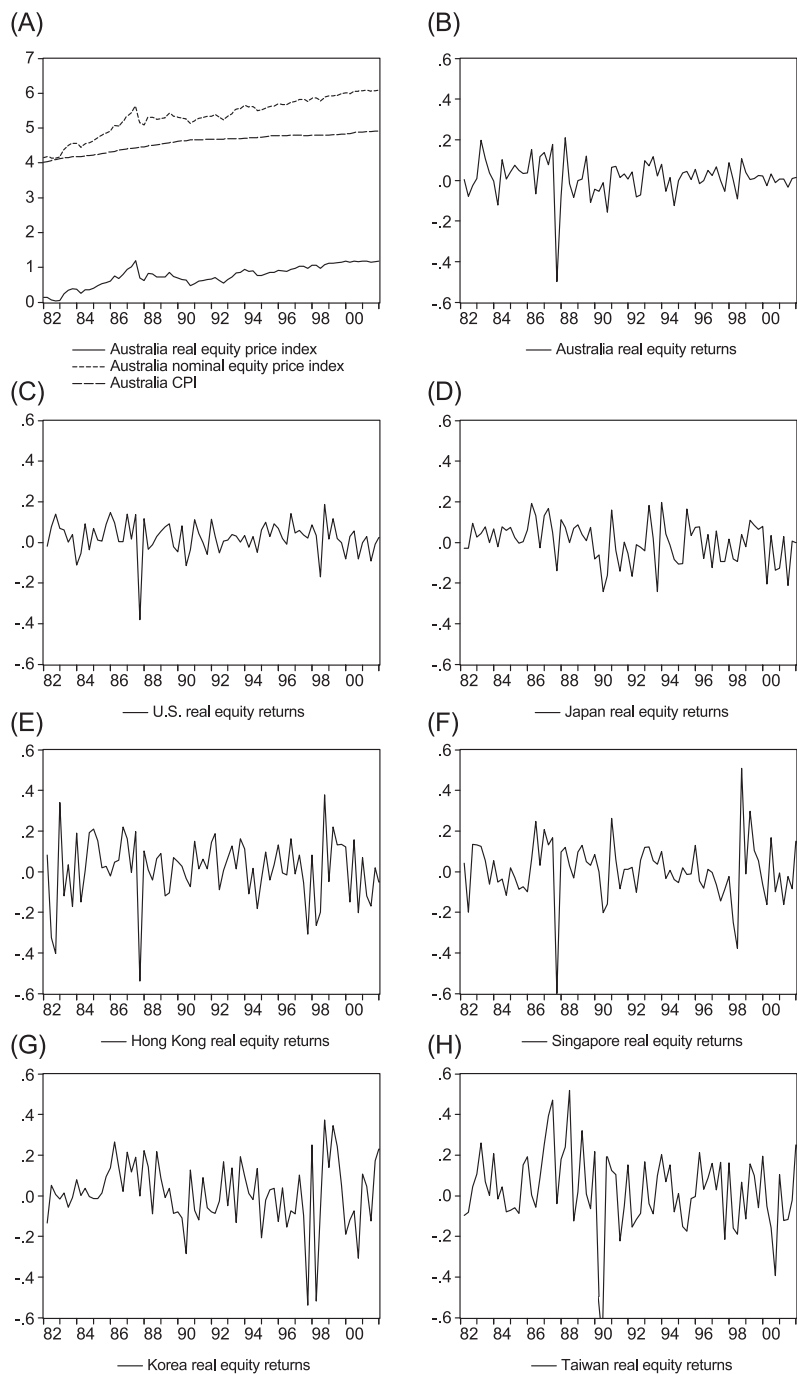


Fig. 1. Australian equity and goods prices (natural logarithms) and international real equity returns (quarterly percentages), 1982–2002.

resilient against the effects of the East Asian financial crisis, the dot-com collapse, and the decline in the world economy early in this millennium. Investments in Australian equities provided diversification opportunities over the 1990s. For this reason, we seek to discover the relative contributions of international equity markets and domestic financial and real factors in determining the performance of the Australian real equity returns. These results form a basis for assessing why Australian equities formed an effective part of a diversified portfolio.

An important contribution of the paper is the methodology for undertaking this assessment. The relative contributions of shocks to real equity prices are assessed using a structural vector autoregressive (SVAR) model with a set of long-run restrictions imposed on the dynamic adjustment paths using the approach of [Blanchard and Quah \(1989\)](#). A distinguishing feature of the model is that the number of identifiable shocks exceeds the number of variables in the system. A typical SVAR model contains an equivalent number of shocks and variables. Here, we also identify common shocks that impact simultaneously on international equity markets. A relatively large common international component can be interpreted as evidence of international integration of the Australian equity market, as found in work such as [Ragunathan \(1999\)](#).

Apart from the common international influences that may impact on the Australian equity market, we consider the impact particularly of shocks from the U.S., Japanese, and East Asian equity markets. These are Australia's most prominent trading partners, with a combined weight in the Australian Trade Weighted Index of the exchange rate of almost 50%; the strong effects of U.S. markets have been documented in [de Roos and Russell \(2000\)](#).¹ The East Asian markets provided the greatest growth in demand for exports during the period, as well as the source of the most dramatic shock from within the region in the form of the East Asian financial crisis of 1997–1998. The domestic influences we consider are idiosyncratic shocks to the Australian real equity returns and shocks sourced from domestic interest rates and output. The choice of those indicators is discussed in Section 2 but is consistent with the existing literature on influences on equity market returns.

A synopsis of the results from the SVAR model is that there is substantial scope for diversification in Australian equity markets during this period. The idiosyncratic Australian equity market factor accounts for over half of the variance in Australian equity returns at the 3-month horizon and one third at longer horizons. The idiosyncratic Australian equity market factor and the common international factor are the two most important contributors to the variance in Australian real equity returns. In the longer horizon, the common factor accounts for up to 35% of the variance in Australian real equity returns. While this is substantial, it also indicates that there remain important opportunities for diversification. On a bilateral basis, only the United States and Hong Kong have significant impacts on the Australian equity market variance, contributing 14% and 5%, respectively. The Australian output and interest rate shocks account for less than 10% of the variance in real equity returns at a greater than 3-month horizon.

¹ The remaining large components of the TWI are the Euro area at 12% (of which the largest contributor is Germany at around 4%), China at 9%, and the UK and New Zealand at 5%.

The East Asian and dot-com crises are both found to have had negative impacts on Australian real equity values. However, in the former crisis, the market performed around the level of the conditional forecasts from the model and was held up by the impact of a relatively strong U.S. market. In the lead up to the dot-com crisis, Australian equities underperformed the conditional forecasts but the timing is such that the nadir of the idiosyncratic market factor occurs at the point of the dot-com crisis and then improves. We postulate that Australian equities were suffering from an ‘old economy’ image precrisis, which in fact provided some protection during the dot-com slump.

The rest of the paper proceeds as follows. A structural VAR of real equity prices is specified in Section 2. International and domestic shocks are identified by imposing long-run restrictions on the dynamics adjustment paths. The SVAR model is applied in Section 3 to identifying the relative importance of various common international and domestic shocks on Australian real equity values. Special attention is given to identifying the impact of various financial crises on the Australian equity market, including the role of contagious transmission mechanisms operating during the Asian financial crisis of 1997–1998, as well as the dot-com crisis in U.S. equities in 2000. Some concluding comments are contained in Section 4.

2. A SVAR model of real equity prices

The use of VARs to model equities in the tradition of [Campbell and Shiller \(1988\)](#) is well established. The growth of VAR applications, which consider the interrelationships among international equity markets, includes [Knif and Pynnonen \(1999\)](#) for Europe, [Dekker, Sen, and Young \(2001\)](#) for Australasia, [Cha and Oh \(2000\)](#) for Asia, [Masih and Masih \(1997\)](#) for developed countries, and [Ratanapakorn and Sharma \(2002\)](#) across regions. Increasingly, the VAR methodology is also being used to examine the question of which fundamental indicators may be seen as providing information on equity values, as in [Kaneko and Lee \(1995\)](#) for U.S. and Japanese stocks, [Papapetrou \(2001\)](#) for Greece, and [Hassapis and Kalyvitis \(2002\)](#) for the G7 countries.

In this paper both the linkages between international equity markets and the potential influence of domestic fundamentals are incorporated in an SVAR framework. In a related work, [Rapach \(2001\)](#) investigates U.S. real equities with identification achieved by the imposition of long-run restrictions on the dynamics of the underlying processes. The SVAR developed in this section provides a general framework for modeling real equity prices in Australia. A special feature of the model is the identification of common shocks in international share markets through the imposition of long-run restrictions on the dynamic adjustment paths. This feature results in the number of shocks driving the model, exceeding the number of observable variables in the model.

There are nine variables included in the SVAR model.² The first seven variables are the real share prices in Australia ($S_{AU,t}$) and six international share markets: the United States

² The full data sources, descriptive statistics, unit root tests, and coefficient estimates from the SVAR are contained in the working paper version of this paper; see [Dungey, Fry, and Martin \(2003\)](#).

($S_{US,t}$), Japan ($S_{JP,t}$), Hong Kong ($S_{HK,t}$), Singapore ($S_{SG,t}$), Korea ($S_{KO,t}$), and Taiwan ($S_{TW,t}$).³ The United States and Japan are chosen as they are the largest stock markets in the region as well as Australia's largest trading partners. The inclusion of the United States also enables the effects on Australia of the dot-com crisis that occurred in U.S. equities to be studied. The other East Asian countries are of interest because they represent the most rapidly growing part of Australia's export markets at this time, as well as the source of the East Asian financial crisis. The inclusion of the six East Asian economies (including Japan) allows a detailed examination of the direct sources of the crisis. A similar group of countries is examined in Janakiramanan and Lamba (1998).⁴

The seven real share price returns are shown in Fig. 1B–H over the sample period. Fig. 1 highlights a number of shocks that have occurred in world share markets during the period 1982–2002. The most pronounced of these are the 1987 stock market crash and the large falls in other Asian markets, particularly Korea. This period also coincides with the long bull run in U.S. equity markets prior to the start of the dot-com collapse in April 2000.

The remaining two variables of the VAR capture domestic factors, which impact upon the Australian share market, here represented by domestic interest rates (R_t) and output (Y_t). Interest rates are expected to have a generally negative impact on equity market returns, in line with theoretical arguments that positive interest rate shocks cause a given future income stream to be discounted at a higher rate and hence a fall in share prices.

In the models of Blanchard (1981) and Fama (1981), exogenous shocks can cause output and equity markets to move in the same direction. One potential source of this shock is an interest rate (monetary policy) shock, so that our specification of equity market returns controlling for both output and interest rate shocks is consistent particularly with Blanchard. The relationship between equity returns and output shocks is positive in Blanchard because, for example, an exogenous monetary policy shock producing higher interest rates affects expected future profits and hence consumption, output, and equity prices. In addition, there is broad agreement that equity market returns are contemporaneously predetermined for output shocks, as adopted here. This line of reasoning expects a positive relationship between equity market returns and output shocks, such as documented in Lee (1992). More recently, the direction of this relationship has been questioned. Hassapis and Kalyvitis (2002) provide a theoretical underpinning for this possibility, based on a growth model and present evidence of the negative relationship between real equity prices and output shocks across the G7, albeit not all the estimated coefficients are significant. The inclusion of domestic interest rates and output allows us to investigate the outcomes for the Australian case. In particular, we subject the results of Hassapis and Kalyvitis to the criticism of Fama (1981) and Lee (1992) that bivariate relationships are moderated by including further relevant control variables, in this case the domestic interest rate.

³ The real share prices are constructed as the log of Dow Jones Industrial, Nikkei-225, Hang Seng, Singapore Straits Times, Korean Composite, Taiwan Weighted, and Australian S&P/ASX200 indices deflated by country-specific CPI indices. All data were obtained from the dX database.

⁴ A potential extension of this research is to expand the set of international equity markets, in particular from Europe. One way to do this would be to construct regional equity market indices, as for example, Ratanapakorn and Sharma (2002), although at the cost of being unable to look at individual markets.

The inclusion of output and interest rates is consistent with existing Australian work; see [Bilson, Brailsford, and Hooper \(2001\)](#), [Fraser and Groenewold \(1997, 2001\)](#), and [Ragunathan, Faff, and Brooks \(1999\)](#). The inclusion of other variables may also be desirable at some point; for example [Faff and Brailsford \(1999\)](#) found that oil prices have effects over a broad range of sectors.

Let the full set of variables in the current application be summarized as

$$Z_t = \{S_{AU,t}, S_{US,t}, S_{JP,t}, S_{HK,t}, S_{SG,t}, S_{KO,t}, S_{TW,t}, Y_t, R_t\}, \quad (1)$$

where all variables with the exception of the interest rate (R_t) are expressed in natural logarithms. The VAR is specified as

$$(I - \Phi_1 L - \Phi_2 L^2 - \dots - \Phi_p L^p) \Delta Z_t = \alpha + e_t, \quad (2)$$

where $L^k Z_t = Z_{t-k}$ is the lag operator, $\Delta = (I - L)$ is the first difference operator, Φ_k are (9×9) matrices of autoregressive parameters, α is a (9×1) vector of intercept parameters to capture the levels of the variables, and e_t is a nine variate multivariate normal random error with zero mean $E[e_t] = 0$, a contemporaneous covariance matrix $E[e_t e_t'] = \Omega$, and is non-autocorrelated $E[e_t e_{t-s}'] = 0, \forall s \neq 0$. The length of the lag structure of the VAR is controlled by p . The use of the first difference operator $(I - L)Z_t$ ensures that the set of variables are covariance stationary.⁵ As the real share prices and real output are measured in natural logarithms, the VAR for these variables represents a model of real share returns and real output growth, respectively.

To identify the sources of shocks underlying the movements in the variables in the VAR, it is convenient to derive the vector moving average (VMA) representation of the VAR. This is achieved by inverting the matrix polynomial $(I - \Phi_1 L - \Phi_2 L^2 - \dots - \Phi_p L^p)$ in Eq. (2)

$$\begin{aligned} \Delta Z_t &= (I - \Phi_1 L - \Phi_2 L^2 - \dots - \Phi_p L^p)^{-1} (\alpha + e_t), \\ \Delta Z_t &= \beta + (I + \Theta_1 L + \Theta_2 L^2 + \dots + \Theta_q L^q + \dots) e_t, \end{aligned} \quad (3)$$

where Θ_k are (9×9) matrices of moving average parameters that are functions of the autoregressive parameters of the VAR, and $\beta = (I - \Phi_1 - \Phi_2 - \dots - \Phi_p)^{-1} \alpha$ is a (9×1) vector of intercept parameters.⁶ The VMA has an infinite lag structure, although as ΔZ_t is covariance stationary, the moving average parameter matrices eventually die out for longer lags. As the shocks e_t are contemporaneously correlated, a set of independent shocks are identified as follows

$$e_t = G v_t, \quad (4)$$

where G is a matrix of unknown “structural” parameters and v_t a set of “structural” shocks with the properties $E[v_t] = 0$, $E[v_t v_t'] = I$, and $E[v_t v_{t-s}'] = 0, \forall s \neq 0$. Substituting Eq. (4) into

⁵ Unit root tests show that all variables are integrated processes of order one. Test statistics are available in [Dungey et al. \(2003\)](#).

⁶ The matrix polynomial inversion used to generate the vector moving average representation is usually computed numerically; see [Hamilton \(1994, p. 260\)](#).

Eq. (3) gives the moving average representation of the model in terms of the structural shocks v_t

$$\Delta Z_t = \beta + (I + \Theta_1 L + \Theta_2 L^2 + \dots + \Theta_q L^q + \dots) \mathbf{G} v_t. \quad (5)$$

From Eq. (5), the effect of a structural shock at time t on the changes in the variables at time $t+s$ is immediately given by

$$\frac{\partial \Delta Z_{t+s}}{\partial v_t'} = \Theta_s \mathbf{G}. \quad (6)$$

Alternatively, the effect of a shock at time t on the level of the variables at time $t+s$ is the cumulative sum of the shocks over the period

$$\frac{\partial Z_{t+s}}{\partial v_t'} = \sum_{j=0}^s \Theta_j \mathbf{G}. \quad (7)$$

In the limit, the long-run effect of a shock at time t is then

$$\lim_{s \rightarrow \infty} \frac{\partial Z_{t+s}}{\partial v_t'} = \lim_{s \rightarrow \infty} \sum_{j=0}^s \Theta_j \mathbf{G} = (1 - \Phi_1 - \Phi_2 - \dots - \Phi_p)^{-1} \mathbf{G}. \quad (8)$$

The second component of the SVAR is the identifying restrictions embodied in $\mathbf{G}$, needed to identify the sources of the shocks v_t . The approach adopted is to use the expression in Eq. (8) to impose long-run restrictions on the processes of the VAR. This approach is originally discussed by [Blanchard and Quah \(1989\)](#) and is in contrast to the more common approach of specifying short-run restrictions among the variables. An advantage of this form of identification is that the imposition of long-run restrictions circumvents the nonuniqueness problems of recursive VARs arising from variable reordering. As an example of the latter approach, [Janakiraman and Lamba \(1998\)](#) base their ordering on market opening times. An alternative framework that also circumvents the nonuniqueness problem is the generalized impulse response approach of [Pesaran and Shin \(1998\)](#), which has been recently applied by [Dekker et al. \(2001\)](#).

Letting $\mathbf{H}$ represent the long-run effects of a shock on the levels of the variables

$$\lim_{s \rightarrow \infty} \frac{\partial Z_{t+s}}{\partial v_t'} = \mathbf{H}, \quad (9)$$

then from Eq. (8)

$$\mathbf{H} = (1 - \Phi_1 - \Phi_2 - \dots - \Phi_p)^{-1} \mathbf{G}. \quad (10)$$

Thus, the matrix $\mathbf{G}$ used to identify the effects of shocks in Eqs. (6)–(8) is given by

$$\mathbf{G} = (1 - \Phi_1 - \Phi_2 - \dots - \Phi_p) \mathbf{H}. \quad (11)$$

In specifying the long-run restrictions, not only are the effects of shocks arising from all nine variables in the VAR taken into account, but the effects of common shocks

simultaneously arising in all financial markets are also included. This results in a system of equations whereby the number of shocks, 10 in total, exceeds the number of variables in the model, 9 in total. More specifically, the set of restrictions imposed on the model's long-run dynamics embodied in Eq. (9), are given by the following (9×10) matrix

$$\mathbf{H} = \begin{bmatrix} \lambda_1 & \phi_1 & \delta_1 & \delta_2 & \delta_3 & \delta_4 & \delta_5 & \delta_6 & \gamma_1 & \gamma_2 \\ \lambda_2 & & \phi_2 & & & & & & & \\ \lambda_3 & & & \phi_3 & & & & & & \\ \lambda_4 & & & & \phi_4 & & & & & \\ \lambda_5 & & & & & \phi_5 & & & & \\ \lambda_6 & & & & & & \phi_6 & & & \\ \lambda_7 & & & & & & & \phi_7 & & \\ & & & & & & & & \phi_8 & \\ \rho_1 & & & & & & & & & \rho_2 \quad \phi_9 \end{bmatrix} \quad (12)$$

where all blank cells represent a zero and hence no long-run relationship between the pertinent variable and a specific shock. The parameters

$$\lambda_1, \lambda_2, \dots, \lambda_7,$$

represent the impact of common shocks in financial markets on the real share prices in the seven equity markets. These parameters are identified through the comovements of equity markets and thus represent common movements occurring in all equity markets. The parameters

$$\phi_1, \phi_2, \dots, \phi_9,$$

control the impact of idiosyncratic shocks. The long-run effect of shocks in any of the six international share markets on Australian real share prices is determined by

$$\delta_1, \delta_2, \dots, \delta_6.$$

In the empirical analysis, these parameters provide a test of contagion following the work of Dungey and Martin (2001), Favero and Giavazzi (2002), Forbes and Rigobon (2002), Fraser and Groenewold (2001), and Pericoli and Sbracia (2001), as they represent the impact of unanticipated shocks on the Australian equity market, see also Dornbusch, Park, and Claessens (2000) and Masson (1999a, 1999b, 1999c) for a discussion of the definition of contagion.

The inclusion of domestic output and interest rates is used to identify the effects of real and nominal domestic shocks on Australian real share prices; see also Rapach (2001). The long-run effects of these two shocks are given by the parameters

$$\gamma_1, \gamma_2,$$

respectively. The expected signs of these parameters are motivated by assuming that equity prices are set at present value levels whereby prices are determined by the discounted expected future dividend stream. In the case of output shocks, these are expected to have a positive affect on share prices ($\gamma_1 > 0$) as increases in output raise expectations of higher earnings in the future resulting in higher share valuations. To the extent that real equity prices can reflect only real economic activity, this parameter might be anticipated to have a value of one in the long run and in the presence of efficient allocation by capital markets; the latter is debated in the literature with Dekker et al. (2001) attesting to relative efficiency in the region, while Wurgler (2000) shows that allocative efficiency does not hold for most of the markets investigated here. Interest rate shocks are expected to have a negative impact on share prices ($\gamma_2 < 0$) as a positive shock in interest rates causes a given future dividend stream to be discounted at a higher rate, which in turn leads to a fall in share prices.

The second last line of **H** in Eq. (12) imposes the condition that output in the long-run is affected only by idiosyncratic shocks and not by shocks from other markets including equity and bond markets. These restrictions represent the imposition of long-run equilibrium in the output market whereby output, and in turn, unemployment, operates at the natural rate. Finally, the last row of **H** in Eq. (12) represents the impact of various shocks on interest rates

$$\rho_1, \rho_2.$$

The parameter ρ_1 represents the impact of common shocks to all financial markets on the Australian bond market. This parameter is anticipated to be positive, as a shock that has a positive impact on equity prices in the long run should also have a positive impact on other financial markets if equilibrium in financial markets is to be maintained. Finally, the parameter ρ_2 captures the effect of domestic output shocks on the interest rate. The sign of this parameter is indeterminate a priori. In a standard IS-LM macroeconomic model without wealth effects, it is anticipated that $\rho_2 < 0$, as shocks to aggregate output needs to be matched by increases in aggregate demand for goods market equilibrium and that this is achieved through reductions in the interest rate. Introducing wealth effects for example can change the sign so $\rho_2 > 0$, as shocks to aggregate output results in higher share valuations through expectations of higher future dividends. The higher real share valuations raise wealth, which has a positive impact on aggregate demand resulting in higher interest rates.

As the equity market indices are deflated by local prices, this imposes implicitly purchasing power parity across equity markets in the long run.⁷

⁷ An alternative approach is to express the equity prices in terms of a common currency. This approach was also tried where the model was estimated using national equity indices transformed into Australian dollar equivalents and then deflated by the Australian CPI. The result from estimating this model was qualitatively similar to the results presented below.

3. Empirical analysis

In this section, the SVAR model specified in Section 2 is applied to decomposing real share prices in Australia over the period 1982–2002. Attention is also given to uncovering the importance of contagion through the Asian financial crisis of 1997–1998 as measured by the statistical significance of unanticipated shocks from the Asian equity markets to the Australian equity market as well as the impact of the dot-com crisis in 2000.

3.1. Data

The equity markets studied are Australia, United States, Japan, Hong Kong, Singapore, Korea, and Taiwan. The additional Australian variables used to capture aggregate output and interest rate shocks in Australia are real GDP and the 90-day bank accepted bill rate, respectively. The data are quarterly beginning in March 1982 and ending in March 2002, a total of $T=81$ observations. All data are extracted from the dX database. As Australian output and inflation data are only available on a quarterly basis, the monthly country share prices and the Australian interest rate are converted into quarterly data by taking the midpoint of each quarter. Real share prices are obtained by deflating each share price by the relevant price index. All country price indexes are based on consumer prices. Real share prices and real GDP in Australia are transformed by natural logarithms and then scaled by 100 so that when the variables are differenced in specifying the VAR in Eq. (2), they have the interpretation of being expressed as quarterly percentages.

3.2. Model specification and estimation

The VAR in Eq. (2) is estimated for a range of lags p using Gauss version 3.2.⁸ As the lag structure across all equations is the same, ordinary least squares estimation of each of the nine equations in the VAR yields asymptotically efficient parameter estimates. The results of the lag tests are given in Table 1. In performing the lag length tests, a maximum lag of $p=3$ is chosen initially. The outcome of the likelihood ratio test based on the Sims degrees of freedom correction suggests one lag, whereas the AIC, SIC, and HIC statistics suggest no lags. Inspection of some of the t statistics associated with individual lags suggests that restricting the VAR to no lags is too strong. Other diagnostic tests reported in Dungey et al. (2003) support a VAR(1) structure.

Having estimated the VAR, the long-run parameters in Eq. (12) are estimated as follows. Letting $\hat{e}_t$ be the (9×1) vector of estimated residuals from the nine-variate VAR, the log of the likelihood for the t th observation is given by

$$\ln L_t = -\frac{N}{2} \ln(2\pi) - \frac{1}{2} |\Omega| - \frac{1}{2} \hat{e}_t' \Omega^{-1} \hat{e}_t,$$

⁸ The VAR also includes a dummy variable to capture the effect of the 1987 stock market crash in the fourth quarter of 1987. This variable is needed to satisfy the diagnostic tests performed on the VAR reported in Dungey et al. (2003).

Table 1
Alternative tests of the lag structure of the VAR

Lag	Statistic				
	ln L	LR	AIC	SIC	HIQ
0	999.071	n.a.	− 25.482 ^a	− 24.934 ^a	− 25.263 ^a
1	1060.665	105.590 ^a	− 24.978	− 21.965	− 23.773
2	1115.161	80.682	− 24.290	− 18.811	− 22.098
3	1195.951	100.725	− 24.284	− 16.340	− 21.107

The sequential modified likelihood ratio test is computed as $LR=(T-M) (\ln L_j - \ln L_{j-1})$, $j=0, \dots, 3$, $T=77$, $M=11$ is the number of estimated parameters in one equation of the VAR, and $\ln L_j$ is the log of the likelihood with j lags. The test statistic is asymptotically distributed as χ^2_{81} under the null hypothesis that the restrictions are satisfied.

The Akaike information criterion is computed as $AIC=-2 \ln L/T+2K/T$, where K is the total number of estimated parameters of the VAR.

The Schwarz information criterion is computed as $SIC=-2 \ln L/T+K \ln(T)/T$.

The Hannan–Quinn information criterion is computed as $HIQ=-2 \ln L/T+2 K \ln[\ln(T)]/T$.

^a Signifies the optimal lag structure.

where $N=9$ is the number of equations. The variance–covariance matrix of the VAR errors is given by

$$\Omega = \mathbf{G}\mathbf{G}',$$

with

$$\mathbf{G} = (\mathbf{I} - \hat{\Phi}_1)\mathbf{H},$$

where $\hat{\Phi}_1$ is the estimated autoregressive parameter matrix of the VAR in Eq. (2) with $p=1$, and $\mathbf{H}$ is the matrix of unknown parameters defined in Eq. (12). For a set of T observations, the full likelihood is given by

$$\ln L = \sum_{t=1}^T \ln L_t,$$

which is maximized by choosing the parameters in $\mathbf{H}$. The optimization is performed in GAUSS Version 3.2 using the software MAXLIK with the derivatives computed numerically.

The parameter estimates of the long-run matrix $\mathbf{H}$ are presented in Table 2. The standard errors and associated t statistics reported are quasi-maximum likelihood estimates. These correspond to the end points shown in the impulse responses given in Fig. 2. The parameter estimates of the common shock component (λ_i) are all positive and statistically significant. The estimates of the parameters on the output shock, γ_1 , and the domestic interest rate shock, γ_2 , on the Australian equities are positive and negative, respectively. This is consistent with the present value model where the interest rate acts as a discounting factor and income represents dividend streams, see also Blanchard (1981). The short-run impact of an output shock on equities (not reported in Table 2 but evident in Fig. 2) is positive, in contrast to the evidence for the G7 countries reported in Hassapis and Kalyvitis (2002).

Table 2

Maximum likelihood estimates of the long-run parameters of the SVAR given by Eq. (12) standard errors and t statistics are based on quasi maximum likelihood estimates

	Parameter	Estimate	Standard error	t statistic
<i>Common shocks</i>				
Australia	λ_1	4.463	0.771	5.789
United States	λ_2	3.118	0.661	4.714
Japan	λ_3	10.003	1.193	8.388
Hong Kong	λ_4	5.122	1.969	2.602
Singapore	λ_5	10.177	2.148	4.738
Korea	λ_6	13.512	2.424	5.574
Taiwan	λ_7	19.302	3.023	6.386
<i>Idiosyncratic shocks</i>				
Australia	ϕ_1	4.305	0.356	12.100
United States	ϕ_2	5.168	0.415	12.462
Japan	ϕ_3	5.308	1.159	4.578
Hong Kong	ϕ_4	11.388	1.060	10.743
Singapore	ϕ_5	9.192	1.155	7.961
Korea	ϕ_6	9.816	1.231	7.973
Taiwan	ϕ_7	14.637	1.804	8.116
Output	ϕ_8	1.166	0.116	10.048
Interest	ϕ_9	1.094	0.107	10.223
<i>Contagion effects from</i>				
United States	δ_1	2.806	0.582	4.819
Japan	δ_2	0.035	0.045	0.775
Hong Kong	δ_3	1.728	0.554	3.118
Singapore	δ_4	0.350	0.685	0.511
Korea	δ_5	−0.912	0.636	−1.434
Taiwan	δ_6	0.884	0.761	1.163
<i>Impact of shocks on interest rates</i>				
	ρ_1	0.051	0.158	0.320
	ρ_2	0.813	0.141	5.776
<i>Impact of domestic shocks on share prices</i>				
	γ_1	1.885	0.695	2.713
	γ_2	−1.005	0.619	−1.624

Of the six international stock markets included in the empirical analysis, just the United States (δ_1) and Hong Kong (δ_3) operate with an additional statistical linkage with the Australian stock market over and above the common equity market linkage. It is interesting to observe that the long-run parameter estimate connecting Korea and Australia is negative (δ_5), although statistically insignificant at conventional significance levels. This is in contrast to all of the other long-run parameter estimates connecting international stock markets with the Australia stock market.

The δ_i parameters measure the effects of unanticipated transmissions to the Australian equity market and as such are interpreted as evidence of contagion effects from the individual markets to Australia. The evidence here is that only the U.S. and Hong Kong

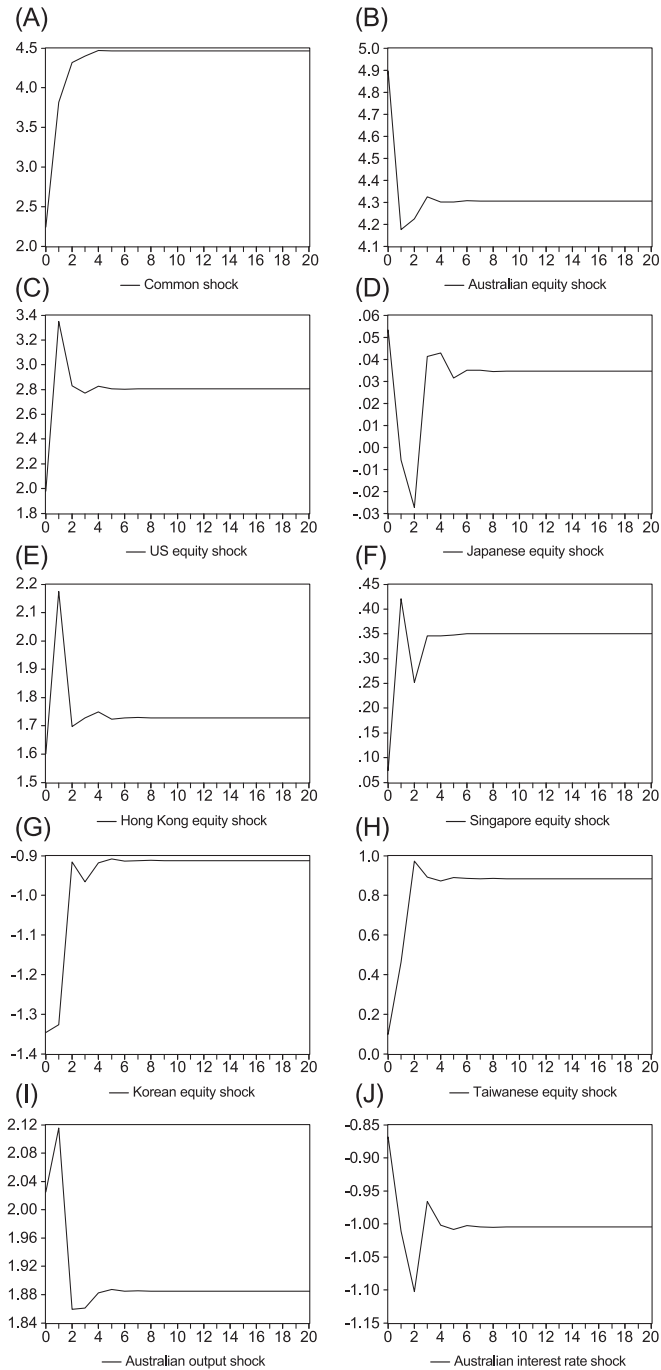


Fig. 2. Dynamic impulse responses for Australian real share prices (in logs).

markets transmitted statistically significant contagion effects. This concurs with the period under examination, where Hong Kong was the source of the Asian equity shock in 1997 and the United States was the source of the dot-com shock in 2000. The significance of contagion from the United States is also consistent with the analysis of Kaminsky and Reinhart (2002), who conclude that developed financial centers are important in transmitting crises between equity markets. The insignificant contagion effects from the other countries are also consistent with the findings of Ellis and Lewis (2000).

To identify the statistical significance of shocks in the five Asian stock markets, a likelihood ratio test is performed by comparing the unconstrained log of the likelihood with the constrained value based on setting

$$\delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0,$$

in Eq. (12). The value of the test statistic is 13.873, which has a p -value of .016. This suggests that at the 5% level shocks in the Asian stock markets are jointly significant. As already noted above, the t statistics reported in Table 2 show that this result is primarily due to shocks originating in Hong Kong.

As a further test of the joint significance of shocks in both the Asian equity markets and the U.S. equity market, a likelihood ratio test is performed by testing the restrictions

$$\delta_i = 0, \forall i.$$

The value of the test statistic is 37.207, which has a p -value less than .001 showing evidence of significant contagion from all international equity markets studied, to Australia.

The parameter estimate of ρ_1 shows that common shocks in financial markets do not have a statistically significant long-run effect on Australian interest rates. However, the effect is positive showing that increased returns in equity markets are matched by increased returns in bond markets to maintain long-run equilibrium in asset markets.

3.3. Dynamics

To investigate both the short-run and intermediate-run dynamical interrelationships among equity markets, the dynamic impulse responses are given in Fig. 2 for the case of real Australian share prices in terms of the 10 shock variables in the SVAR model. The impulse responses are constructed from the estimated VAR model with the variables expressed in returns and then cumulated to obtain the impulse responses for the Australian real share price (expressed in natural logarithms). The long-run impulse responses by construction correspond to the long-run parameter estimates reported in Table 2.

The results show that a positive shock common to all equity markets leads to an immediate increase in the Australian real share price. Further increases in the Australian real share prices follow, converging eventually to a higher level. The higher share price in Australia is also associated with higher share prices in all countries included in the model as a result of the estimates of λ_i reported in Table 2 being all positive.

A positive shock to real Australian equities is followed by a correction to the market as the Australian share price falls, and then levels off within a year at a positive level. Rapach (2001) finds similar results for U.S. portfolio shocks on the U.S. share price, although the

correction takes place over a longer time horizon. The response of the Australian share price to shocks in the U.S., Hong Kong, and Singapore equity markets result in similar dynamic response paths, with the Australian real share price increasing in the first quarter, correcting in the second quarter, and leveling off within the year at a higher value. A shock in the Taiwanese equity market also behaves in the same way except that the Australian real share price increases over two quarters before showing signs of a correction. Shocks originating in the Japanese equity market at first result in an increase in the Australian real share price, but after two quarters there is an over correction in Australian equities with real share prices falling below the preshock level. There is yet another correction in the positive direction whereby the Australian real share price settles at a higher level in the long run.

An Australian output shock immediately raises expectations of increases in future earnings and subsequent higher dividend streams, leading to higher real share prices in Australia. There is a correction in the real share price with the net effect of a positive increase in real share prices in the long run from the output shock. A shock to Australian interest rates immediately causes a devaluation in share prices as a result of the higher discounting of future dividends. Australian real share prices fall over the next two quarters before settling upon a lower level in the long run.

3.4. Decomposing shocks

The relative strength of various shocks to the volatility of Australian real share prices is given in Table 3. This table gives the percentage contribution of the cumulative effects of each of the 10 shocks to the variance of real share prices in Australia over selected forecast horizons. The long-run decompositions for Australian real share prices are computed analytically as follows

$$\begin{aligned}
 \text{Common shock :} & \quad 100\lambda_1^2/\text{Total} \\
 \text{Australian equity shock :} & \quad 100\phi_1^2/\text{Total} \\
 \text{U.S. equity shock :} & \quad 100\delta_1^2/\text{Total} \\
 \text{Japanese equity shock :} & \quad 100\delta_2^2/\text{Total} \\
 \text{Hong Kong equity shock :} & \quad 100\delta_3^2/\text{Total} \\
 \text{Singaporean equity shock :} & \quad 100\delta_4^2/\text{Total} \\
 \text{Korean equity shock :} & \quad 100\delta_5^2/\text{Total} \\
 \text{Taiwanese equity shock :} & \quad 100\delta_6^2/\text{Total} \\
 \text{Australian output shock :} & \quad 100\gamma_1^2/\text{Total} \\
 \text{Australian interest rate shock :} & \quad 100\gamma_2^2/\text{Total}
 \end{aligned} \tag{13}$$

Table 3

Variance decomposition of Australian real share prices arising from alternative shocks: percentage of total

Quarters	Common equity	Australian equity	U.S. equity	Japanese equity	Hong Kong equity	Singapore equity	Korean equity	Taiwan equity	Australian output	Australian interest
1	11.905	56.850	9.299	0.007	6.079	0.013	4.302	0.024	9.734	1.789
2	20.037	42.350	15.486	0.003	7.460	0.186	3.655	0.229	8.776	1.817
3	25.196	39.068	15.270	0.002	6.709	0.162	2.910	0.773	7.937	1.974
4	27.853	37.728	14.926	0.003	6.371	0.177	2.587	0.953	7.502	1.900
8	31.985	35.419	14.547	0.002	5.864	0.198	2.022	1.185	6.922	1.855
12	33.294	34.704	14.414	0.002	5.695	0.206	1.843	1.261	6.740	1.841
16	33.937	34.353	14.349	0.002	5.612	0.209	1.755	1.298	6.651	1.835
20	34.319	34.144	14.310	0.002	5.563	0.212	1.702	1.320	6.597	1.831
∞	35.819	33.324	14.158	0.002	5.370	0.220	1.496	1.407	6.388	1.815

where the total variance is given by

$$\text{Total} = \lambda_1^2 + \phi_1^2 + \delta_1^2 + \delta_2^2 + \delta_3^2 + \delta_4^2 + \delta_5^2 + \delta_6^2 + \gamma_1^2 + \gamma_2^2.$$

The estimates of the long-run decompositions are obtained by substituting the parameter estimates from Table 2 in Eq. (13).

Table 3 shows that over half of the variance of real share prices originates from the Australian equity market in the short run. There are also important contributions from common shocks associated with all equity markets (11.9%), shocks in the U.S. equity market (9.3%), and a smaller role from the Hong Kong equity market (6.1%). The importance of the U.S. shock is also emphasized by Dekker et al. (2001) and Janakiraman and Lamba (1998) using daily data without controlling for common and domestic shocks and in de Roos and Russell (2000). In addition, Dekker et al. find that Hong Kong is important across a range of equity markets and that the contribution from Japan is quite small, consistent with the results reported in Table 3. Here, domestic output shocks contribute just under 10% to the Australian equity market. Shocks arising in the Japanese, Singaporean, and Taiwanese equity markets contribute less than 1% each to volatility in real Australian share prices. Domestic interest rate shocks are also found to contribute very little to movements in Australian real share prices.

Over time, the importance of common shocks experienced by all equity markets on Australian real share prices increases, with over one third of the variance of real share prices in Australia being explained by these common shocks after 20 quarters. The relative importance of U.S. equity market shocks also rises over time with the contribution being almost 15% after 5 years. Using daily data, Dekker et al. (2001) and Eun and Shim (1989) report a forecast error variance decomposition effect of the United States on Australian equity markets of 18% and 15%, respectively, at a 15-day horizon, without controlling for common factor effects.

The relative role of Australian output shocks in the short-run diminishes over time, as does shocks arising in the Hong Kong equity market. All other shocks contribute very little to Australian real share prices over all time periods investigated.

In the long run, the main contributors to explaining real share prices in Australia are common equity market shocks and shocks originating in the Australian equity market, with nearly 70% of the variance in the real share prices explained by these two shocks. U.S. equity shocks in the long run explain nearly 15% of variations in Australian real share prices. The remaining seven shocks explain about 15% of variations in Australian real share prices with equity shocks in Hong Kong (5.4%) and domestic output shocks (6.4%) providing the largest contribution within this set.

3.5. The Asian financial crisis and the U.S. dot-com crisis

The effects of contagion from international equity markets to the Australian equity market were tested by the significance of the parameters δ_i in Section 3.2. These tests were constructed for the entire period, while contagion effects are arguably centered on the crisis periods of the East Asian and dot-com crises. One way to proceed is to use the estimated SVAR model to perform a historical decomposition of Australian real share prices over the period of the crises. The historical decomposition provides a time series of the relative importance of shocks, which are used to identify any significant channels that transmit unanticipated shocks from international equity markets to the Australian equity market. To identify the contagious transmissions separately, it is necessary to identify the base forecast of the model initially. These are the forecasts of real share prices over the crisis periods, conditional on information prior to the crises. If there are negative shocks occurring in international equity markets, there should be a significant devaluation of Australian real share prices below these base forecast levels.

The historical decomposition of Australian real share prices in terms of the 10 “structural” shocks and the base forecast is constructed from the VMA representation of the model in Eq. (5)

$$\Delta Z_t = \beta + (I + \Theta_1 L + \Theta_2 L^2 + \dots + \Theta_q L^q + \dots) \mathbf{G} v_t$$

$$\Delta Z_t = \beta + \sum_{i=0}^{\infty} \Theta_i \mathbf{G} v_{t-i},$$

where $\Theta_0 = I$. Writing this model at time $T+H$ and defining the crisis period as $T+1$ to $T+H$ gives the historical decomposition over all forecast horizons H

$$\Delta Z_{T+H} = \sum_{i=0}^{H-1} \Theta_i \mathbf{G} v_{T+H-i} + \left[\beta + \sum_{i=H}^{\infty} \Theta_i \mathbf{G} v_{T+H-i} \right]. \quad (14)$$

The term in square brackets represents the forecasts of the variables given information at time T . Defining T to be the end of the precrisis period, this term captures the conditional forecasts as it represents what the values of the variables should be over the crisis period if they are to follow their sample dynamics. The first term in Eq. (14) gives the separate impact of each of the 10 “structural” shocks at each point in time over the forecast period on the variables in the model.

The results of the historical decomposition are given in Fig. 3. The end of the precrisis period (T) is taken as the first quarter of 1997. The historical decomposition is then performed over the remaining sample; that is, $\mathbf{H}$ begins in the June quarter of 1997 and ends on the last day of the sample, the March quarter of 2002. The historical decomposition is computed by replacing the unknown parameters by their estimated values. The “structural” shocks are computed from Eq. (4) by taking the inverse of $\mathbf{G}$ to get

$$v_t = \mathbf{G}^+ e_t, \quad (15)$$

where e_t is replaced by the estimated residuals obtained from the estimated VAR, and $\mathbf{G}^+$ is the generalized inverse of a matrix using the Moore–Penrose inverse, which is needed as $\mathbf{G}$ is a rectangular matrix. Finally, all terms in the historical decomposition in Eq. (14) are cumulated to obtain the historical decomposition in terms of real Australian share prices.

Panel A in Fig. 3 compares the base forecast over the crises period, with actual real share prices in Australia, expressed in natural logarithms and multiplied by 100. This

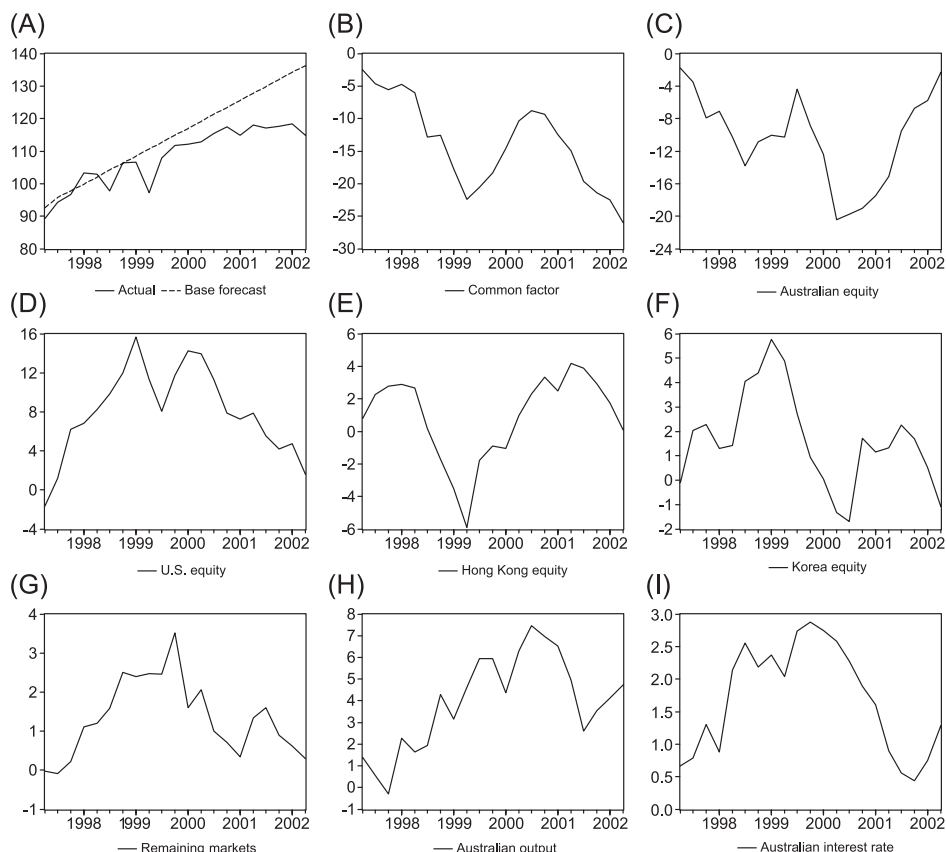


Fig. 3. Decomposition of Australian real equity prices into contributions of alternative shocks to Australian real share prices, in natural logarithms multiplied by 100, 1997–2002.

graph shows that in the immediate aftermath of the Asian crisis, Australian real share prices tended to keep pace with the conditional forecasts. Panel B, however, shows that the common factor was reflecting a general downturn in the selection of equity markets at this time—the line is below the zero point. In addition, panel C shows negative shocks arising from the Australian equity market—given as the negative and declining value of the line in panel C over 1998. The offsetting effect that results in the base forecast and actual observed equity price being aligned over the first 2 years of the decomposition as shown in panel A is due to positive contributions from the U.S. equity market in 1998 and 1999—shown in panel D.

In 1999, Australian share prices fell below the base forecast, a gap emerges between the two lines in panel A. This is a result of the continual deterioration of world equity markets given by the decline in the common factor (panel B). In addition, the Hong Kong market contributes negatively to the Australian share price at this point as shown by the dip in the Hong Kong equity market factor in panel E.

The widening gap between the base forecast and realized real share prices shown in panel A after 2000 appears to be mainly associated with the dot-com collapses from April 2000. There are relatively large negative influences from the common factor shown in panel B and the Australian equity factor in panel C during this period. The negative shocks in the United States are reflected by the negative slope of the U.S. equity factor (panel D) from April 2000.

The Australian equity factor (panel C) reaches its nadir shortly before the dot-com crisis and then begins to accumulate relatively rapidly to the end of the sample. This is despite the U.S.-based negative productivity shock reflected in the U.S. equity market index. The characteristics of the Australian equity factor are consistent with its so-called old economy investment structure. In 1999, this was seen as a negative factor (de Long, 2000) but from 2000 onwards has protected the Australian equity market from international declines. This analysis is consistent with Edison and Sløk (2001) who find that changes in new economy stock prices have greater consumption effects in the United States than old economy stocks. However, this result is in contrast to Castrén, Miller, and Stiegert (2003) and Greenspan (2002) who indicate that the expansion in the U.S. economy and subsequent dot-com productivity shock were distributed internationally through the holdings of U.S. equities by international investors in a form of international ‘risk sharing.’

4. Conclusions

In this paper, a structural VAR model is used to identify the sources of shocks to Australian real share prices. Both shocks common to international equity markets as well as shocks originating in individual country equity markets are identified. In addition, the relative importance of domestic output and interest rate shocks is also studied. An important feature of the model, which distinguishes the model from other SVAR models, is that the number of shocks exceeds the number of variables in the model. This feature of the model is used to identify common shocks arising in international equity markets and thereby provides a parsimonious parameterization of the model.

The key empirical results of the paper are that real share prices in Australia are primarily determined by equity shocks common to all international equity markets and shocks originating in the Australian equity market. The relative importance of the uniquely Australian equity shocks points to potential diversification opportunities in Australian equities over this period. U.S. equity market shocks are also found to be significant and tend to become relatively more significant over longer horizons. There are minor roles given to shocks originating in the Hong Kong equity market as well as domestic output markets; however, the relative contribution of these shocks dissipate over time. There are no substantial linkages identified from other international equity markets or from shocks arising from domestic interest rates. That the two major shocks to international equity markets during the sample period occurred in Hong Kong and the United States are consistent with the evidence here of contagion from those two countries but not from the other equity markets.

The model was also used to identify the contribution of contagious transmission mechanisms arising from the Asian financial crisis in 1997–1998 and the dot-com crisis in the U.S. equities in 2000 to the Australian share market. The main outcome of this empirical analysis was that again common shocks and Australian equity shocks were the most important components during these periods. Australian equities were sustained during the dot-com crisis primarily by domestic factors in the face of negative effects from U.S. and common shocks. The results showed evidence of contagion from Hong Kong and the United States, consistent with the origins of the equity market shocks of the Asian and dot-com crises, respectively. Other countries in the sample had little impact.

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References

- Bilson, C. M., Brailsford, T. J., & Hooper, V. J. (2001). Selecting macroeconomic variables as explanatory factor of emerging stock market returns. *Pacific Basin Finance Journal*, 9, 401–426.
- Blanchard, O. (1981). Output, the stock market and interest rates. *American Economic Review*, 71, 132–143.
- Blanchard, O., & Quah, D. (1989). The dynamic effects of aggregate demand and supply disturbances. *American Economic Review*, 79, 655–673.
- Campbell, J. Y., & Shiller, R. J. (1988). Stock prices, earnings and expected dividends. *Journal of Finance*, 43, 661–676.
- Castrén, O., Miller, M., & Stiegert, R. (2003). *Growth expectations, capital flows and international risk sharing*. European Central Bank Working Paper, no. 237.
- Cha, B., & Oh, S. (2000). The relationship between developed equity markets and the pacific basin's emerging equity markets. *International Review of Economics and Finance*, 9, 299–322.
- Dekker, A., Sen, K., & Young, M. R. (2001). Equity market linkages in the Asia Pacific region. A comparison of the orthogonalised and generalized VAR approaches. *Global Finance Journal*, 12, 1–33.

- de Long, J. B. (2000). What went right in the 1990s? Sources of American and prospects for world economic growth. In D. Gruen, & S. Shrestha (Eds.), *The Australian economy in the 1990s: Proceedings of a conference (Reserve Bank of Australia, Sydney)* (pp. 8–23).
- de Roos, N., & Russell, B. (2000). An empirical note on the influence of the US stock market on Australian economic activity. *Australian Economic Papers*, 39, 291–300.
- Dornbusch, R., Park, Y. C., & Claessens, S. (2000). Contagion: Understanding how it spreads. *World Bank Research Observer*, 15, 177–197.
- Dungey, M., Fry, R., & Martin, V.L. (2003). *Identification of common and idiosyncratic shocks in real equity prices: Australia, 1982–2002*. Australian National University Trade and Development Working Paper, 2003/18.
- Dungey, M., & Martin, V. L. (2001). *Contagion across financial markets: An empirical assessment*. New York Stock Exchange Conference Paper, February 16–17, 2001, Hawaii.
- Edison, H., & Sløk, T. (2001). *Wealth effects and the new economy*. International Monetary Fund Working Paper WP/01/77.
- Ellis, L., & Lewis, E. (2000). The response of financial markets in Australia and New Zealand to news about the Asian crisis. In *BIS Conference on International Financial Markets and the Implications for Monetary and Financial Stability, Basel, 25–26 October, 1999*, vol. 8, pp. 308–348.
- Eun, C. S., & Shim, S. (1989). International transmission of stock market movements. *Journal of Financial Quantitative Analysis*, 24, 241–256.
- Faff, R. W., & Brailsford, T. J. (1999). Oil price risk and the Australian stock market. *Journal of Energy Finance and Development*, 4, 69–87.
- Fama, E. (1981). Stock returns, real activity, inflation and money. *American Economic Review*, 71, 545–565.
- Favero, C. A., & Giavazzi, F. (2002). Is the international propagation of financial shocks non-linear? Evidence from the ERM. *Journal of International Economics*, 57, 231–246.
- Forbes, K., & Rigobon, R. (2002). No contagion, only interdependence: Measuring stock market co-movements. *Journal of Finance*, 57, 2223–2262.
- Fraser, P., & Groenwold, N. (1997). Share prices and macroeconomic factors. *Journal of Business Finance and Accounting*, 24, 1367–1383.
- Fraser, P., & Groenwold, N. (2001). Mean-variance efficiency, aggregate shocks and return horizon. *Manchester School*, 69, 52–76.
- Greenspan, A. (2002). *World finance and risk management, speech*. London: Lancaster House.
- Hamilton, J. (1994). *Time series analysis*. Princeton, NJ: Princeton University Press.
- Hassapis, C., & Kalyvitis, S. (2002). Investigating the links between growth and real stock price changes with empirical evidence from the G-7 economies. *Quarterly Review of Economics and Finance*, 42, 543–575.
- Janakiraman, S., & Lamba, A. S. (1998). An empirical examination of linkages between Pacific basin stock markets. *Journal of International Financial Markets, Institutions, and Money*, 8, 155–173.
- Kaneko, T., & Lee, B. (1995). Relative importance of economic factors in the US and Japanese stock markets. *Journal of the Japanese and International Economies*, 9, 290–307.
- Kaminsky, G. L., & Reinhart, C. M. (2002). *The center and the periphery: The globalization of financial turmoil*. Paper presented at the Third Joint Central Bank Research Conference on Risk Management and Systemic Risk, 7–8 March, 2002 (BIS, Switzerland).
- Knif, J., & Pynnonen, S. (1999). Local and global price memory of international stock markets. *Journal of International Financial Markets*, 9, 129–147.
- Lee, B. -S. (1992). Causal relations among stock returns, interest rates, real activity and inflation. *Journal of Finance*, 47, 1591–1603.
- Masih, A. M. M., & Masih, R. (1997). Modelling the dynamic linkages and the propagation mechanism among major international stock markets: Empirical evidence from the pre- and post-crash eras based on a multivariate cointegration/VECM approach. *Quarterly Review of Economics and Finance*, 37, 859–885.
- Masson, P. (1999a). Contagion: Macroeconomic models with multiple equilibria. *Journal of International Money and Finance*, 18, 587–602.
- Masson, P. (1999b). *Contagion: Monsoonal effects, spillovers and jumps between multiple equilibria*. In P. R. Agenor, M. Miller, D. Vines, & A. Weber (Eds.), *The Asian financial crisis: Causes, contagion and consequences*. Cambridge, UK: Cambridge University Press, pp. 265–280.

- Masson, P. (1999c). *Multiple equilibria, contagion and the emerging market crises*. IMF Working Paper # 99/164.
- Papapetrou, E. (2001). Oil price shocks, stock market, economic activity and employment in Greece. *Energy Economics*, 23, 511–532.
- Pericoli, M., & Sbracia, M. (2001). A primer on financial contagion, Banca D'Italia Temi di discussione, 407.
- Pesaran, M. H., & Shin, Y. (1998). Generalised impulse response analysis in linear multivariate models. *Economic Letters*, 58, 17–29.
- Ragunathan, V. (1999). Financial deregulation and integration: An Australian perspective. *Journal of Economics and Business*, 51, 505–514.
- Ragunathan, V., Faff, R. W., & Brooks, R. D. (1999). Correlations, business cycles and integration. *Journal of International Financial Markets, Institutions, and Money*, 9, 75–95.
- Rapach, D. (2001). Macro shocks and real stock prices. *Journal of Economics and Business*, 53, 5–26.
- Ratanapakorn, O., & Sharma, S. C. (2002). Interrelationships among regional stock indices. *Review of Financial Economics*, 11, 91–108.
- Wurgler, J. (2000). Financial markets and the allocation of capital. *Journal of Financial Economics*, 58, 187–214.