THE RESPONSE OF AUSTRALIAN STOCK, FOREIGN EXCHANGE AND BOND MARKETS TO FOREIGN ASSET RETURNS AND VOLATILITIES

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ABSTRACT

This paper is a data-analytic study of the relationships among international asset price volatilities and the time-varying correlations of asset returns in a small open economy (Australia) with international asset returns.

Making use of recent developments in time-series approaches to volatility estimation, impulse response functions, variance decomposition, and Kalman filtering, I show that the Australian stock market volatility is most closely linked with volatility in the UK stock market, and the correlation of Australian stock returns with UK returns are high when there is increasing turbulence in financial markets. Volatility in the Australian dollar/US dollar exchange rate is most closely linked with volatility measures of the US dollar/Canadian dollar rate, and volatility in Australian long-term bond yields is most closely linked to volatility measures of long term German bond returns.

The results indicate that asset markets in a small open economy can adapt in different ways during periods of high or increasing volatility. The ways in which domestic volatility measures react to foreign turbulence, and the ways in which domestic returns correlate with international returns, depend on the particular circumstances (such as transactions costs and degree of risk aversion) which prevail in each financial market.

TABLE OF CONTENTS

THE RESPONSE OF AUSTRALIAN STOCK, FOREIGN EXCHANGE AND BOND MARKETS TO FOREIGN ASSET RETURNS AND VOLATILITIES

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1. INTRODUCTION

This paper is a study of the relationships between changing volatilities in international asset prices and time-varying correlations of domestic returns in a small open economy with international asset returns. In particular, I examine whether returns in Australian stock prices, long-term bond yields and exchange rates are more highly correlated with corresponding foreign stock prices, bond yields and exchange rates when measures indicate higher than normal volatility in the domestic or international markets.

The paper is data-analytic rather than model-theoretic. I make use of recent time-series methods, involving Schwert measures of volatility, VAR estimation, Granger causality, impulse response functions, variance-decomposition analysis and Kalman filtering to identify and quantify the international factors affecting the volatility of Australian asset prices.

The analysis draws on recent work by Kupiec (1991) as well as that by King and Wadhwani (1988) and King, Sentana, and Wadhwani (1991). While Kupiec drew attention to increasing correlations when market volatility is high, his empirical analysis was based on simple correlation coefficients in different sub-samples, when volatilities were higher than normal. He did not provide a direct test of the influence of volatility measures on time-varying correlations.

The correlation of international asset prices has been explained by the contagion model. King and Wadhwani argue that, in a "non-fully revealing equilibrium", price changes in one market depend on price changes in other markets through structural contagion coefficients. Such an equilibrium exists when the information structure is complex, and when domestic market prices do not reveal all relevant information to agents. Thus, valuable information is contained in prices that other traders in other markets are willing to pay. In this setting, of course, mistakes or idiosyncratic changes may be transmitted from one market to another[1].

There is also the possibility that, in periods of high or increasing turbulence in domestic or foreign markets, asset prices may also be more strongly correlated with their own past values. The reason for the presence of serial correlation when volatility is high is that during such periods, "rational investors may be unwilling to absorb the risk resulting from the transaction that would be necessary to eliminate this arbitrage opportunity" (King and Wadhwani (1988), p. 24).

I measure the volatility of the domestic and international asset prices by the Schwert (1988) index[2]. The time-varying estimates of international stock price correlations are computed by a Kalman filtering program described in Hansen and Sargent (1991). With time series for both the volatilities and the return correlations, I first examine the contemporaneous correlations among the volatility indices, as well as temporal patterns of causal interactions through VAR estimation and impulse response functions. I then consider the contemporaneous correlations and causal patterns among the international asset-return correlations and the volatility measures[3].

The next section is an analysis of the Australian and international stock prices. The two succeeding sections treat foreign exchange rates and bond yields. The final section concludes.

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[1] One justification for the non-fully revealing equilibrium offered by King and Wadhwani is the fact that markets are not open around the clock. Thus traders have an incentive to watch other markets for relevant information.

[2] The Schwert volatility index is computed as follows: (1) regress the stationary asset prices on seasonal dummies and lagged returns; (2) take absolute values of the residuals from the first stage, and regress these absolute values on their own lags and seasonal dummies. The predicted values from the second step are estimates of the standard deviation of the asset prices. This procedure is a two-step least-squares "short-cut" for the Bollerslev (1986) GARCH (generalized autoregressive conditional heteroskedastic) maximum likelihood estimation of the volatilities or "conditional variances" of the stock prices.

[3] All calculations for this paper were computed with MATLAB-386. Copies of the programs are available from the author or from the Economic Research Department of the Reserve Bank of Australia.

2. STOCK PRICE VOLATILITIES AND CORRELATIONS

Figures 1 through 6 picture the monthly (end-of-month series) stock price indices and estimated Schwert volatilities for six countries: Australia, Germany, Japan (Nikkei index), Singapore, United Kingdom (Financial Times) and the United States (Dow Jones).

For computing the volatility indices, all data were transformed into logarithmic values and first-differenced. The sample runs from the beginning of 1982 through March 1992. The end-of month data are normalised with January 31, 1985 set at 100[4].

All the figures show breaks in the stock price series at the time of the October 1987 crash. The "Black Monday" (or "Black Tuesday") crash appears as a sharper break in Australia, Singapore, the UK and the US than in Germany and Japan. The Nikkei index did plunge, but several years later, and the fall was less sharp than the break in Australia or Singapore.

The volatility measures appear to oscillate around a band close to .05, with very few departures, except on Black Monday/Tuesday, 1987. At this time, the volatility measure increased almost four-fold in Australia, three-fold in Singapore, and two-fold in the United Kingdom. Our results concur with Kupiec that there is no obvious trend toward increasing volatility in the 1980s.

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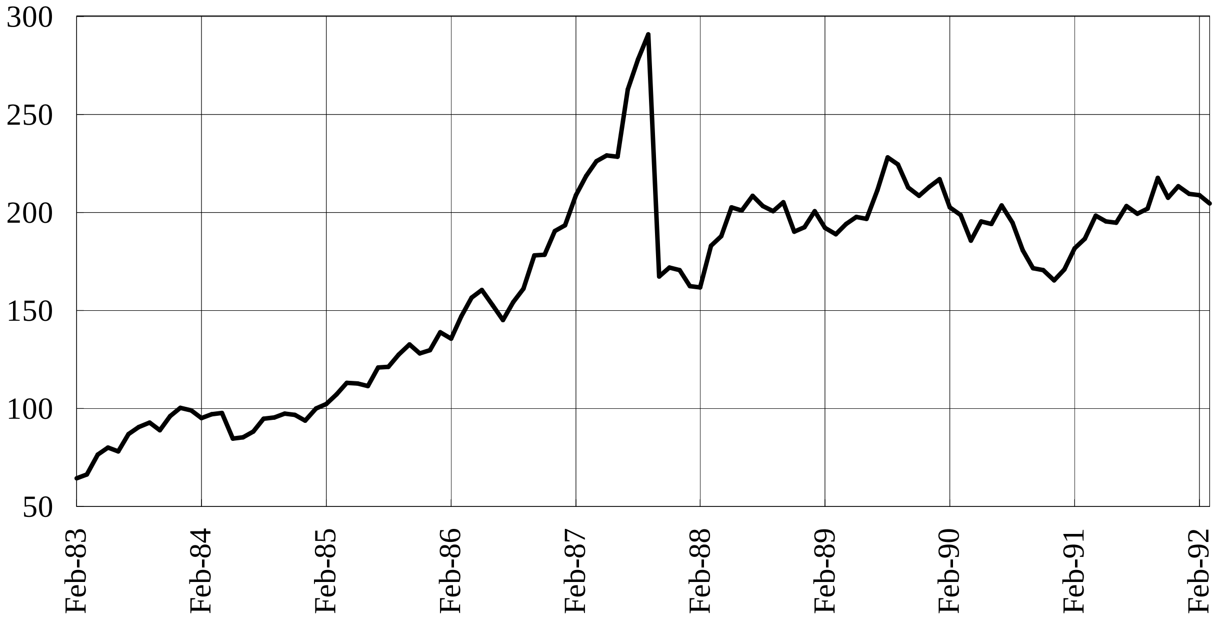
[4] In several cases, the Schwert volatility measures become negative. This is a drawback of this measure. Pagan and Schwert (1989) point out the importance of non-linearities in stock return behavior that can be captured neither by the ARCH nor GARCH model, nor by the Schwert measure, of asset-price volatility.

Figure 1

Australian Stock Index



Australian Stock Index: Volatility Measure

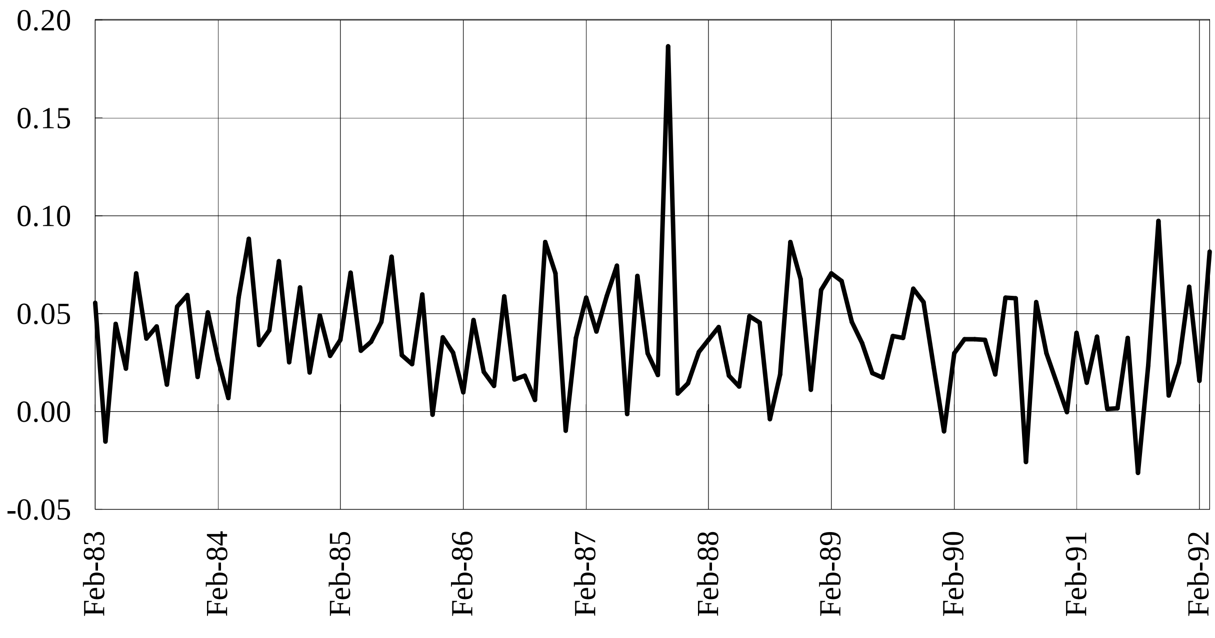
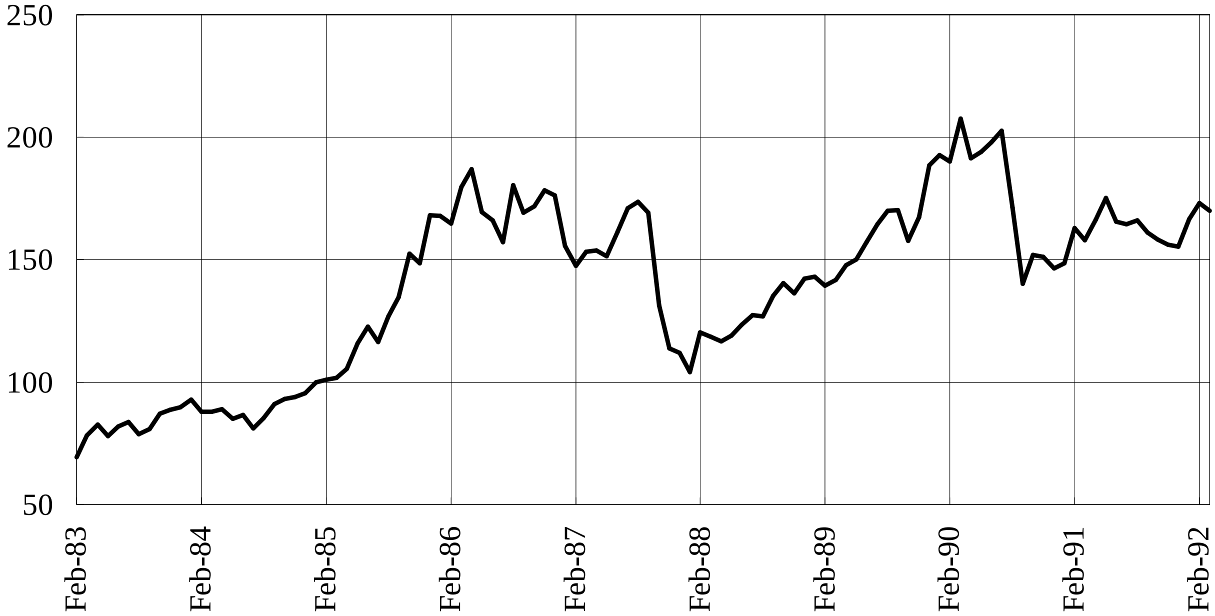


Figure 2

German Stock Index



German Stock Index: Volatility Measure

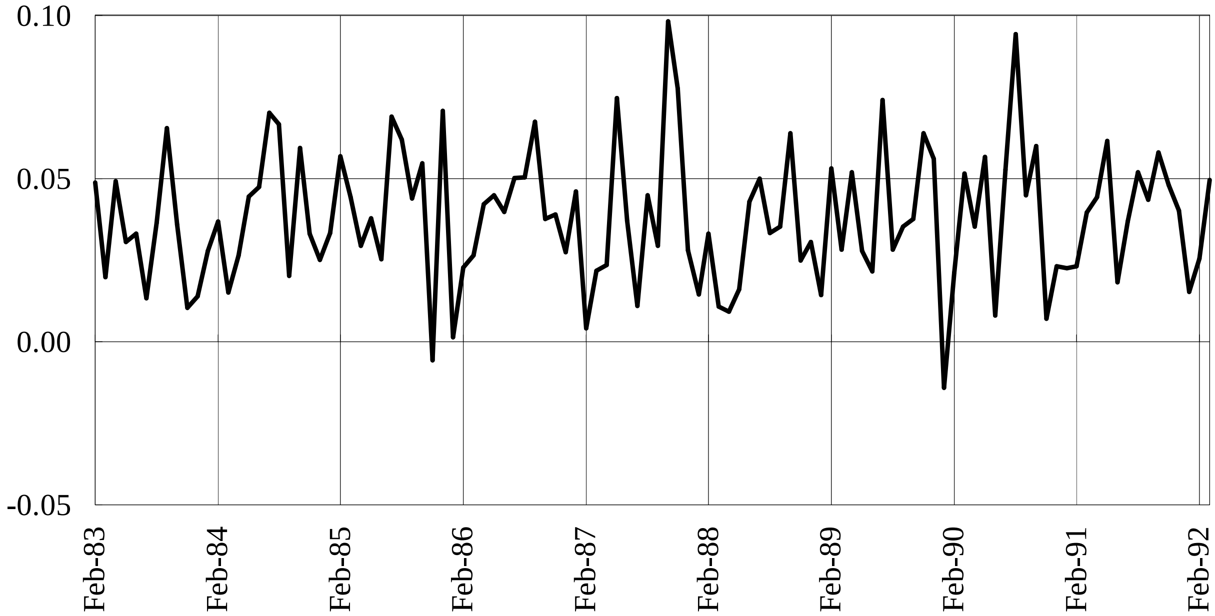
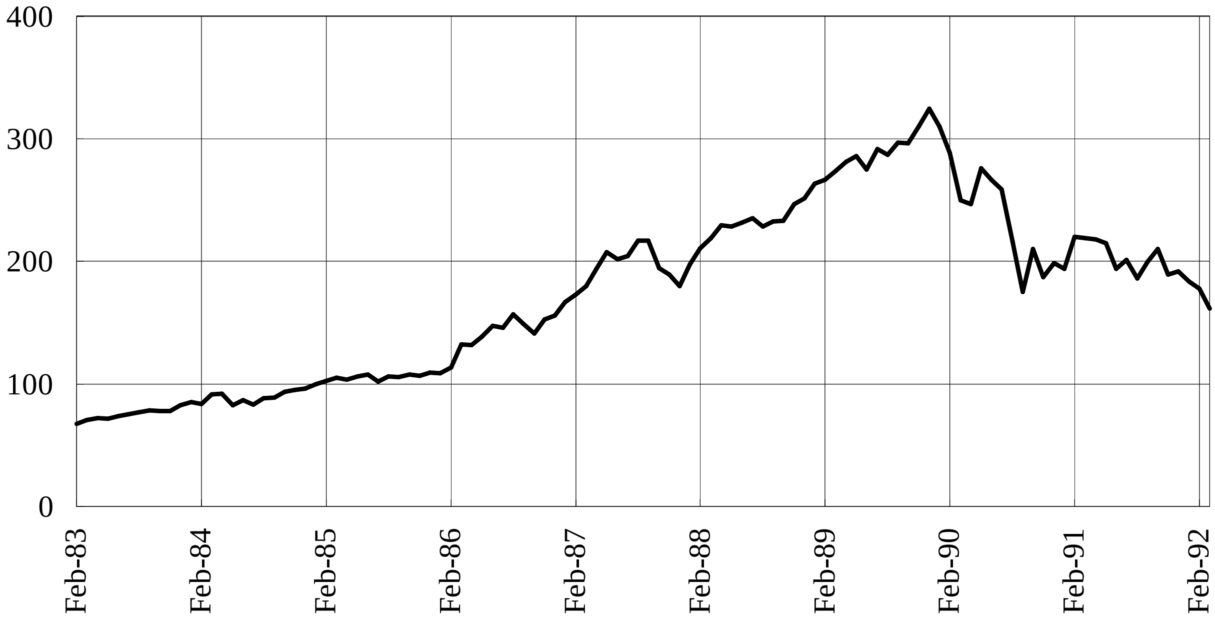


Figure 3

Japanese Stock Index



Japanese Stock Index: Volatility Measure

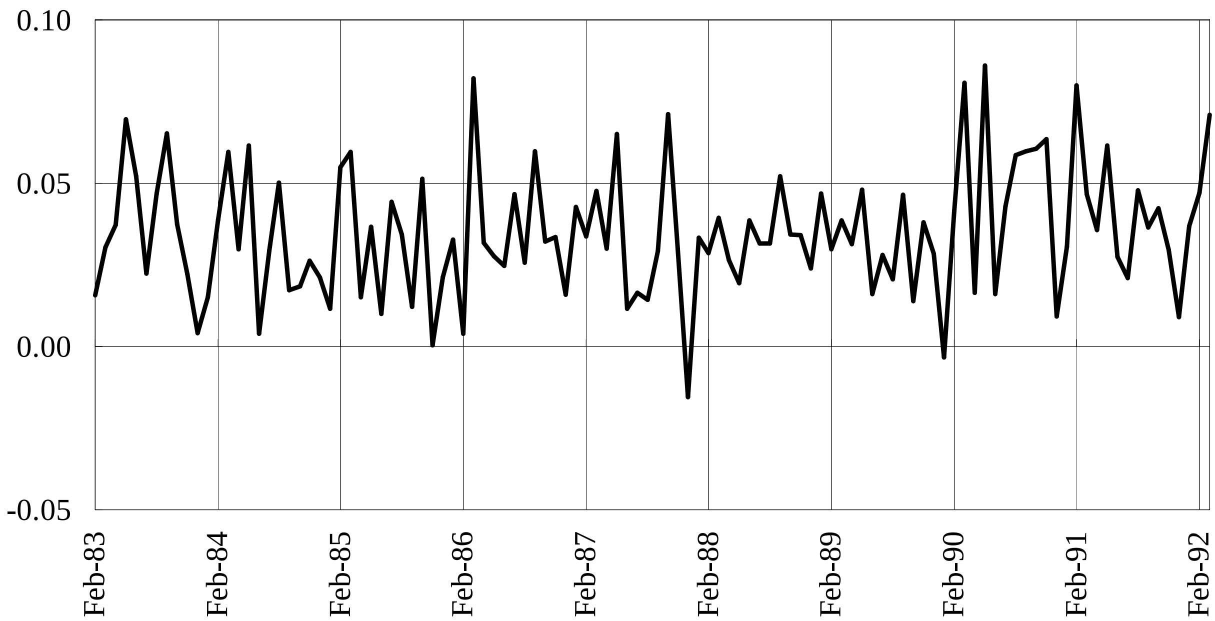
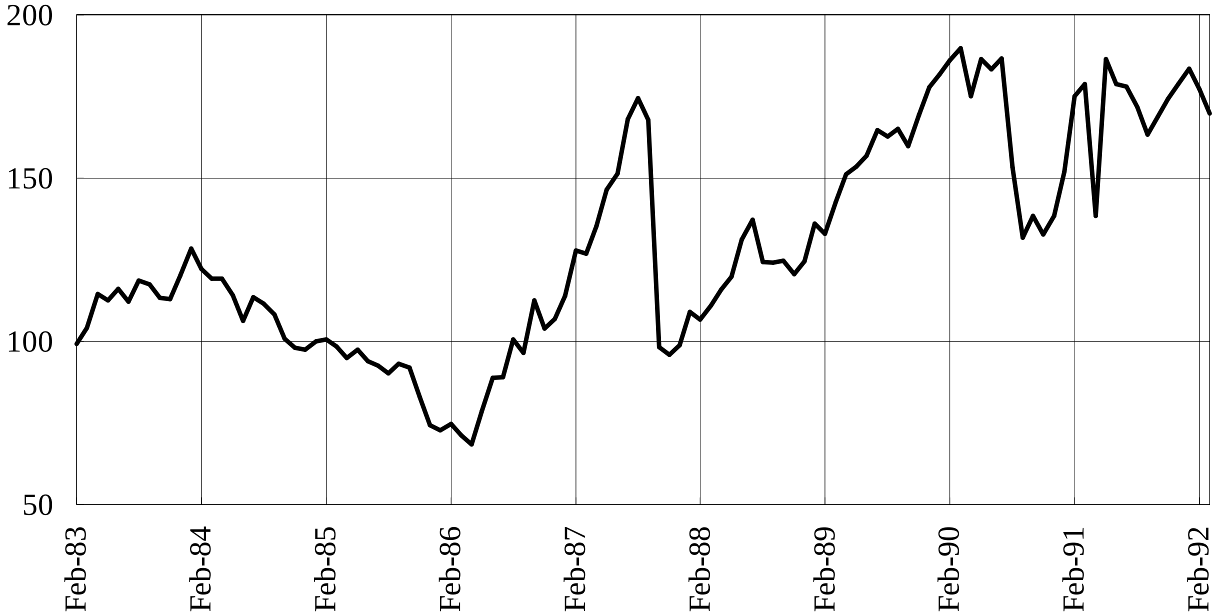


Figure 4

Singaporean Stock Index



Singaporean Stock Index: Volatility Measure

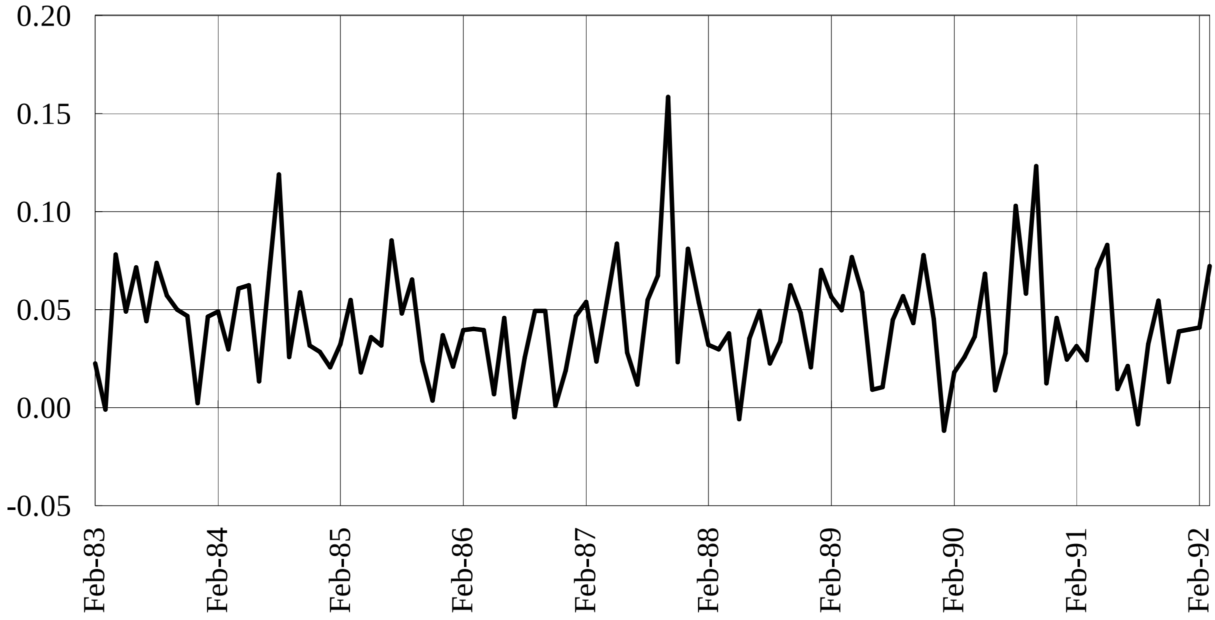
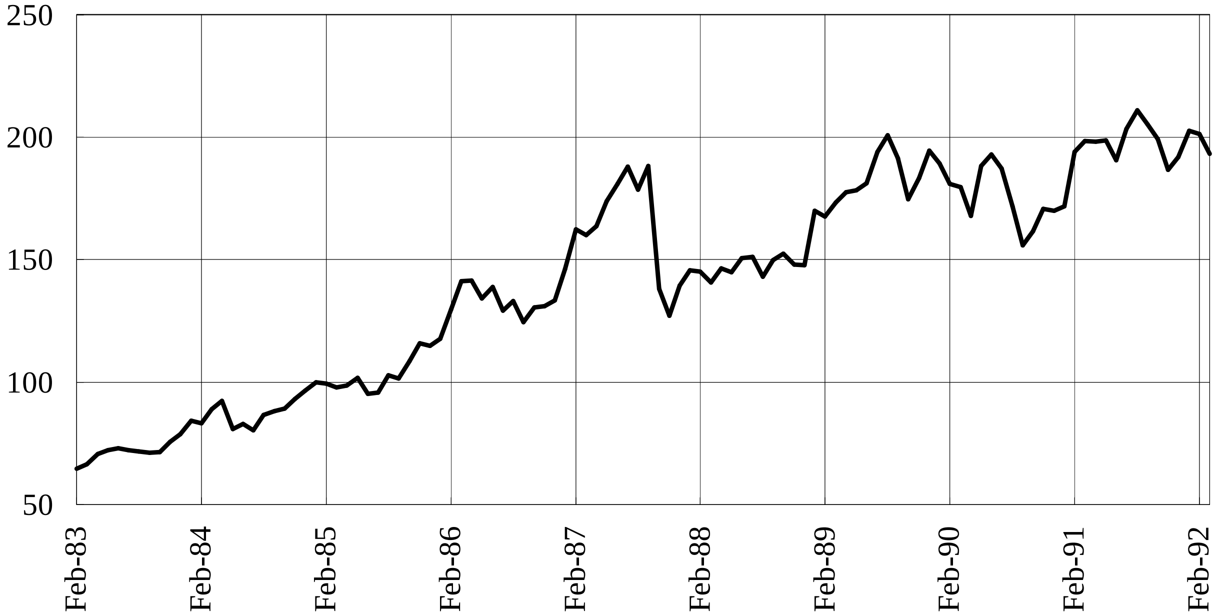


Figure 5

United Kingdom Stock Index



United Kingdom Stock Index: Volatility Measure

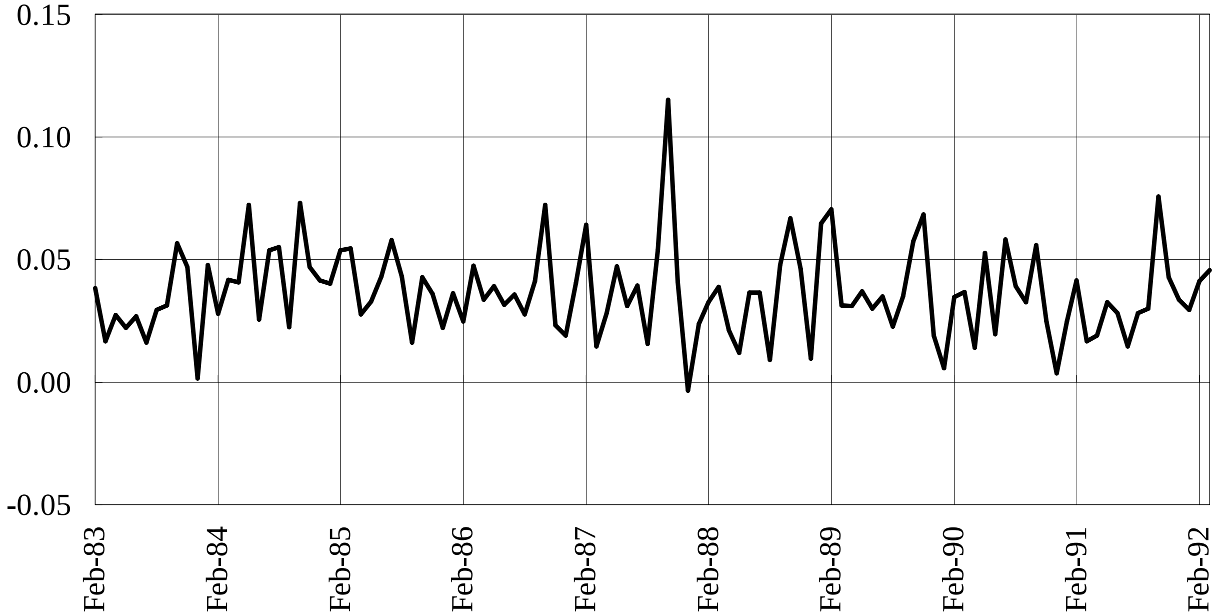
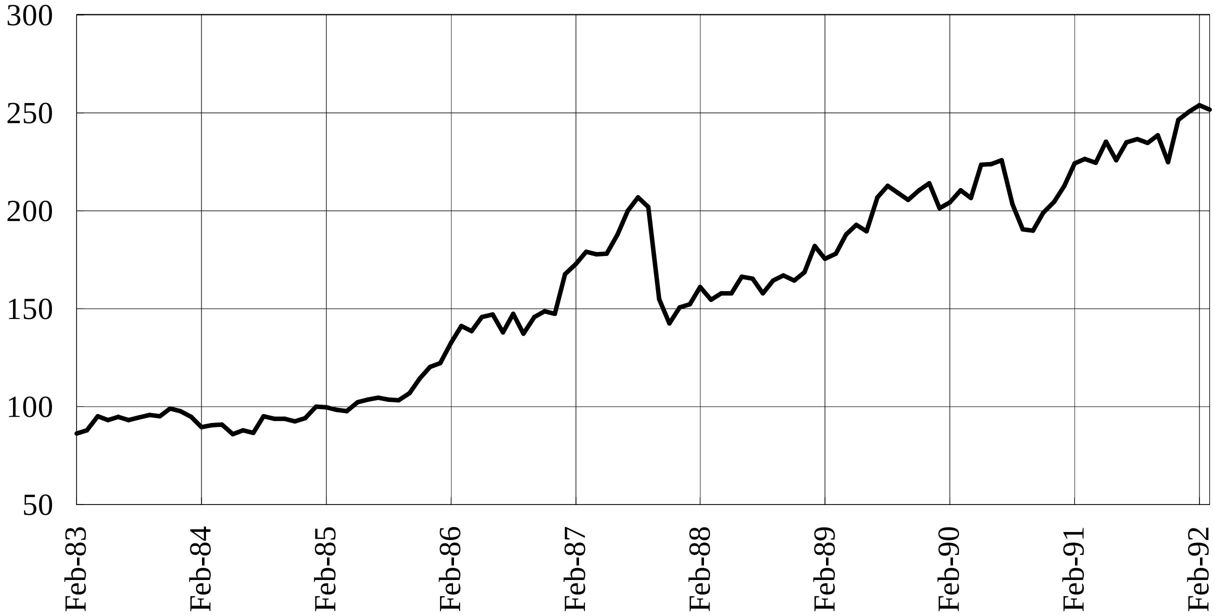
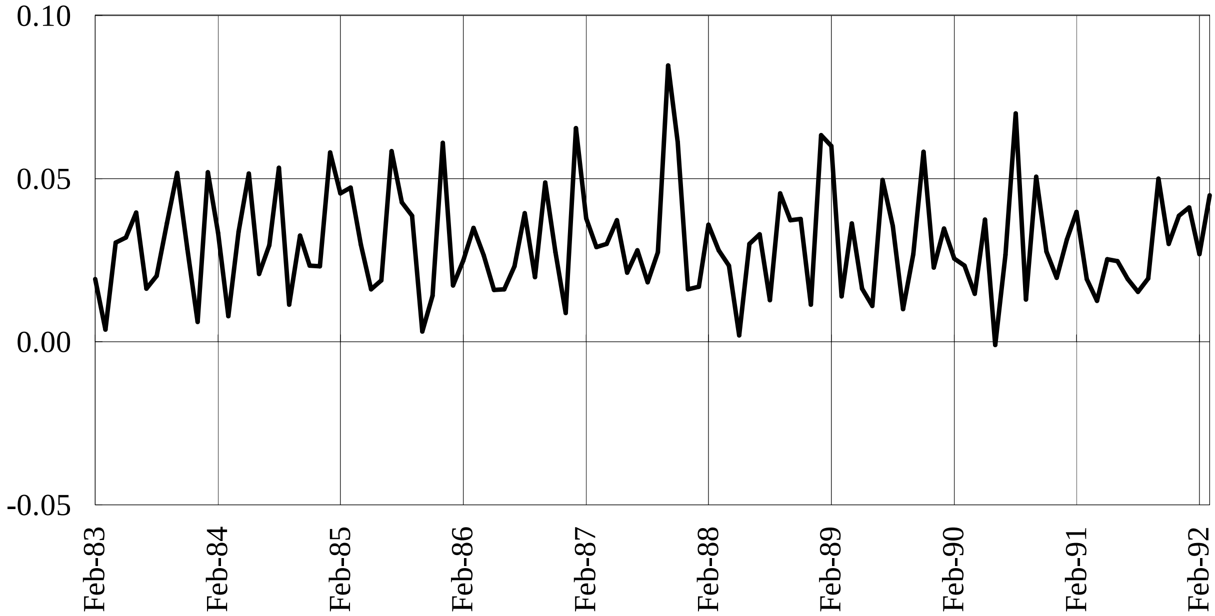


Figure 6

United States Stock Index



United States Stock Index: Volatility Measure



2.1. Contemporaneous Correlations

The estimated correlation coefficients of the volatilities appear in Table I, Panel A. What is surprising is the low correlation of Australian stock price volatility with volatility of the Nikkei index. The three highest correlations, in descending order, are with the UK Financial Times index, the Singapore index, and the US Dow Jones index. The correlation of the UK index with the Australian index is higher than the correlation of the UK index with the Dow Jones index.

2.2. Tests of Granger Causality

The F-statistics for a joint test of zero restrictions on the coefficients of the lags of each country in a VAR model of the volatility estimates appear in Panel B of Table I. The Wald statistics (calculated using a heteroskedasticity correction) for testing these zero restrictions appear in Panel C. Since the volatility of the data alters over the sample period, the heteroskedastic-consistent Wald statistics represent both a check on the standard F-test and a more accurate measure of significance[5].

The VAR model is a regression of each volatility measure on its own six lags, and the six lags of the five other countries. The critical values for the joint F-statistics are given in Panel B. If the joint F-statistics are below the critical values, then the past values do not provide significant information for predicting the dependent variable. The same holds true for the critical χ^2 values for the heteroskedastic-consistent Wald statistics.

Panel B shows that information on the volatility of the Australian index does not help to predict the volatility of the five other stock price indices. Information on the Australian stock index volatility only helps in prediction of the Australian stock index itself.

The joint F-tests also show the "most significant" volatility measure for predicting volatility in the Australian index is the volatility measure for the UK Financial Times index. This volatility measure has greater significance than the past values of the

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[5] See Judge, Hill, Griffiths, Lutkepohl, and Lee (1988) for a description of the Wald statistic for testing linear restrictions.

Table I

PANEL A

Correlation Coefficients of Stock-Price Volatility Measures, Schwert Index

	Aust	Germ	Nikkei	Sing	UK	DJ
Aust	1.00					
Germ	0.31	1.00				
Jap	0.27	0.38	1.00			
Sing	0.58	0.51	0.37	1.00		
UK	0.68	0.41	0.43	0.50	1.00	
DJ	0.54	0.48	0.28	0 50	0.61	1.00

PANEL B

VAR Model of Stock-Price Volatilities

F-Statistic on Zero Restrictions

F(6/56) = 2.27(5%); 3.08(1%)

	Dependent Variable					
	Australia	Germany	Japan	Singapore	UK	US
Australia	2.91	1.37	0.66	1.40	1.38	1.10
Germany	3.88	2.91	2.41	6.04	2.96	2.79
Japan	2.53	2.23	3.05	5.76	1.70	1.62
Singapore	3.37	1.31	4.22	3.56	2.82	1.54
UK	4.40	3.91	2.73	3.44	2.54	3.34
US	2.64	1.43	3.36	1.58	3.19	2.98

PANEL C

Wald Statistics (With Heteroskedasticity Correction)

VAR Model of Stock-Price Volatilities

$X^2(6) = 12.59(5\%); 16.81(1\%)$

	Dependent Variable					
	Australia	Germany	Japan	Singapore	UK	DJ
Australia	67.4	38.7	18	66.7	22.1	24.2
Germany	107	67.4	34	143	40.2	44.4
Japan	171	114	68	249	66.2	73.4
Singapore	61.4	33	22	71.3	20.9	22.6
UK	182	120	60	192	65.2	78.1
US	142	87	57	146	61.9	67.8

Australian volatility index. The significance levels on past volatilities of the German and Singaporean index are also higher than the significance level for past values of the Australian index. Note, however, that higher significance levels do not necessarily imply a more economically important effect.

The heteroskedastic-consistent Wald statistics show a slightly different pattern: the UK Financial Times index, the Nikkei index (rather than the German index), and the Dow-Jones index are the three most significant explanators of the Australian stock-price volatility. However, information on the German index continues to outweigh the significance of past values of the Australian index itself.

The other "small" country considered is Singapore. The two most significant determinants of its stock-price volatility are the Nikkei index and the Financial Times index. By contrast, the most significant determinant of volatility in the Nikkei index is its own lagged values.

Of course, one limitation on this analysis is that the VAR and Granger causality pattern assume linear stochastic processes for the variables. In fact, the volatility measures, which approximate variances, are non-linear transformations of the logarithmic first-differences of the stock prices. Thus, the significance of the F and Wald statistics is subject to qualification.

2.3. Impulse Response Functions and Variance Decomposition

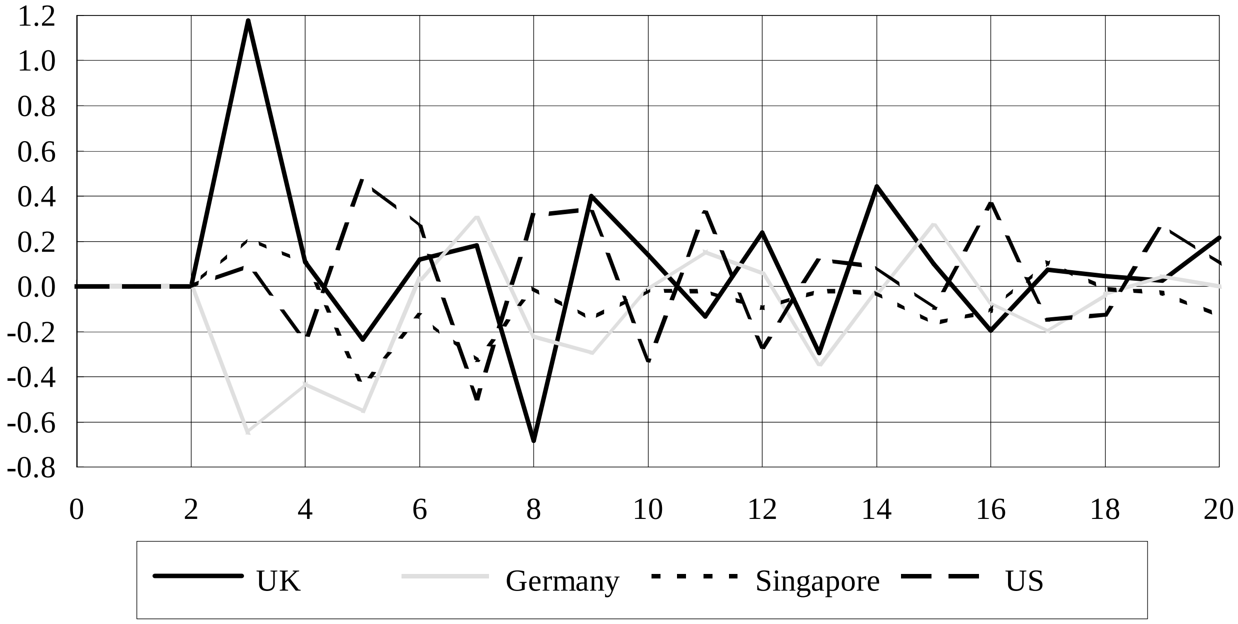
The impulse response functions for the volatility measure of the Australian share market index for unit shocks in UK, German, Singapore, and US volatility measures appear in Figure 7.

The impulse response functions come from inversion of a VAR model, via the Wald transformation, to a moving-average representation. The advantage of the impulse-response function is that it allows "innovation accounting". In this procedure, one sets all initial values to zero, and shocks one of the variables to a unit value at time t = 1. The response function indicates what happens to the system in succeeding periods, from period t = 2 onwards, if no further shocks occur. In Figure 7, the impulse response extends twenty periods[6].

Figure 7 shows that the largest response comes from a unit shock in the UK volatility measure. A one percent increase in volatility of the Financial Times index leads, within three months, to a 1.2 percent increase in volatility in the Australian index. An increase in volatility in the German market actually dampens volatility in the Australian index for the first five months. Figure 7 also shows that the effects of the external volatility shocks have their largest effects within six months[7].

Figure 7

Impulse Response of Australian Volatility to Foreign Shocks



Further information about the relative importance of domestic and foreign shocks for the Australian stock price volatility is given by examining the proportion of the

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[6] See Judge, Hill, Griffiths, Lutkepohl, and Lee (1988), pp. 771-776, for further information on this method. In the MATLAB program, the initial period is t=1, so that the initial shock occurs at t=2 and the responses appear by t=3.

[7] While the stock market volatility in several foreign markets causes a decline in Australian volatility, the only significant volatility effect, from the UK, is strongly positive for the initial periods.

variance of the forecast error at differing horizons, which are due to each of the shocks. These variance decompositions appear in Table II[8].

Table II

Variance Decomposition for Australian Stock Volatility

Horizon	Percentage of Variance Due To:					
	Australia	Germany	Japan	Singapore	UK	US
1	46.27	0	3.15	1.59	48.70	0.29
5	36.99	0	17.53	5.73	31.95	7.80
10	25.42	0.96	26.12	5.18	28.61	13.71
15	23.91	1.20	24.76	5.17	30.01	14.94
20	23.01	1.63	24.99	5.26	29.43	15.67
40	22.63	1.70	24.99	5.37	29.39	15.92
60	22.61	1.70	25.00	5.37	29.38	15.93

Table II shows clearly that forecast errors of the Australian rate at both short and longer horizons are about equally due to shocks in the UK Financial Times index as to the Australian rate itself. The Nikkei index becomes more important at longer intervals, even more important than the Australian rate at 40 and 60 month horizons. Thus, variance-decomposition analysis reveals a more important role for volatility in the Nikkei index than does analysis of contemporaneous correlations or the impulse-response function.

2.4. Analysis of Time-Varying Return Coefficients

The time-varying return coefficients for the Australian stock index are obtained from Kalman-filter estimation of the following model:

$$\Delta s_{A,t} = b_{F,t}\left[\Delta s_{G,t} \quad \Delta s_{J,t} \quad \Delta s_{S,t} \quad \Delta s_{UK,t} \quad \Delta s_{US,t}\right] + d_t \Delta s_{A,t-1} + e_t \tag{1}$$

[8] See Lowe (1992) for an application of variance-decomposition analysis to Australian real exchange rates.

where $[\Delta s_{G,t}\ \Delta s_{J,t}\ \Delta s_{S,t}\ \Delta s_{UK,t}\ \Delta s_{US,t}]$ is the matrix of logarithmic first differences of the German (G), Japanese (J), Singapore (S), British (UK) and Dow-Jones (US) stock indices at time t, $\Delta s_{A,t}$ is the first difference of the Australian return at time t, $[ß_t\ \ \delta_t]$ are the time-varying coefficient matrices of the contemporaneous foreign returns and lagged own return, and ε_t is a random variable, with independent and identical distribution.

Kalman-filter estimation of the coefficients in equation (1) allows us to see how returns across countries become more closely linked during periods of high or rising volatility. In this sense, the time-varying parameters in (1) represent "contagion" coefficients, which should be closely correlated with the volatility measures[9].

The Kalman filter method is described in Hansen and Sargent (1991). Equation (1) is estimated in a recursive manner, in which the coefficients evolve so as to give the best one-period forward predictions. The updating of the coefficients is based on an error-correction or learning mechanism, in which current and more recent forecast errors weigh more heavily than past forecast errors for updating the coefficients. Unlike rolling regressions, Kalman filtering allows an optimal discounting of past data, so that the more recent observations and forecast errors have more influence on the parameter values. With rolling regressions, all observations have equal weight[10].

Figure 8 pictures the paths of the coefficient of the UK stock return and the Australian lagged return during the sample period.

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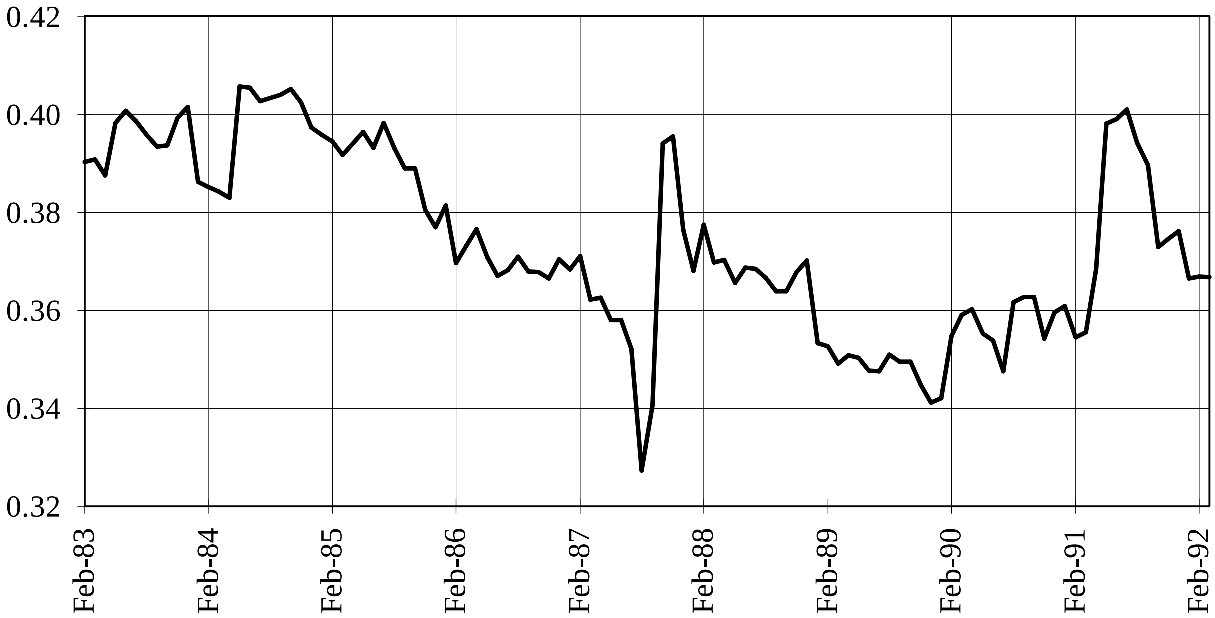
[9] By the simple efficient markets theory, under the assumption of risk neutrality, the logarithmic stock price index should behave as a random walk. Thus, $[\delta_t]$ should not depart from zero, since the vector is a set of coefficients of data observed at time t-1. Any increase in the absolute values of the coefficients in this matrix when volatility measures are higher than normal indicates a departure from market efficiency, narrowly defined. The contagion model permits such a departure, even for "efficient markets". Thus, my use of time-varying parameter estimation during times of increasing volatility is not an "excess-volatility" test of market efficiency. Shiller's (1989) "excess volatility" tests are based solely on present-value models of asset price behavior and rational expectations and do not consider international linkages of volatilities.

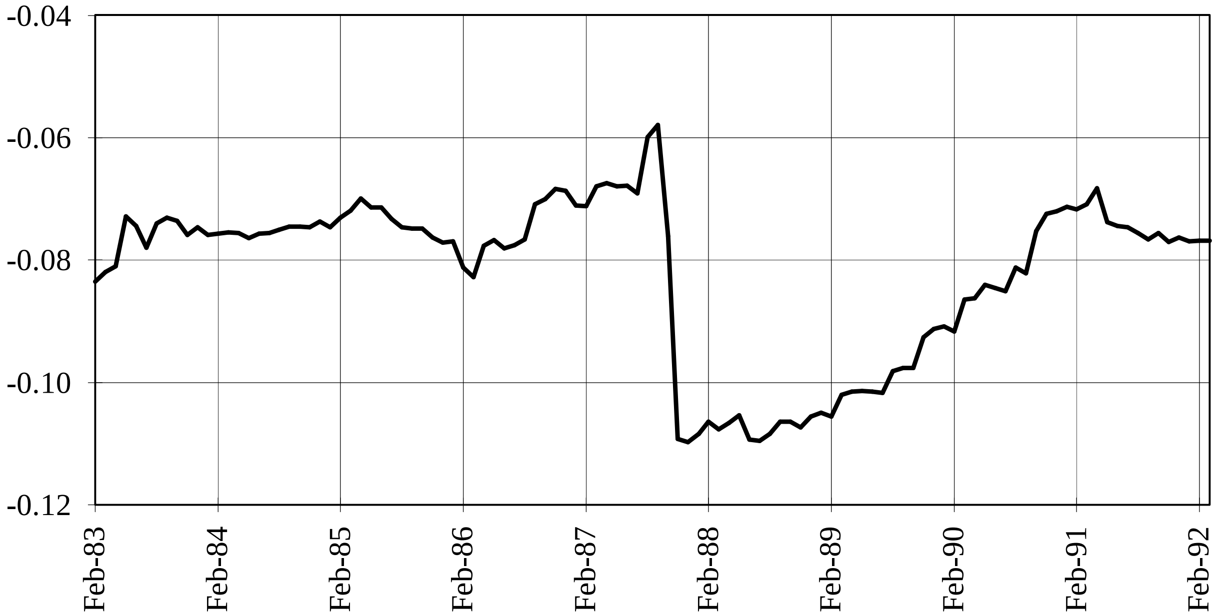
[10] Unfortunately, the distribution of the Kalman filter coefficients is not known so it is not possible to test if movements of the time-varying coefficients beyond specified bounds indicate significant departures from particular parameter values.

Figure 8

Time-Varying Coefficient of Australian Return with UK Return



Time-Varying Coefficient of Australian Return with Own Lag



Both time-varying estimates show sharp jumps at the time of the 1987 crash. Before the crash, the correlation of the Australian return with the UK return was gradually diminishing, but it increased by about 20% on the crash date. Figure 8 also shows that there was a large increase in the negative serial correlation of the Australian index on "Black Tuesday".

Table III contains the correlations of the two time-varying return coefficients with the international volatility measures, during the turbulent period from 1987.01 through 1988.12[11]. This sub-sample is chosen, because it is the period prior to and following "Black Monday", when stock-market turbulence was highest. The correlations show that, during the two year period, volatility in the UK and US markets increased in tandem with the return coefficient linking the Australian rate to the UK rate. Given the negative sign of the time-varying Australian autocorrelation coefficient, the positive correlations indicate that as volatility increased in all of the markets, the Australian autocorrelation coefficient diminished in absolute value. The market became progressively more responsive to international prices as international turbulence grew, and less dependent upon its own history.

Table III

Correlations of Return Coefficients with Volatility Measures, 1987-88

Volatility Index:	Coefficients	
	$b_{UK,t}$	d_t
Australia	0.2643	0.2395
Germany	0.3337	0.1272
Japan	0.2405	0.1794
Singapore	0.1915	0.1454
UK	0.3069	0.2723
US	0.5068	0.1263

[11] Only two coefficients appear in Table III, that of Australia with the UK stock index, and the Australian index with its own lag, because these are the only coefficients which showed significant variation in the Kalman filter estimation. Table III shows the correlations of these Kalman coefficients with the volatility indices for the five countries to show the different ways these time-varying parameters are related to uncertainty measures in the various markets.

3. EXCHANGE RATE VOLATILITIES AND CORRELATIONS

The time-series and Schwert volatility measures for the Australian dollar/US Dollar, the US dollar/Canadian dollar, US dollar/German mark, US dollar/UK pound, and US dollar/Japanese yen exchange rates appear in Figures 9 through 13. As with the stock price indices, all data are end-of-month observations[12].

The Schwert volatility measure for the Australian dollar/US dollar exchange rate appears to be centred on a value of two percent. Unlike the stock price index, there is no sharp break in the process. Rather, there is gradual decline in the value of the Australian dollar until the mid-1980s. Then there is a gradual appreciation, followed by a stable value at the end of the decade.

In Figure 10, the US dollar shows a steady appreciation against the Canadian dollar until the mid-1980s, followed by a steady and continuing depreciation. The volatility measure appears to be centred on a mean value of 0.75 percent.

The behaviour of the US dollar with respect to the German market appears in Figure 11. The same pattern of gradual appreciation followed by reversal takes place.

What is interesting is that the value of the US dollar peaks earlier against the German mark than against the Canadian dollar. The volatility measure is centred on a value between 2 and 3 percent. The pattern for the US dollar with respect to the UK pound in Figure 12 mirrors the pattern of the US dollar/German mark exchange rate in Figure 11, both in its rise and fall, and in its volatility index.

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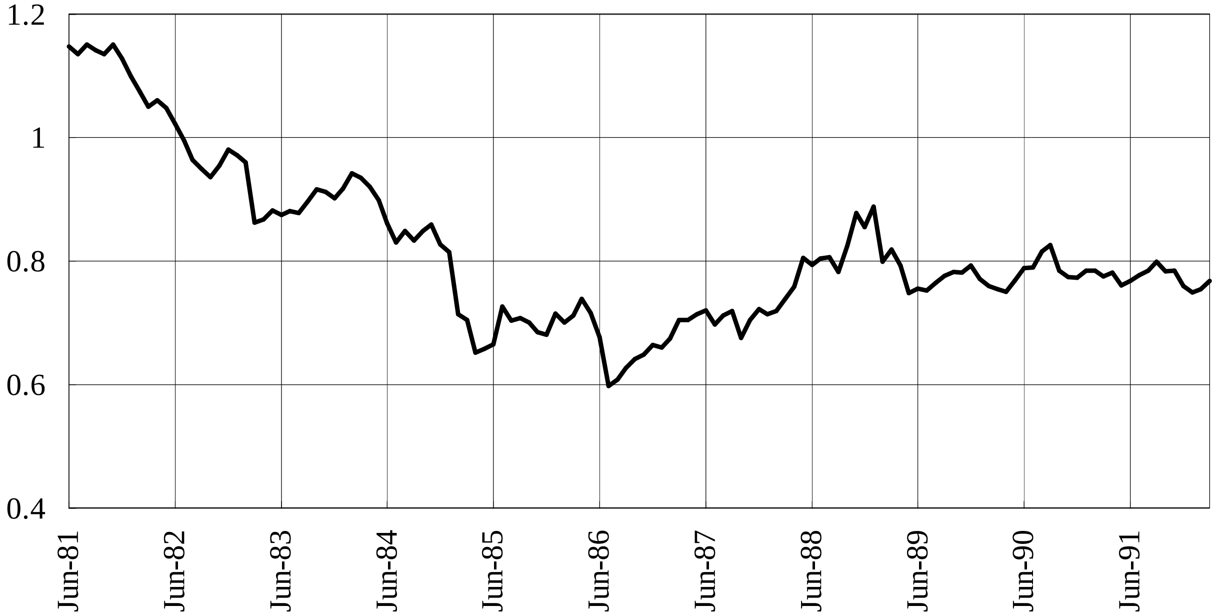
[12] In this section, the Canadian dollar/US dollar exchange rate replaces the Singapore exchange rate. Shocks to the Canadian dollar/US dollar rate are more likely to be correlated with shocks to the Australian dollar/US dollar rate, since the Australian and Canadian economies have a similar agricultural export base, and are subject to similar terms of trade shocks.

Figure 9

Australian Dollar/US Dollar



Australian Dollar/US Dollar: Volatility Measure

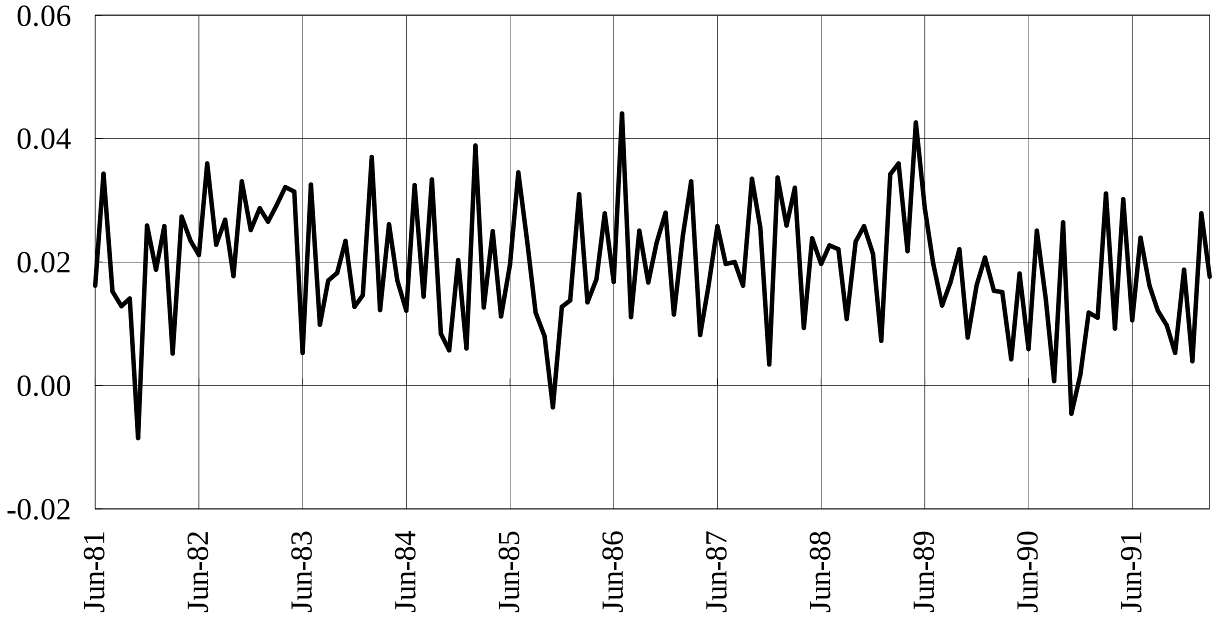
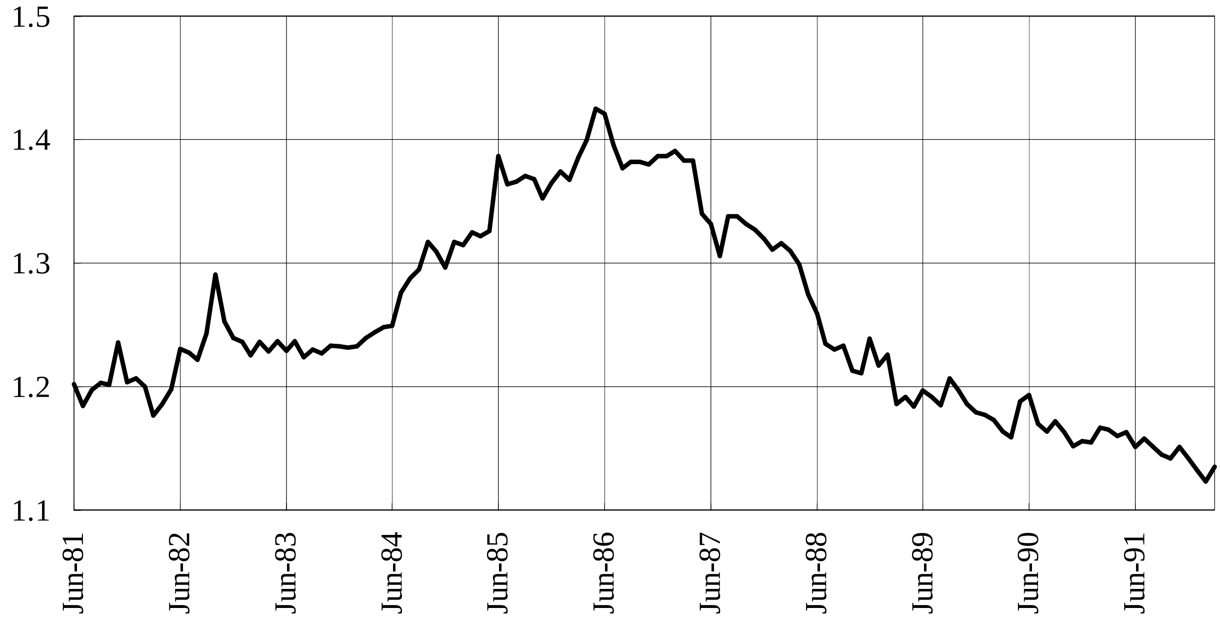


Figure 10

US Dollar/Canadian Dollar



US Dollar/Canadian Dollar: Volatility Measure

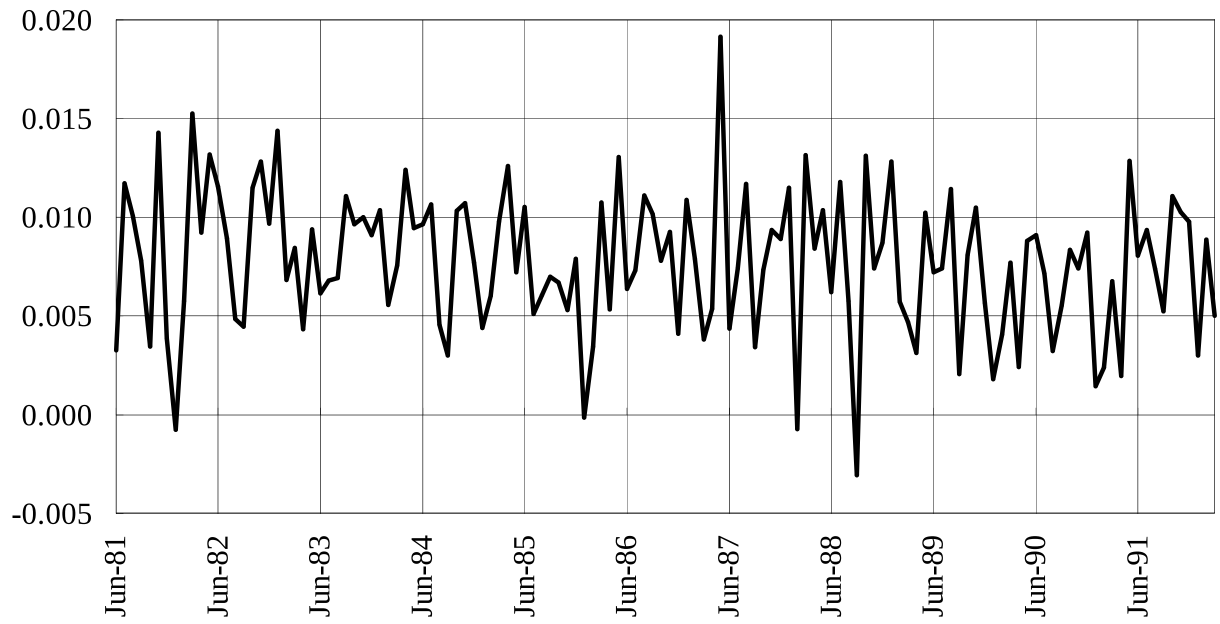
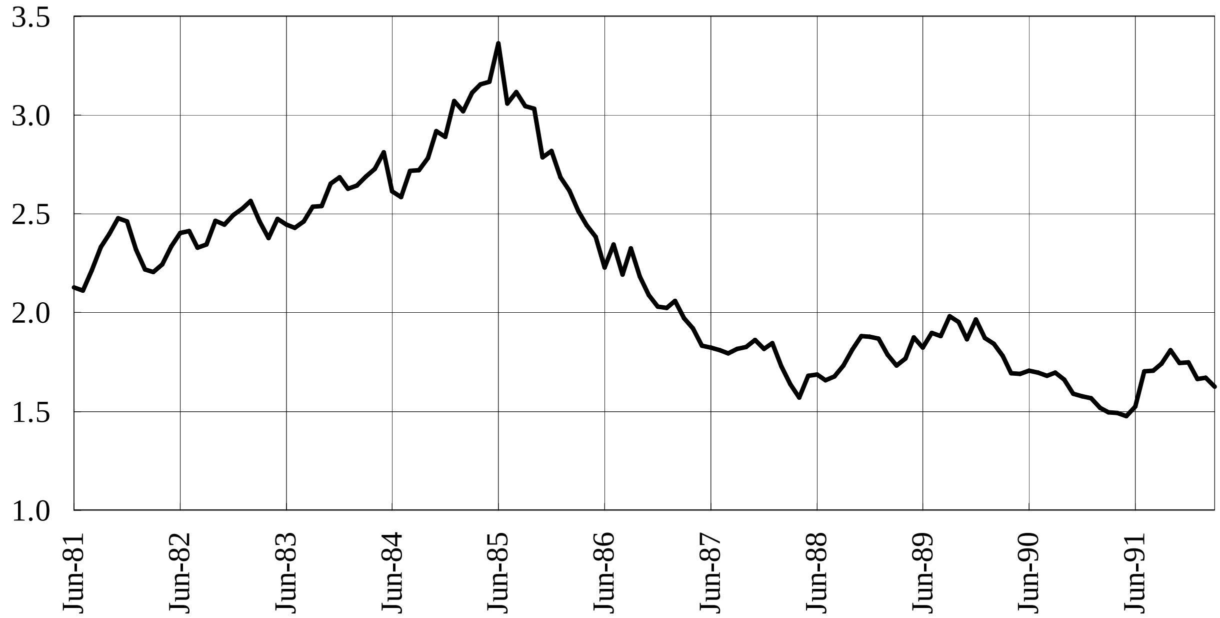


Figure 11

US Dollar/German Mark



US Dollar/German Mark: Volatility Measure

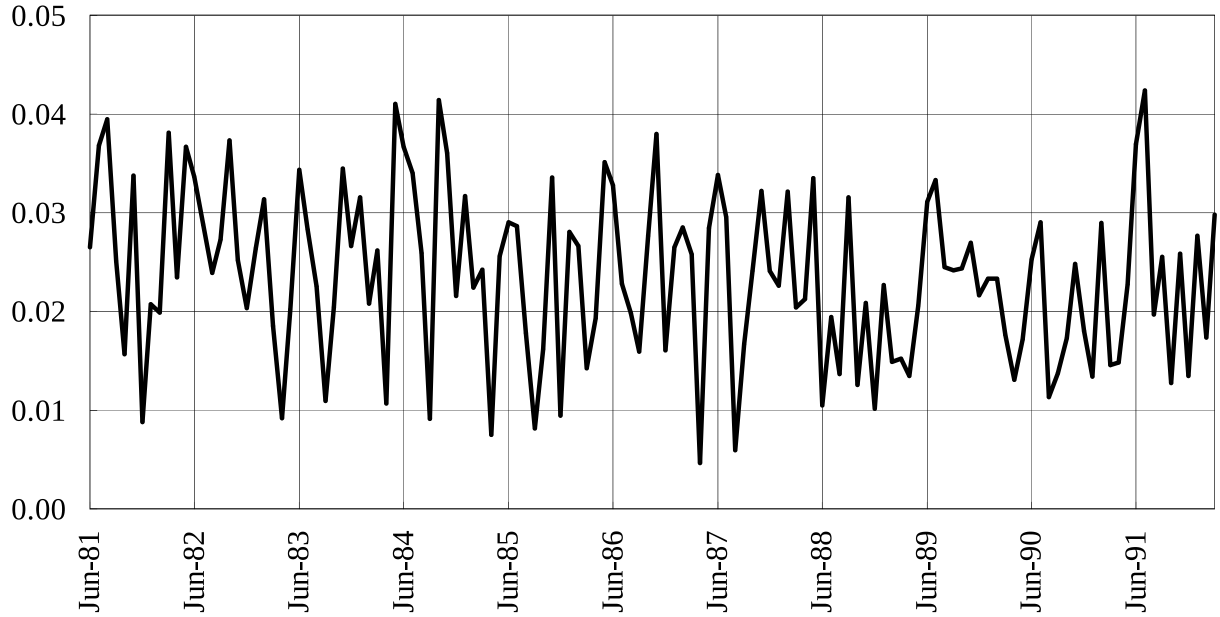
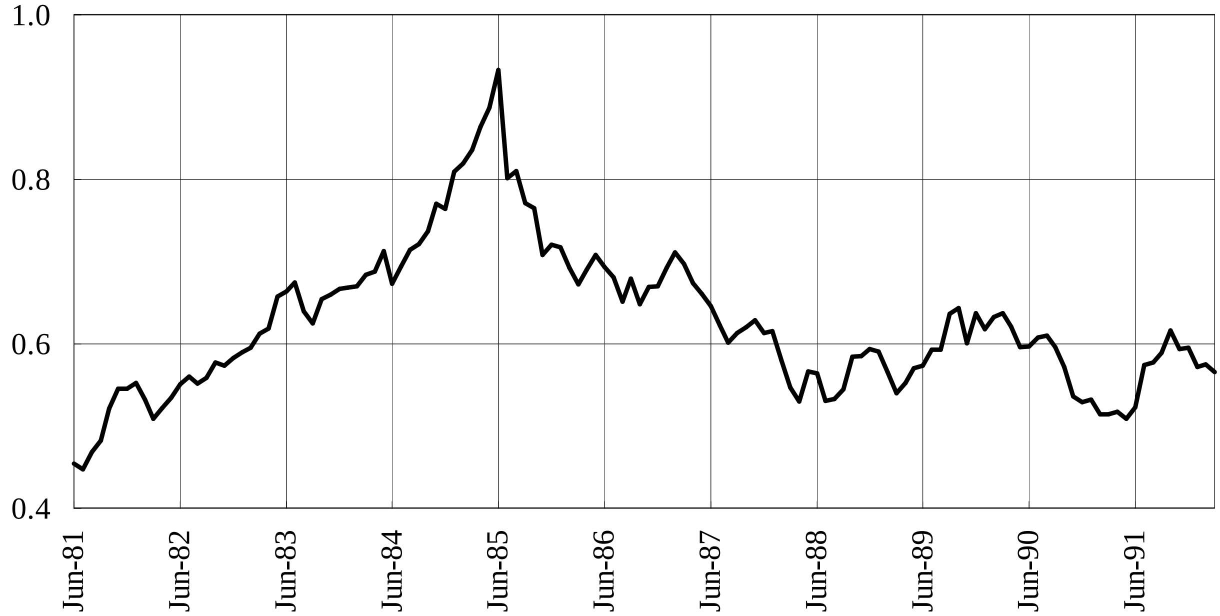


Figure 12

US Dollar/UK Pound



US Dollar/UK Pound: Volatility Measure

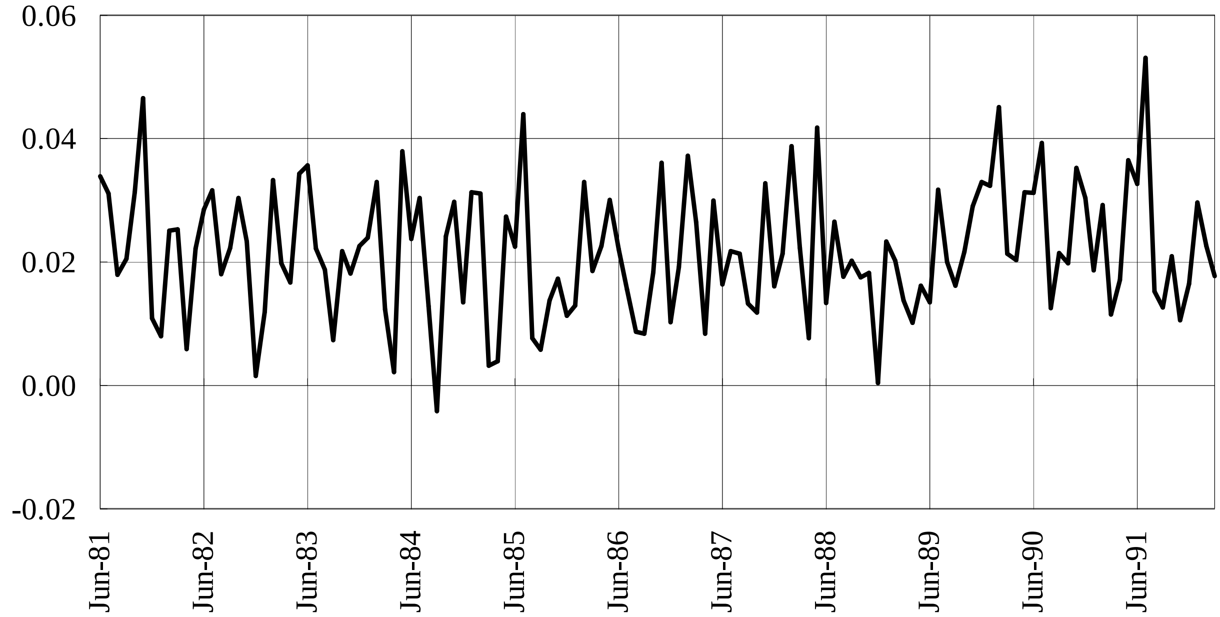
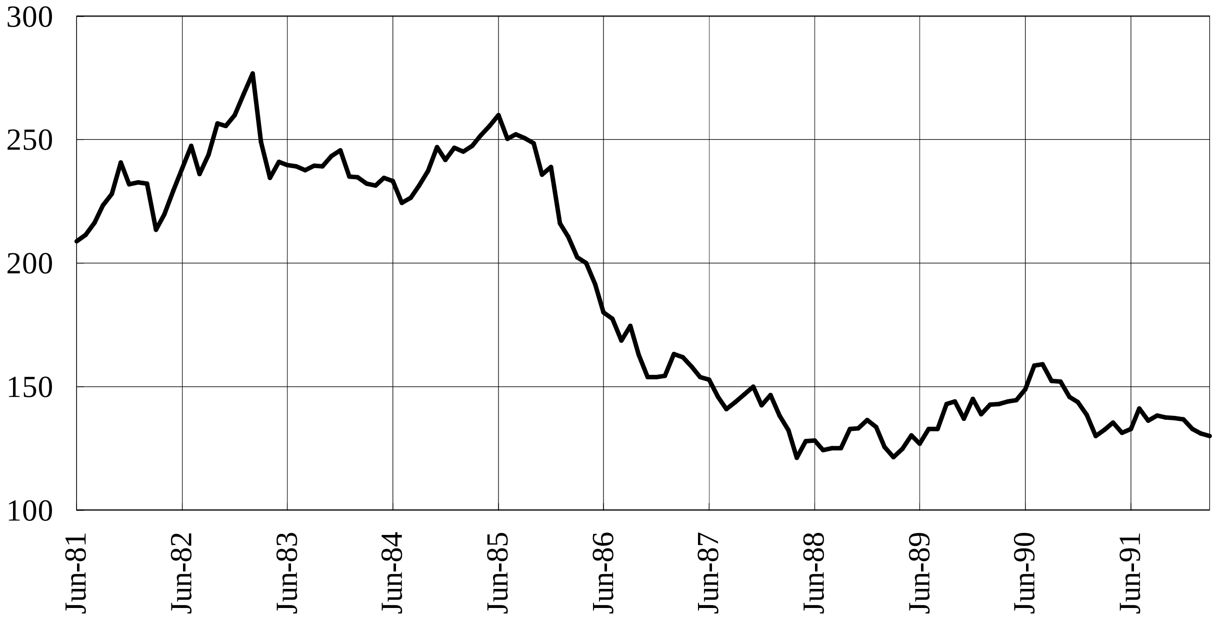
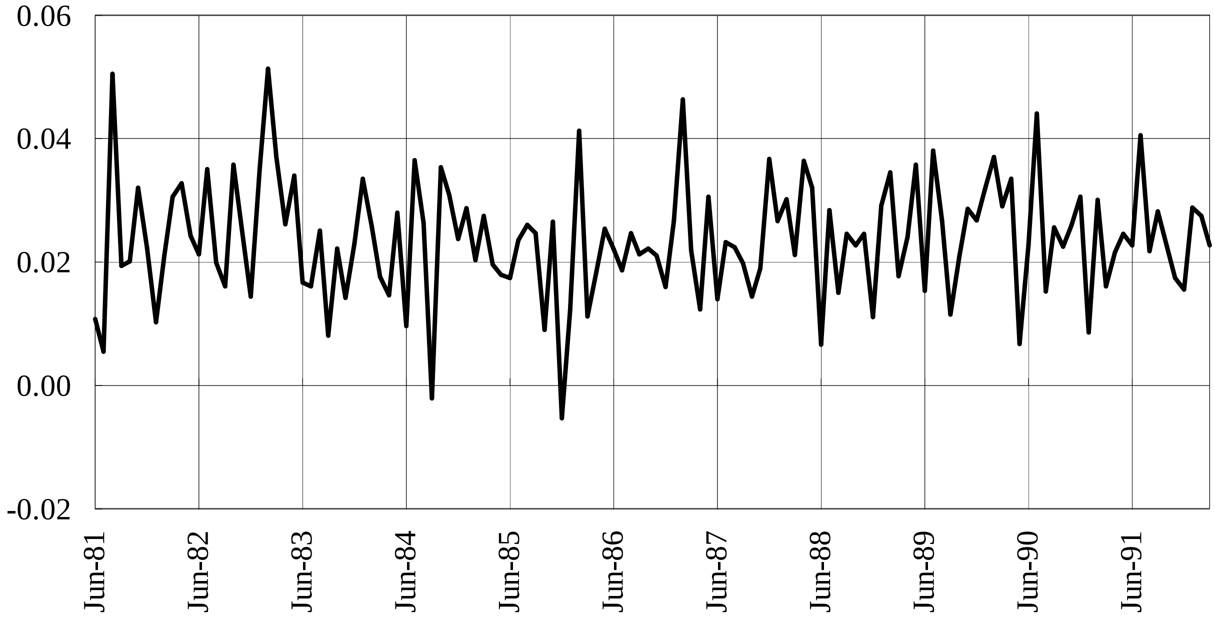


Figure 13

US Dollar/Japanese Yen



US Dollar/Japanese Yen: Volatility Measure



For the US dollar/Japanese yen exchange rate pattern, Figure 13 shows that there is no dramatic appreciation at the beginning of the sample period in the early 1980s. However, in the mid-1980s, a decline in the value of the US dollar against the Japanese yen, similar to the behaviour of the US dollar against the German mark, the UK pound, and the Australian dollar, takes place. By the end of the decade the US dollar appears to have levelled off at the stable, lower value. The Schwert volatility index for the US dollar/Japanese yen exchange rate also appears to be centred on a value slightly above 2 percent.

3.1. Contemporaneous Correlations

Table IV contains the contemporaneous correlations of the estimated volatilities. The volatility in the Australian index shows very little correlation with the foreign exchange rate volatilities. There is even a negative correlation with the US dollar/German mark volatility measure. However, small changes in the interval can cause sign changes in the correlation coefficients, so there is little significance in the signs of the estimates. With the exception of the European Monetary System (EMS) currencies, the foreign exchange correlations are lower than the stock market correlations reported in the previous section.

3.2. Tests of Granger Causality

The F-statistics and Wald statistics in Panels B and C of Table IV show a strong role for the US dollar/Canadian dollar exchange rate volatility index. It is exogenous to the volatility measures of the other exchange rate volatility measures. With significant but lesser importance, both the volatility measures of the US dollar/Japanese yen and US dollar/German mark outweigh, according to the Wald statistics, the own lagged effects for explaining the Australian dollar/US dollar exchange rate volatility.

Table IV

PANEL A
Correlation Coefficients of Exchange Rate Volatility Measures
1981.01-1992.03

	A/US	US/Can	US/DM	US/UK	US/Yen
A/US	1.0000				
US/Can	0.0529	1.0000			
US/DM	0.0828	0.1393	1.0000		
US/UK	0.0059	0.0631	0.5767	1.0000	
US/Yen	0.0212	0.1627	0.3894	0.5029	1.0000

PANEL B
VAR Model of Exchange Rate Volatilities
F-Statistic on Zero Restrictions
F(5/82) = 2.33(5%); 3.25(1%)

Argument	Dependent Variable				
	A/US	US/Can	US/DM	US/UK	US/Yen
A/US	3.69	20.01	6.71	2.75	9.89
US/Can	4.25	2.53	1.82	3.33	4.82
US/DM	1.80	6.48	5.69	2.67	2.46
US/UK	2.49	7.08	2.24	1.57	4.08
US/Yen	3.08	6.11	10.0	2.61	7.85

PANEL C
Wald Statistics (With Heteroskedasticity Correction)
VAR Model of Exchange Rate Volatilities
$X^2(6)$ = 12.59(5%); 16.81(1%)

Argument	Dependent Variable				
	Aus/US	US/Can	US/DM	US/UK	US/Yen
Aus/US	98.2	4.8	45.3	92.4	89.7
US/Can	2013	91	726	1905	1405
US/DM	15.4	9.4	110	227	150
US/UK	91.2	0.6	34.1	85.4	66.3
US/Yen	142	3.3	82.1	138	123

3.3. Impulse Response Functions and Variance Decomposition

Three impulse-response functions for the Australian dollar/US dollar volatility index appear in Figure 14. I picture the response function for changes in the Australian dollar/US dollar volatility index, in the US dollar/Canadian dollar volatility index, and in the US dollar/Japanese yen volatility index.

Figure 14

Impulse Response of Australian dollar/US dollar Volatility to Foreign Exchange Rate Shocks

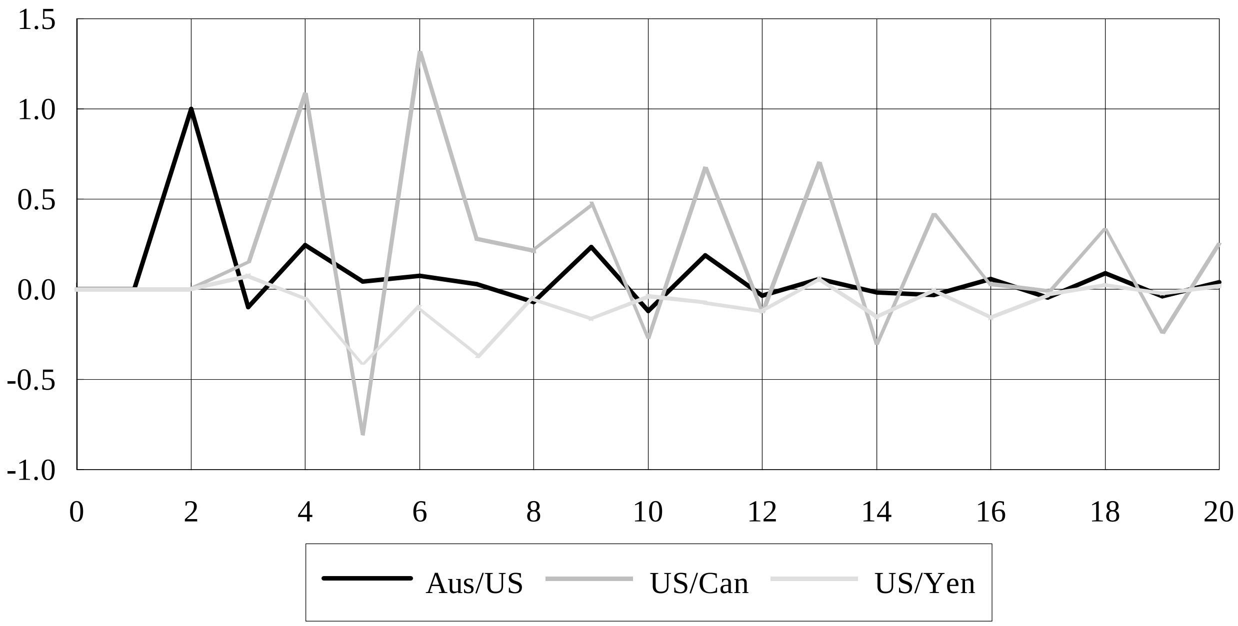


Figure 14 shows that a unit shock to the Australian dollar/US dollar exchange rate volatility disappears rapidly. However, for a unit shock in the US dollar/Canadian dollar volatility index, the effect on the Australian dollar/US dollar volatility measure is more than 100 percent. While there is a fall in the succeeding period, there is no quick dampening, since the intermediate impulses are also high. By comparison, a unit shock in the US dollar/Japanese yen volatility index has rather small initial effects, which quickly dampen. The same is true for the other exchange-rate volatility measures.

The variance-decomposition analysis in Table V confirms the results of the impulse-response functions on the importance of the US dollar/Canadian dollar volatility measure. While shocks to the Australian dollar/US dollar volatility index explain most of its own variance at shorter horizons, at longer horizons shocks to the US dollar/Canadian dollar volatility index become considerably more important. At the longest horizons, the US dollar/Canadian dollar index explains 75% of the variance in the Australian dollar/US dollar measure.

Table V

Variance Decomposition for Australian Dollar/US Dollar Volatility

Horizon	Percentage of Variance Due To:				
	A/US	US/Can	US/DM	US/UK	US/Yen
1	85.70	2.09	6.64	5.04	0.53
5	21.06	68.96	2.52	3.86	3.61
10	18.43	68.06	3.09	4.89	5.53
15	16.34	70.21	3.05	4.58	5.83
20	15.92	70.78	3.05	4.55	5.70
40	15.76	70.92	3.06	4.57	5.68
60	15.75	70.93	3.06	4.57	5.68

3.4. Analysis of Time-Varying Exchange Rate Coefficients

As in Section 2.4, I examine whether or not the asset price in question became more closely correlated with corresponding asset prices when the volatility indices became larger in value. I thus examine the following equation with time-varying parameters:

$$\Delta e_{A/US,t} = b'_{F,t}\left[\Delta e_{US/Can,t} \quad \Delta e_{US/DM,t} \quad \Delta e_{US/UK,t} \quad \Delta e_{US/Yen,t}\right] + d'_t \Delta e_{A/US,t-1} + e'_t \qquad (2)$$

where [$\Delta e_{US/Can,t}$ $\Delta e_{US/DM,t}$ $\Delta e_{US/UK,t}$ $\Delta e_{US/Yen,t}$] is the matrix of logarithmic first differences of the Canadian (Can), German (DM), British (UK), and Japanese (Yen) exchange rates against the US dollar at time t, $\Delta e_{A/US,t}$ is the first difference of the Australian exchange rate against the US dollar at time t, [$ß_t'$ δ_t'] are the time-varying coefficients of the contemporaneous foreign exchange rates and lagged own rate, and ε_t' is a random variable, with independent and identical distribution.

The time-path for two of the time-varying coefficients estimated by Kalman-filtering appear in Figure 15, the coefficient of the US dollar/UK pound exchange rate, and the coefficient of the lagged own exchange rate. Other coefficients showed even smaller variation from zero.

Figure 15 shows some jumps at the same time the stock-market crash occurred, as well as during the time the US dollar began its decline against the Australian and the UK, Canadian, German, and Japanese currencies.

Table VI contains the correlations of the two time-varying coefficients with the volatility measures of the exchange rates during the entire sample period. Narrower sample periods did not affect the correlation coefficients to any noticeable extent. Table VI shows that the correlations at most are slightly less than twenty percent. Volatility in the US dollar/Japanese yen exchange rate has the highest correlation with the coefficient linking the Australian dollar/US dollar rate with the US dollar/UK pound rate, although this correlation may not be significant.

Analysis of the Australian exchange market indicates that volatility of US dollar/Canadian dollar rate has the most significance for forecasting volatility in the Australian dollar/US dollar rate. This result is in contrast to the analysis of the stock market, which links Australian volatility with volatility in the UK stock market.

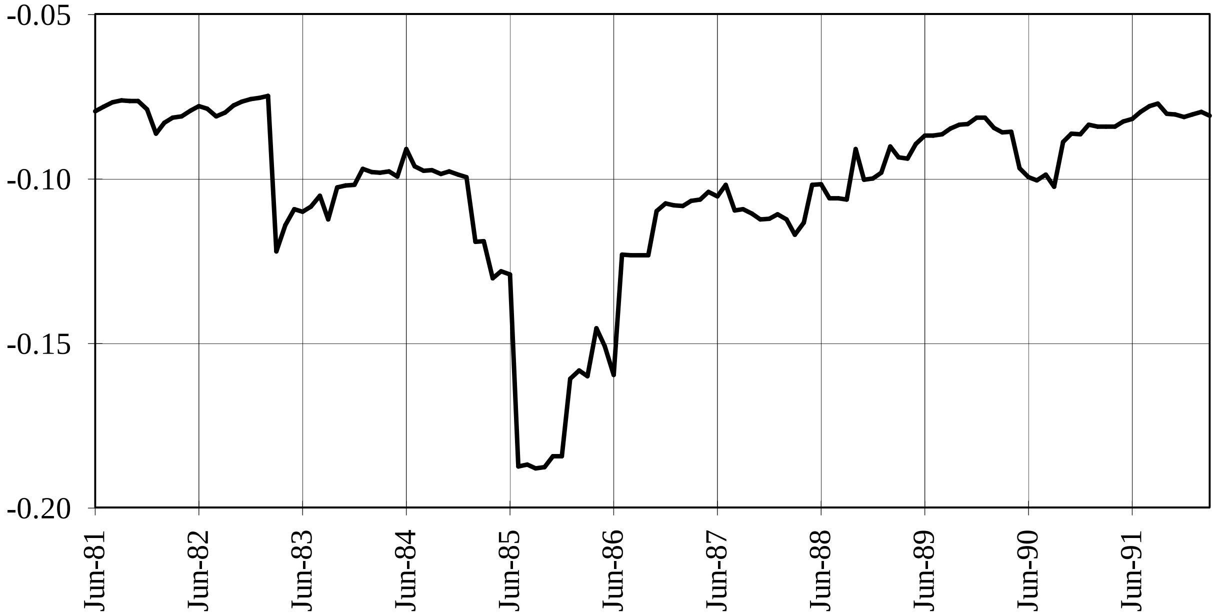
Table VI

Correlations of Return Coefficients with Volatility Measures, 1981-1992

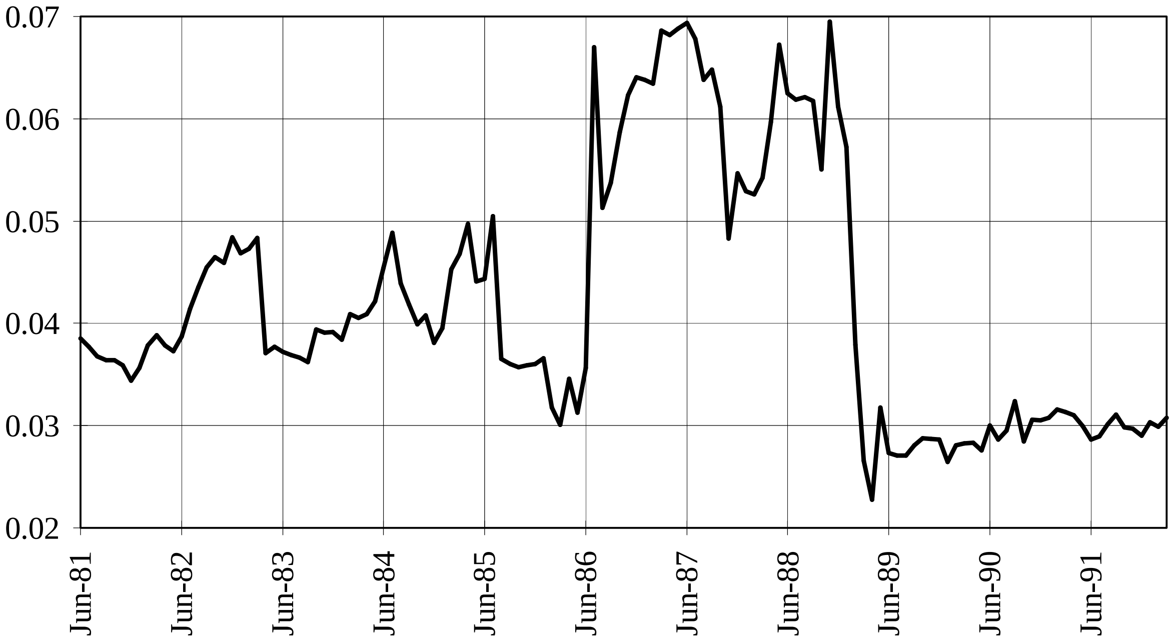
Volatility Index:	Coefficients	
	$\beta'_{US/UK,t}$	δ_t'
Aus/US	0.0080	0.2037
US/Can	0.0770	0.1387
US/DM	0.1356	0.0033
US/UK	0.1507	-0.1184
US/Yen	0.1837	-0.0293

Figure 15

Time-Varying Coefficient of Australian Dollar/US Dollar Exchange Rate with the US Dollar/UK Pound Exchange Rate



Time-Varying Coefficient of Australian Dollar/US Dollar Exchange Rate with Own Lag



4. BOND YIELD VOLATILITIES AND CORRELATIONS

Figures 16 through 20 picture the long-term government bond yields and the estimated Schwert volatility indices for five countries: Australia, Germany, Japan, the United Kingdom, and the United States. The Australian bond yield is the yield on 10 year Treasury bonds; the German yield is the public sector yield on 7-15 year bonds; the Japanese yield is the central government bond yield; the UK rate is the 10 year government security yield; and the US yield is the government security yield for bonds of 10 years or more[13].

Figure 16 shows that the Australian bond yield declined by about six percentage points over the course of the decade, with the greatest decline coming during the past two years. The volatility measure appears to be centred on a mean of 0.3.

The German bond yield shows a steeper decline during the first half of the decade, with a reversal and upward movement in the mid-1980s. The volatility measure for the German yield in Figure 17 shows no obvious trend, and appears to be centred on a mean of 0.12.

The pattern of the Japanese long-term bond yield is similar to that of the German yield, with a decline and then a reversal in the mid-1980s, and with no obvious trend in the volatility index. The index is centred on a mean value of 0.2.

The UK bond yield declined rapidly at the start of the decade, and hovered close to a value of 10 percent until it increased by about two percentage points, temporarily. The volatility index appears to be centred on a value of 0.2.

The behaviour of the US long-term bond yield in Figure 20 shows two periods of sharp decline: one at the beginning of the decade, and another mid-way through the decade. From the mid-1980s, the yield hovers close to a value of 8 percent. The volatility measure for the United States, unlike the measure for the other countries, shows a decline. Its mean value falls from 0.2 to a value of 0.1 towards the end of the decade.

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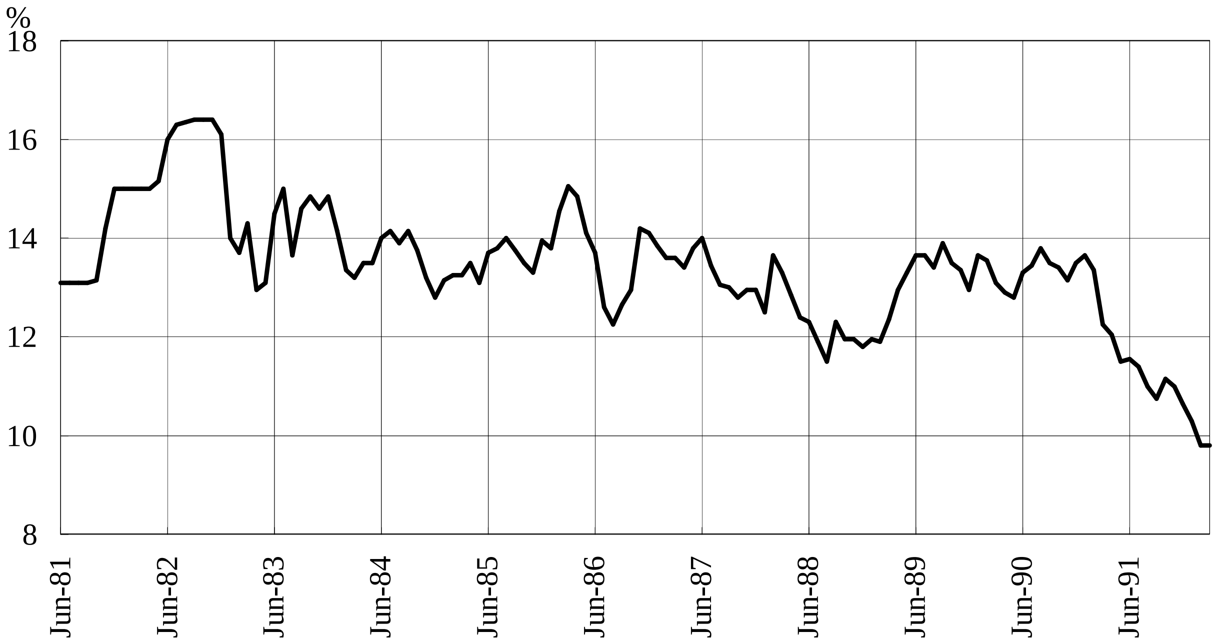
[13] The bond yields come from Table F.11, "Overseas Interest Rates and Government Security Yields", of the Reserve Bank of Australia Bulletin, various issues.

Figure 16

Australian Bond Yield



Australian Bond Yield: Volatility Measure

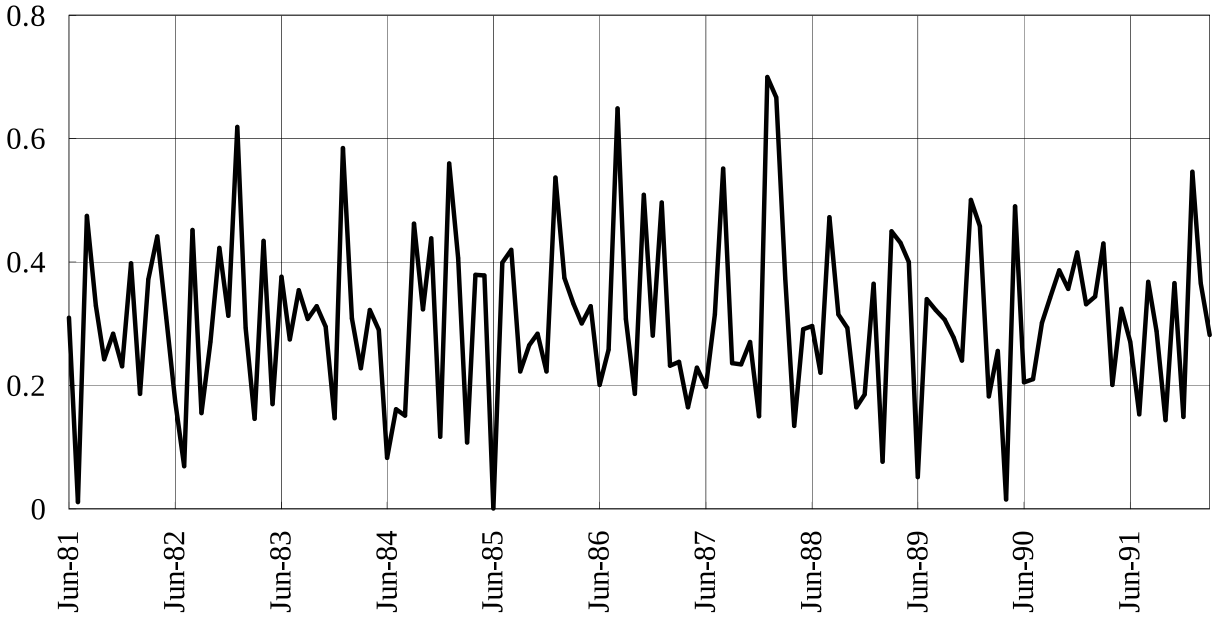
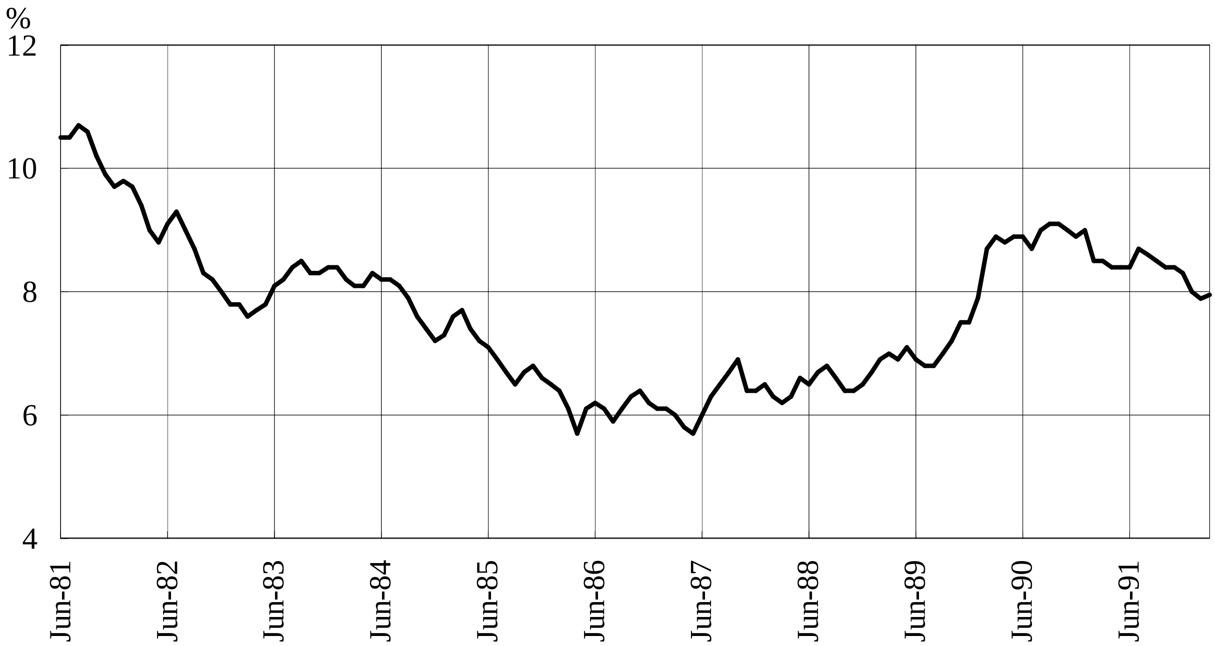


Figure 17

German Bond Yield



German Bond Yield: Volatility Measure

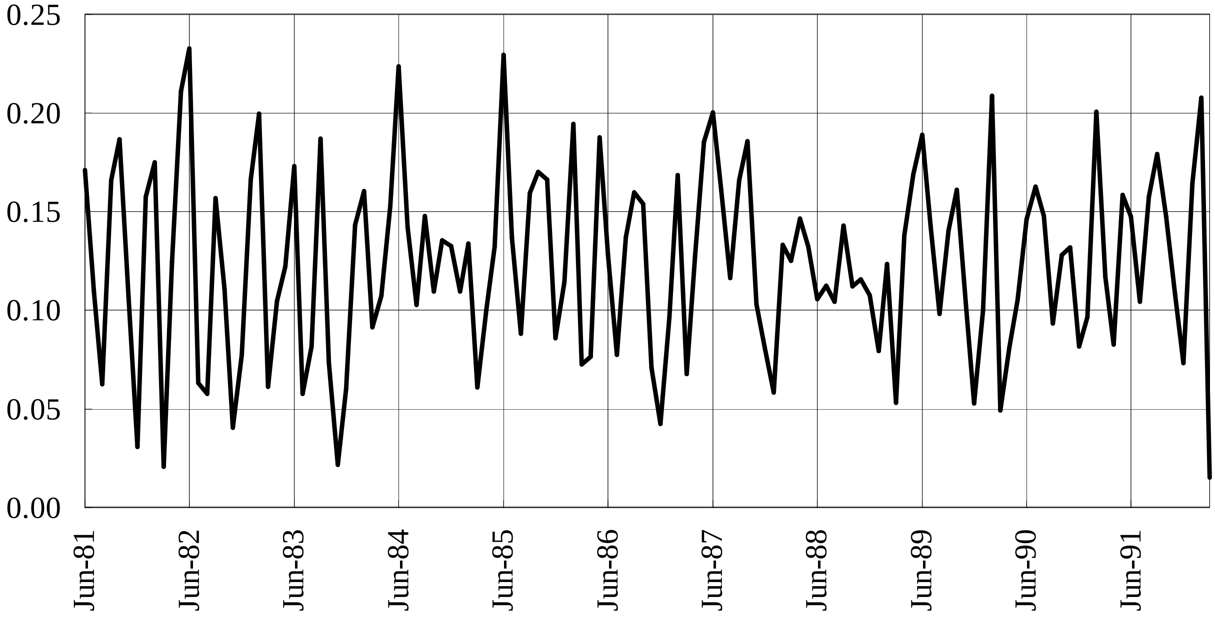
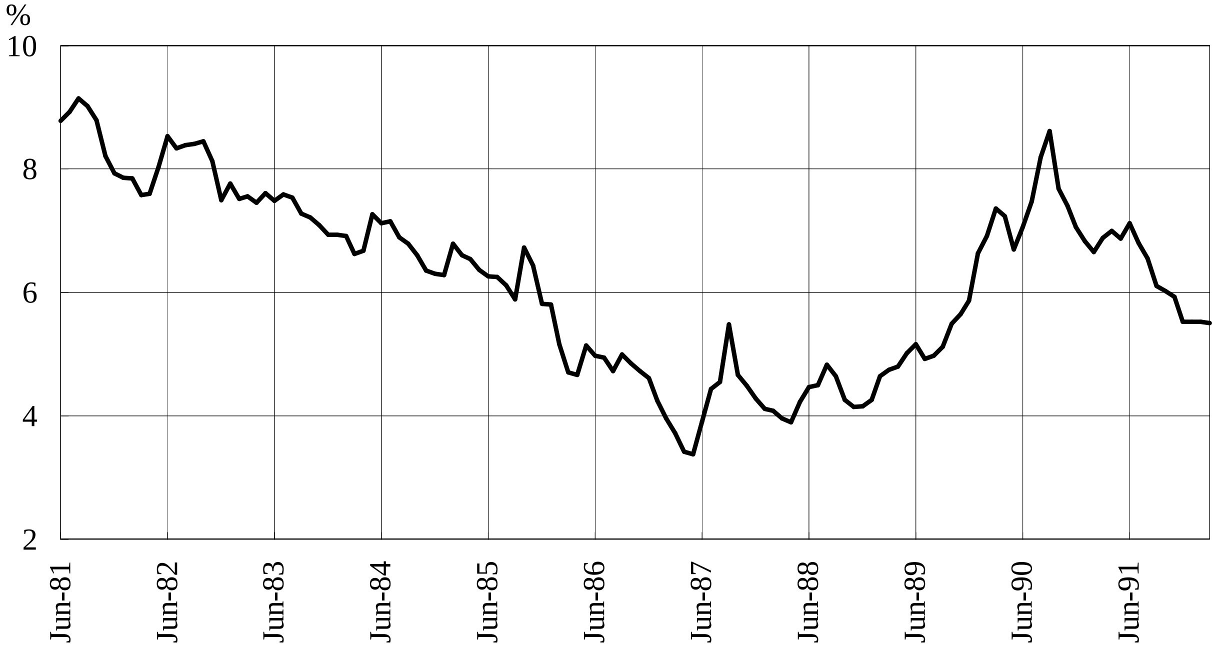


Figure 18

Japanese Bond Yield



Japanese Bond Yield: Volatility Measure

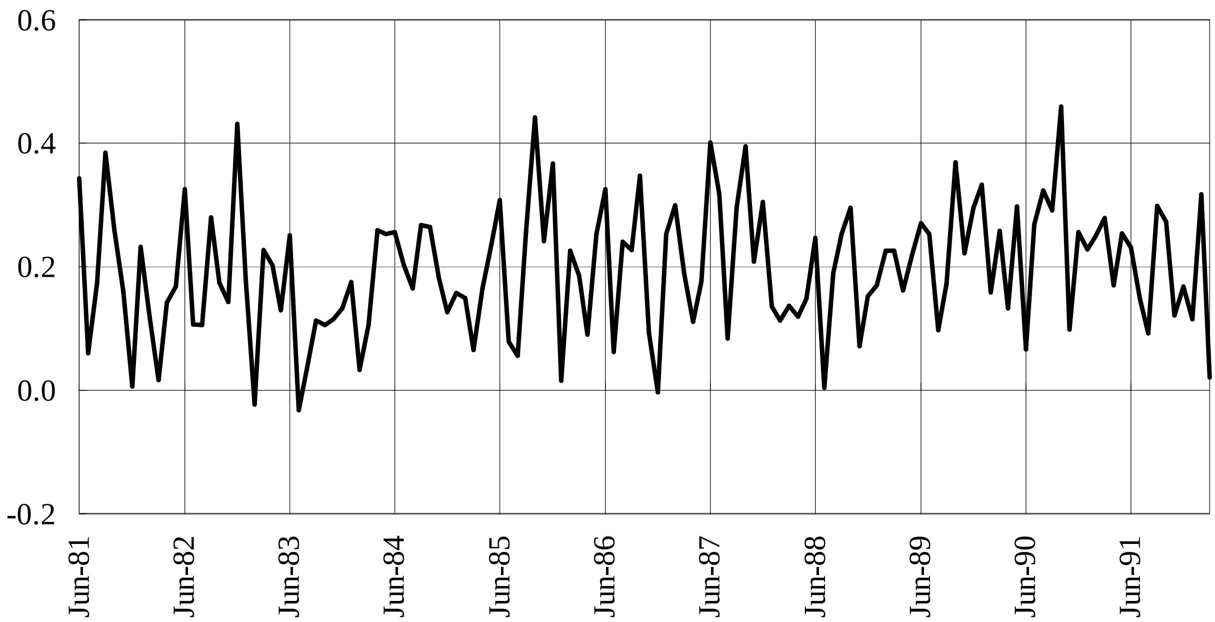
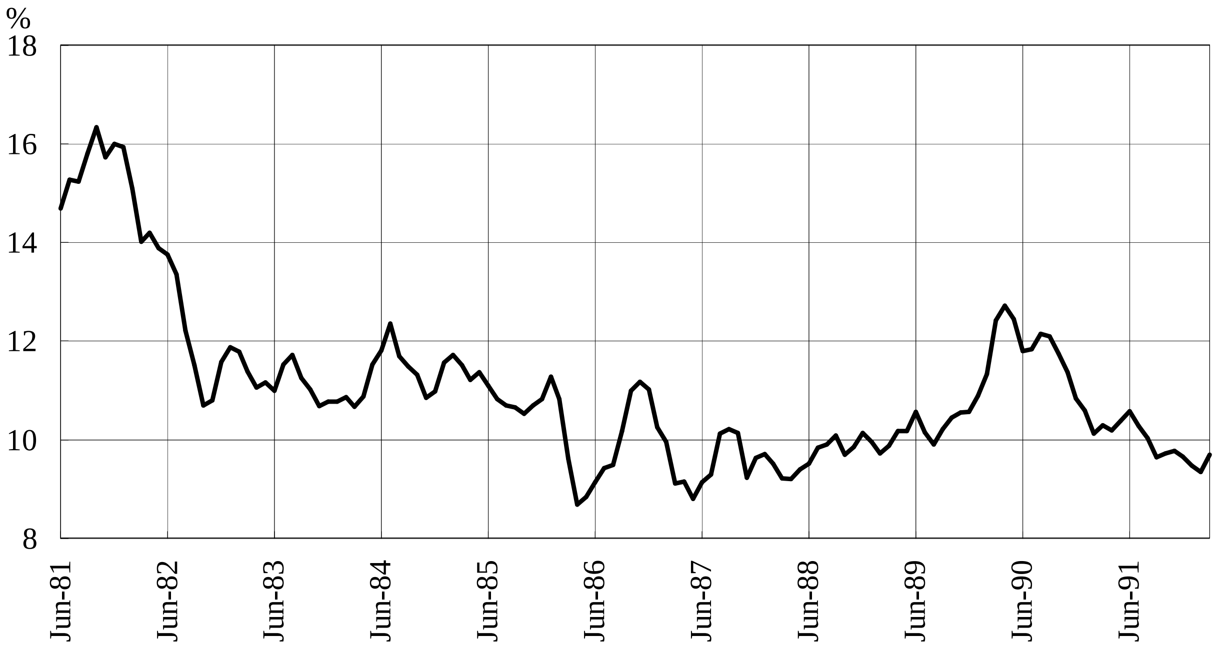


Figure 19

UK Bond Yield



UK Bond Yield: Volatility Measure

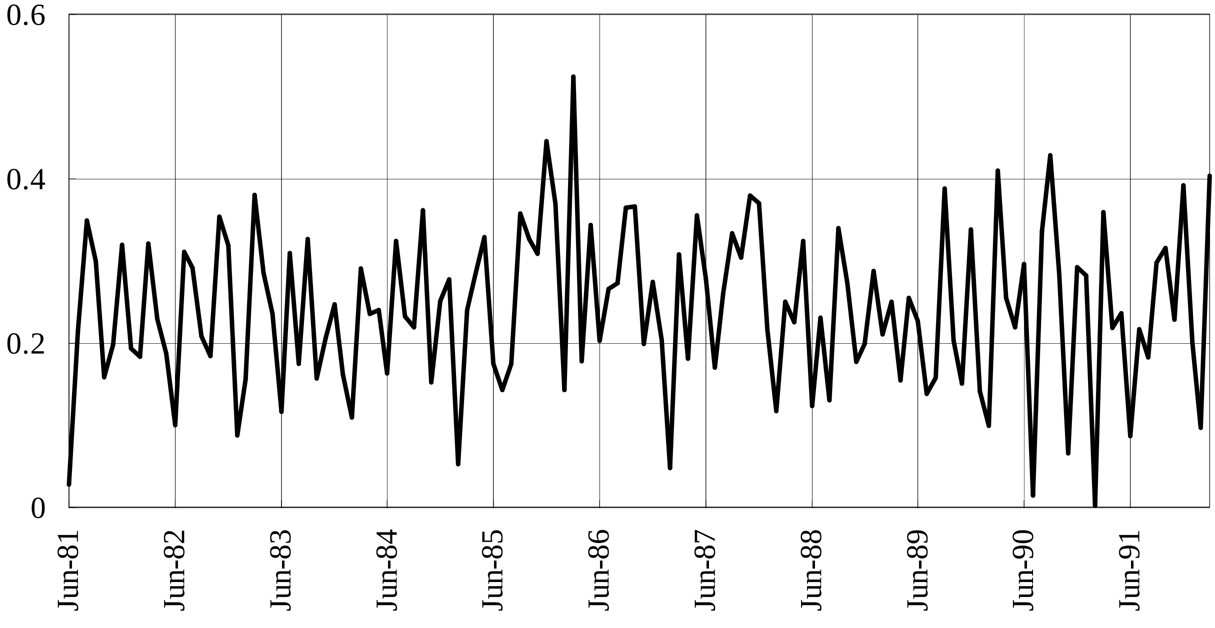
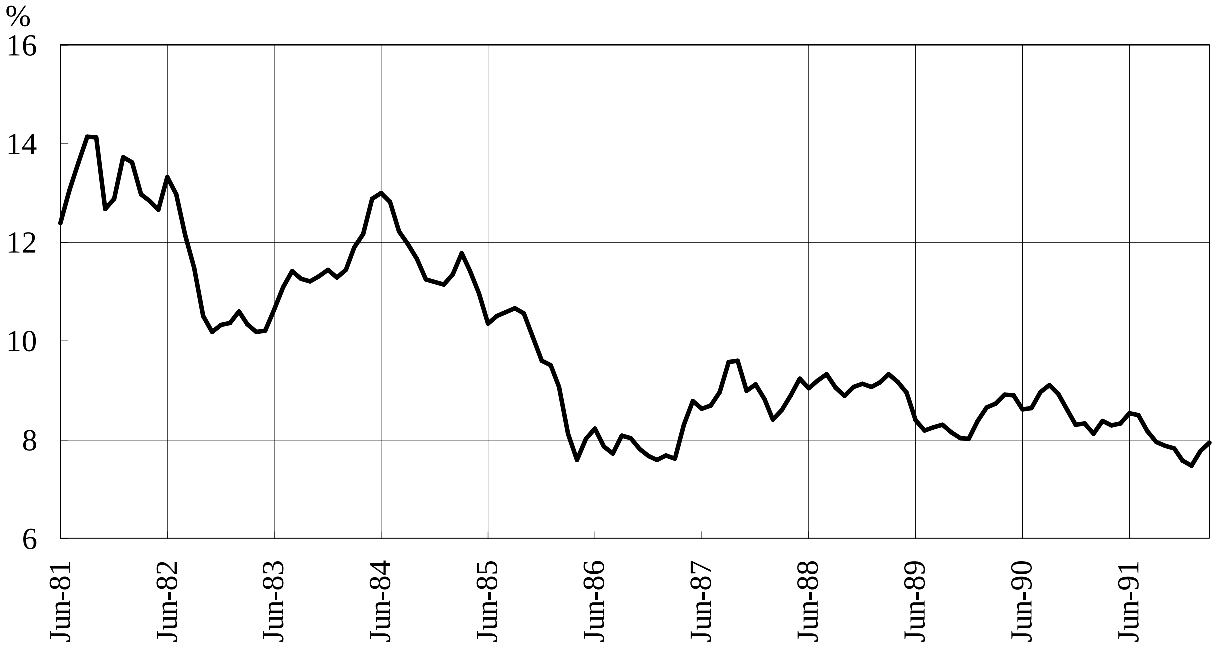
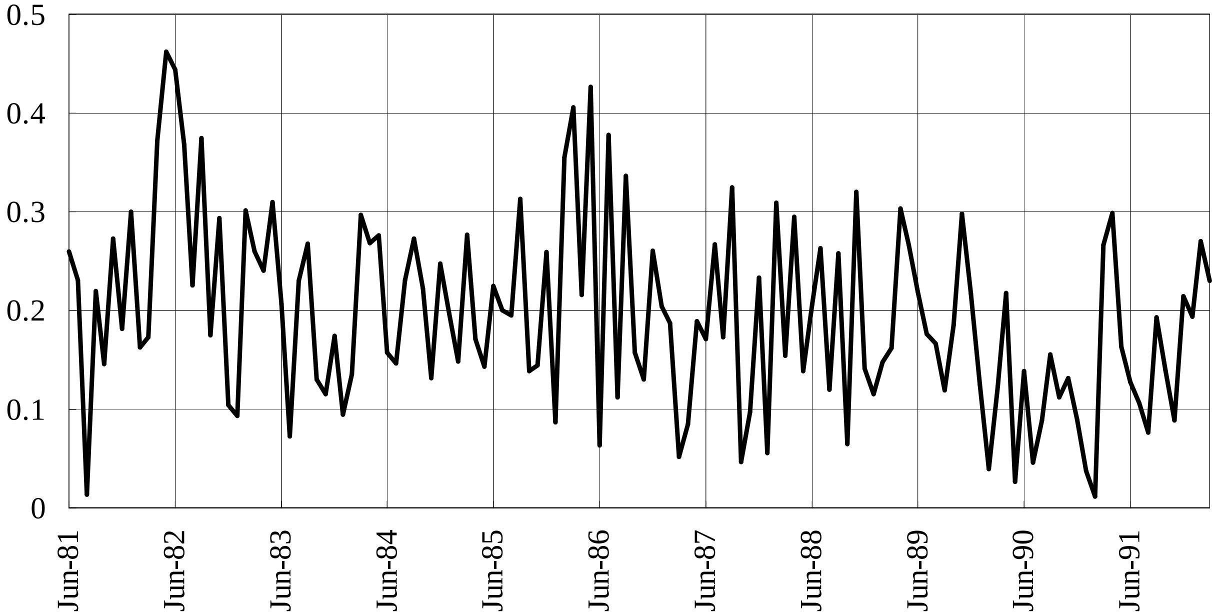


Figure 20

US Bond Yield



US Bond Yield: Volatility Measure



4.1. Contemporaneous Correlations

The contemporaneous correlations in the bond yield volatility measures appear in Table VII, Panel A. The results show negative correlations of the Australian volatility measure with the foreign bond yield volatility measures. The largest positive correlation is between the German and Japanese volatility measures.

4.2. Tests of Granger Causality

The Granger test of causality in Panels B and C of Table VII indicates that the most significant of all of the five bond yield volatilities is the German yield. The Wald statistics show that this measure is exogenous to the Australian bond-yield volatility as well as to the measures of the other bond-yield volatility measures.

Table VII

PANEL A

Correlation Coefficients of Bond-Yield Volatility Measures, Schwert Index

	Aust	Germ	Japan	UK	US
Aust	1.00				
Germ	-0.12	1.00			
Jap	-0.07	0.37	1.00		
UK	-0.11	-0.36	0.10	1.00	
US	-0.16	0.10	-0.08	0.12	1.00

PANEL B

VAR Model of Bond-Yield Volatilities

F-Statistic on Zero Restrictions

F(5/82) = 2.33(5%); 3.25(1%)

Argument	Dependent Variable				
	Australia	Germany	Japan	UK	US
Australia	3.77	7.48	1.17	2.95	7.07
Germany	5.85	4.17	2.11	5.60	3.37
Japan	1.17	1.44	1.17	2.85	6.95
UK	4.23	5.80	4.10	4.24	1.73
US	5.54	2.67	0.95	2.07	4.21

PANEL C

Wald Statistics (With Heteroskedasticity Correction)

VAR Model of Bond-Yield Volatilities

$X^2(6)$ = 12.59(5%); 16.81(1%)

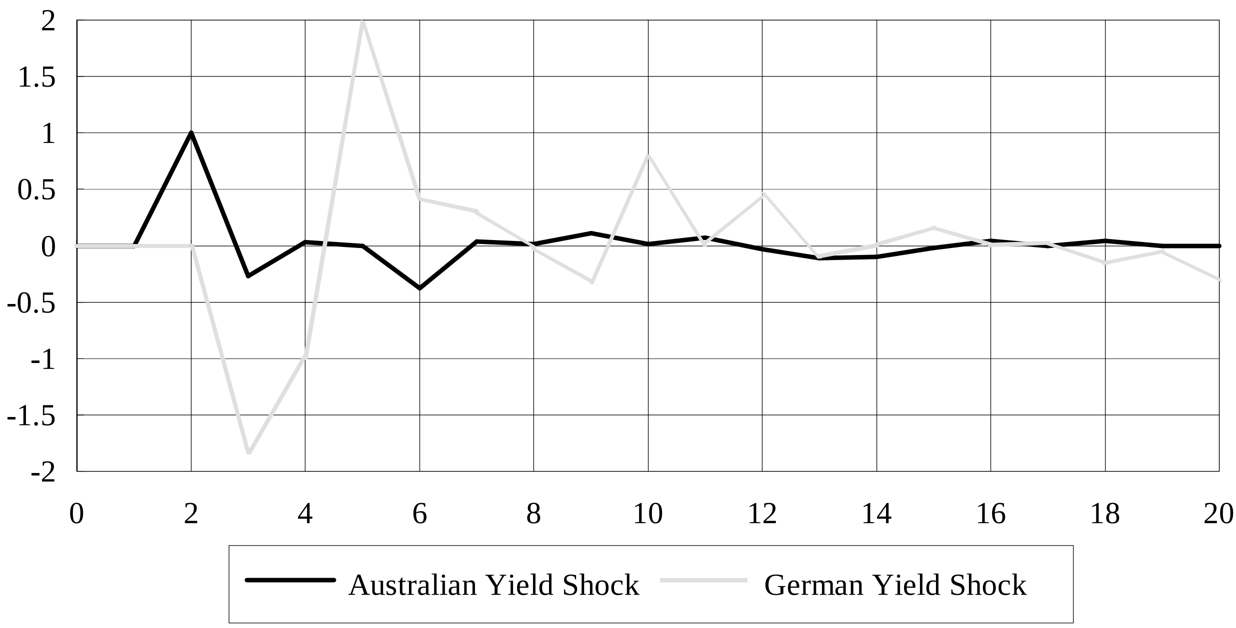
Argument	Dependent Variable				
	Australia	Germany	Japan	UK	US
Australia	98.6	2.0	7.14	34.9	59.8
Germany	184	101	1296	743	999.8
Japan	96.4	6.0	83.1	40	69.3
UK	256	12	220	101	113
US	211	5.7	138	67	101.3

4.3. Impulse Response Functions and Variance Decomposition

Figure 21 pictures the impulse response functions for unit shocks in the Australian bond yield volatility and the German bond yield volatility measures.

Figure 21

Impulse Response of Australian Bond Yield Volatility



This figure shows that the shock in the German volatility outweighs the effect of a unit shock in Australian volatility, in both negative and positive directions. While the contemporaneous correlation coefficients and first-stage impulse-response path show a negative relation between Australian and German bond-market volatility, there is a strong positive reaction in Australian bond yield volatility in intermittent stages.

The variance-decomposition analysis of Table VIII further supports the strong influence of the German volatility measure for Australian bond yield volatility: within one quarter, shocks in this measure account for about 80 percent of the forecast errors of Australian bond volatility.

Table VIII

Variance Decomposition for Australian Bond Yield Volatility

Horizon	Percentage of Variance Due To:				
	Australia	Germany	Japan	UK	US
1	24.08	74.83	0.07	0.03	0.99
5	11.89	81.92	0.55	2.50	3.14
10	10.88	80.94	0.92	3.38	3.88
15	10.75	80.40	1.27	3.34	4.24
20	10.63	80.38	1.40	3.38	4.20
40	10.60	80.37	1.42	3.40	4.20
60	10.60	80.37	1.42	3.40	4.20

4.4. Analysis of Time-Varying Bond Yield Coefficients

As in the analysis of the stock prices and exchange rates, I examine the following time-varying coefficient model:

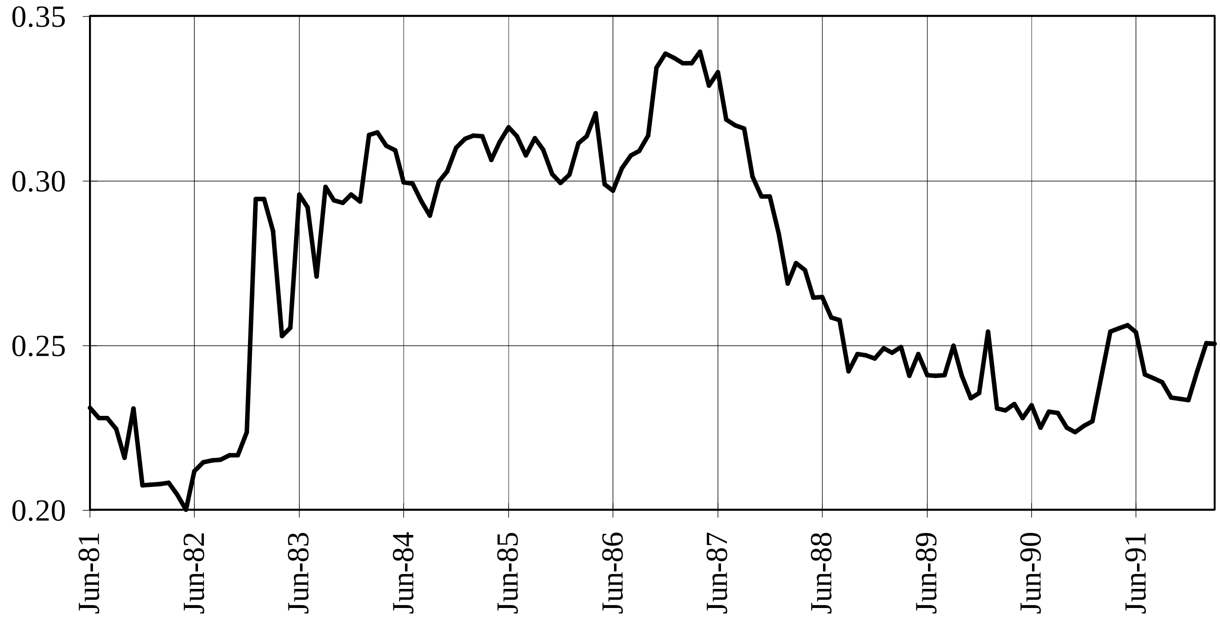
$$\Delta i_{A,t} = b^{*}_{F,t}\left[\Delta i_{Ger,t} \quad \Delta i_{Jap,t} \quad \Delta i_{UK,t} \quad \Delta i_{US,t}\right] + d^{*}_{t}\Delta i_{A,t-1} + e^{*}_{t} \qquad (3)$$

where $[\Delta i_{Ger,t}\ \Delta i_{Jap,t}\ \Delta i_{UK,t}\ \Delta i_{US,t}]$ is the matrix of first differences of the German (Ger), Japanese (Jap), British (UK), and the United States (US) bond yields at time t, $\Delta i_{A,t}$ is the first difference of the Australian yield at time t, $[ß_t^*\ \delta_t^*]$ are the time-varying coefficients of the contemporaneous foreign yields and lagged own yield, and ε_t^* is a random variable, with independent and identical distribution.

Figure 22 shows the time-paths of the time-varying yield coefficients with the German bond rate and the UK bond rate. The coefficient of the German yield becomes more strongly positive, and the coefficient of the UK rate more strongly negative from the beginning towards the middle of the past decade. However, both coefficients fall in absolute value towards the end of the decade.

Figure 22

Time-Varying Coefficient of Australian Yield with German Yield



Time-Varying Coefficient of Australian Yield with UK Yield

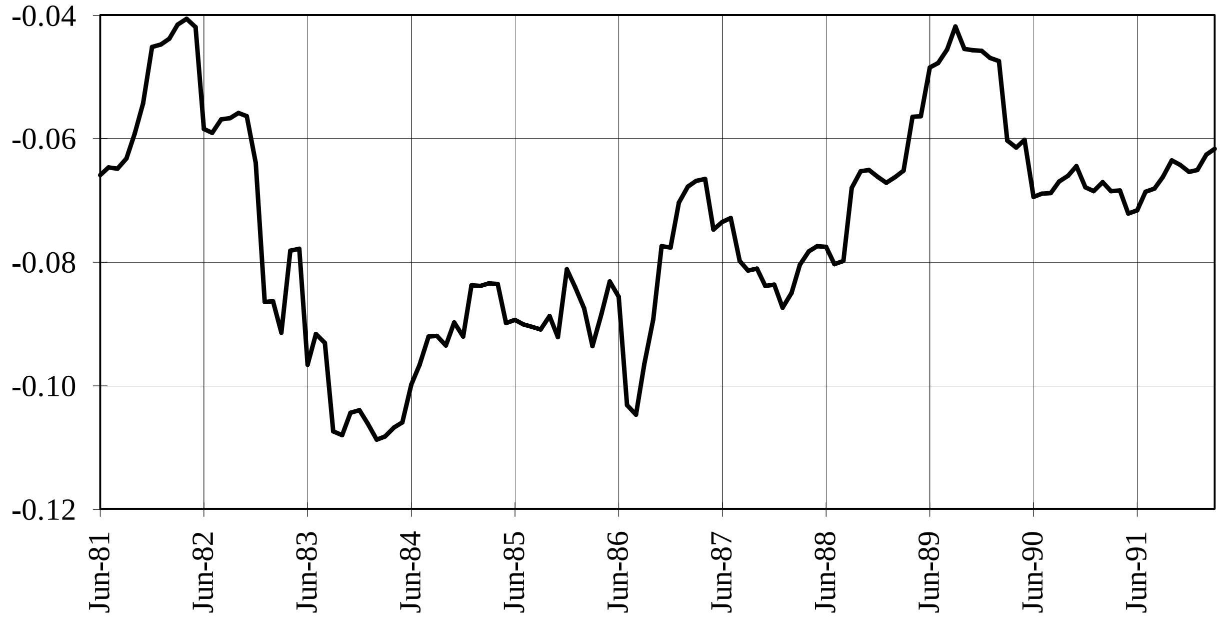


Table IX contains the correlation coefficients of these two time-varying coefficients with the volatility measures for the five bond yields. The table indicates very little degree of correlation of the time-varying coefficients with the volatility measures.

Table IX

Correlations of Yield Coefficients with Volatility Measures, 1981-1992

Volatility Index:	Coefficients	
	β^*_{GER}	β^*_{GER}
Aust	-0.0568	-0.0568
Germ	-0.0154	-0.0154
Japan	0.1076	0.1076
UK	-0.0727	-0.0727
US	-0.0048	-0.0048

The analysis suggests that the German market, if any market at all, has the most significance for the Australian bond market, for predicting both the yields themselves and their volatility through time.

5. CONCLUSION

Recent research has suggested that volatility in one nation's asset markets may be translated into volatility in the markets of other nations through "contagion" effects. These contagion effects reflect both information problems and an inability to take advantage of possible asset price misalignment. This paper represents an attempt to use some recently developed time-series techniques to analyse the relationship between the volatility of Australian asset markets and those abroad.

The empirical results show that the stock, foreign exchange, and bond markets in Australia have adjusted in different ways to international volatilities and asset returns. Volatility in the UK stock market is closely related to Australian stock price volatility. The volatility of the Canadian dollar/US dollar helps predict Australian dollar/US dollar volatility and German long-term bond-yield volatility is most closely related to Australian long-term bond volatility. More detailed exploration of the sources of these correlations is a topic of future research.

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