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Financial Market and Macroeconomic Volatility

— Relationships and Some Puzzles —

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Financial Market and Macroeconomic Volatility[*]
– Relationships and Some Puzzles –

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Abstract

This paper investigates whether the volatility in financial markets is inter-related and whether financial market volatility is related to macroeconomic variability by utilizing a VAR. After investigating Japan, the United States, the United Kingdom and Germany, this paper presents three findings. First, by and large stock and bond return volatility can help predict exchange rate volatility. Second, there is evidence that volatility in some financial markets can help explain the volatility of some macroeconomic measures. There is also evidence that the relationship works in the opposite direction. Finally, this paper identifies some puzzling characteristics of financial markets in Japan. Compared with other countries, Japan has experienced lower bond market volatility and higher foreign exchange volatility, both of which are not associated with macroeconomic volatility.

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1. Introduction

This paper investigates relationships between volatility in financial markets and volatility in macroeconomic measures by comparing Japan with other three major economies, the United States, the United Kingdom and Germany. Many studies have focused on the effects of financial market volatility on economic activities, for instance, the effects of stock market volatility on consumption and private capital investment. Presumably, uncertainty arising from stock market volatility affects saving behavior and decision-making processes for capital investment. Similarly for foreign exchange markets, risk-averse firms reduce exports as foreign exchange volatility raises uncertainty about future profits.[1] Instead of pursuing this avenue, this paper examines the possibility that macroeconomic volatility can explain financial market volatility.[2] For instance, in theory, stock market volatility should be related to macroeconomic development since stock prices are the discounted present value of expected future cash flows. Stock markets may be volatile simply because real economic activities fluctuate.

As far as macroeconomic policy is concerned, it is important that policymakers be able to identify the relationships between financial market and macroeconomic volatility. If financial market volatility leads macroeconomic volatility, policymakers may wish to use financial volatility as a leading indicator to predict future macroeconomic volatility. However, if financial market volatility lags behind macroeconomic volatility, it is not sensible to even attempt to focus on financial market volatility under the assumption that a policymakers' goal is to reduce macroeconomic volatility. Therefore, it is worthwhile that policymakers determine whether macroeconomic volatility can explain financial market volatility or vice versa.

This paper uses a vector autoregression (VAR) model to investigate relationships between financial market volatility and macroeconomic volatility. In a VAR model, one examines whether the lagged values of other variables can predict dependent variables. It is, however, important to note that since the methodology is essentially nonstructural, the results presented in this paper are not necessarily indicative of causal relationships. The financial variables in this paper are stock, government bond and exchange rate returns. Macroeconomic variables include money supply growth, inflation and industrial production growth.

Having investigated the four major industrialized countries during the 1980s and 1990s, this paper presents three findings. First, by and large stock and bond return volatility can help predict exchange rate volatility. Given the importance of interest rate differentials in determining the movement of exchange rates, it is unsurprising that exchange rate volatility is related to bond market volatility. Similarly, the importance of stock markets in influencing foreign exchange markets in recent years – due to the increased volume of cross-border trading – makes it plausible that exchange rate volatility is associated with stock market volatility.

Second, there is some evidence of relationships between financial market volatility and macroeconomic volatility. Financial market volatility can in part predict

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[1] Kimura and Nakayama (2000) find that exchange rate volatility, which is considerably larger in Japan than in other major countries, has substantial negative effects on Japan's exports. See also McKenzie (1999) for a survey of effects of foreign exchange volatility on exports.

[2] Schwert (1989) and Anderson and Breedon (1996) examine this issue for the United States and the United Kingdom, respectively.

macroeconomic volatility. Stock volatility can help predict industrial production volatility in Japan, while bond volatility can explain Consumer Price Index (CPI) inflation volatility in the United Kingdom. There is also evidence of relationship in the opposite direction. For instance, money growth volatility can explain stock return volatility in Germany. In addition, there are a few pairs of financial and macroeconomic variables that can predict each other: bond and industrial production volatility in the United States and bond and Producer Price Index (PPI) inflation volatility in the United Kingdom. There is, therefore, no clear evidence that financial market volatility always explains macroeconomic volatility.

Finally, this paper finds some peculiar characteristics of financial markets in Japan. Bond market volatility is relatively lower than other countries, except for Germany. Furthermore, bond return volatility is not related to other financial return volatility or macroeconomic volatility. On the other hand, Japanese exchange market volatility is by far the highest of the four countries. It is more puzzling that the excessive exchange rate volatility is not related to macroeconomic volatility.

The remainder of this paper contains four sections. Section 2 describes the definition of volatility and compares volatility across countries. Section 3 examines relations between financial market volatility and macroeconomic volatility by using a VAR model. Section 4 discusses some unusual characteristics of Japanese bond and foreign exchange markets. Finally, Section 5 presents concluding remarks.

2. Definition of Financial Market and Macroeconomic Economic Volatility

The data set includes four industrialized countries: Japan, the United States, the United Kingdom and Germany. It mainly covers the period from the early 1980s to the end of 1999. Financial variables considered in this paper are stock returns, government bond returns and the growth rate of the nominal effective exchange rate. Base money growth, money supply growth, PPI inflation and CPI inflation represent nominal macroeconomic variables, while industrial production growth is the only real economic variable. The appendix describes the details of these variables.

Since financial data are available on a daily basis, the monthly standard deviation of financial asset returns calculated from N_t daily returns, r_{it}, in month t shows the volatility of three financial variables, σ_t.

$$s_t = \sqrt{\frac{1}{N_t - 1}\sum_{i=1}^{N_t}(r_{it} - \bar{r}_t)^2}$$

For marcoeconomic data that are not available on a daily basis, but on a monthly basis, this paper calculates the monthly volatility of macroeconomic variables based on Schwert's (1989) procedure as follows:

(i) First, estimate a 12th-order autoregression, or AR(12), for the macroeconomic variables, R_t, with 12 dummy variables, D_{jt}, allowing for different monthly means

$$R_t = \sum_{j=1}^{12} a_j D_{jt} + \sum_{i=1}^{12} b_i R_{t-i} + e_t. \qquad (1)$$

(ii) Estimate a 12th-order autoregression, or AR(12), for the absolute values of the residuals from equation (1), with 12 dummy variables, D_{jt}, allowing for different monthly standard deviations,

$$|\hat{e}_t| = \sum_{j=1}^{12} g_j D_{jt} + \sum_{i=1}^{12} d_i |\hat{e}_{t-i}| + u_t. \qquad (2)$$

The predicted values from equation (2) are the estimates of monthly conditional standard deviations of R_t. Schwert (1989) notes that this methodology to estimate conditional volatility is similar to an autoregressive conditional heteroskedasticity (ARCH) model developed by Engle (1982). Volatility of financial asset returns is also calculated the same way based on monthly return data.

Chart 1 shows volatility based on daily data for three financial asset returns for the four countries. Volatility is simply the average value for sample periods. There is no substantial difference in stock return volatility for the full sample across countries, while bond return volatility in Japan and Germany is substantially lower than in the United States and the United Kingdom. As for exchange rates, Japan's volatility is considerably higher than that of other countries.[3] Chart 1 also shows the volatility during the 1990s to capture any recent developments. Stock volatility in Japan is substantially higher in the 1990s than during the full sample period, while Germany's volatility is as high as Japan's in the 1990s. Another remarkable point is that exchange rate volatility is higher during this time period in Japan than in the full sample period, but there is no significant difference between these two time periods in other countries.

What explains these differences in financial market volatility? Volatility in one financial market may explain volatility in other financial markets. For instance, at first glance, stock market volatility and exchange rate volatility in Japan during the 1990s appear to be related since the volatility of both stock and foreign exchange markets is high during the last decade. Alternatively, macroeconomic volatility may help to predict financial market volatility. Theoretically speaking, since a stock price is the discounted present value of expected future cash flows, stock volatility should be related to economic developments that would affect expected future cash flows and future discount rates. This implies that stock volatility is associated with the volatility of macroeconomic measures such as money supply, inflation and industrial production.

Chart 2 depicts differences in volatility of macroeconomic measures across countries and sample periods. Volatility is the average value over sample periods as in Chart 1. It appears that there are differences in volatility across countries and time periods. Among the notable differences, volatility of almost all measures for the United States is the lowest of the four countries. Base money volatility is substantially higher than money supply volatility in Japan. While industrial production volatility is by no means high compared with other countries except for the United States, Japan is the only country in which volatility increased in the 1990s, possibly reflecting the

[3] Kimura and Nakayama (2000) also report excessive foreign exchange volatility for Japan.

recessions and the series of fiscal injections. The high volatility of industrial production in Japan may also be related to the higher volatility of stock and foreign exchange markets during the last decade.

3. Testing Volatility Relationships

While Section 2 roughly surveys relationships in the volatility of financial markets and macroeconomic measures, this section follows Schwert (1989) by introducing a VAR system of equations to more formally investigate relationships between financial market and macroeconomic volatility:

$$s_t = \sum_{i=1}^{n} a_{1i} s_{t-i} + \sum_{i=1}^{n} b_{1i} b_{t-i} + \sum_{i=1}^{n} g_{1i} e_{t-i} + \sum_{i=1}^{n} d_{1i} x_{t-i} + \sum_{i=1}^{12} q_{1i} D_{it} + e_{1t} \qquad (3)$$

$$b_t = \sum_{i=1}^{n} a_{2i} s_{t-i} + \sum_{i=1}^{n} b_{2i} b_{t-i} + \sum_{i=1}^{n} g_{2i} e_{t-i} + \sum_{i=1}^{n} d_{2i} x_{t-i} + \sum_{i=1}^{12} q_{2i} D_{it} + e_{2t} \qquad (4)$$

$$e_t = \sum_{i=1}^{n} a_{3i} s_{t-i} + \sum_{i=1}^{n} b_{3i} b_{t-i} + \sum_{i=1}^{n} g_{3i} e_{t-i} + \sum_{i=1}^{n} d_{3i} x_{t-i} + \sum_{i=1}^{12} q_{3i} D_{it} + e_{3t} \qquad (5)$$

$$x_t = \sum_{i=1}^{n} a_{4i} s_{t-i} + \sum_{i=1}^{n} b_{4i} b_{t-i} + \sum_{i=1}^{n} g_{4i} e_{t-i} + \sum_{i=1}^{n} d_{4i} x_{t-i} + \sum_{i=1}^{12} q_{4i} D_{it} + e_{4t} \qquad (6)$$

where s is stock return, b is bond return, e is exchange rate return and x is macroeconomic variables.

This system is a more general measure to estimate conditional volatility than equation (2); it allows lagged values of other variables to predict the dependent variable. Omitted variable tests determine the statistical significance of lagged values of other variables in predicting the dependent variable. In order to conduct VAR analysis, it is important that estimated volatility variables be stationary. Table 1 shows the results of augmented Dickey-Fuller (ADF) unit root tests and finds that most volatility series are stationary.[4]

[4] Likelihood ratio (LR) tests determine the number of lags in the unit root tests.

Table 1: ADF Test for a Unit Root

	Japan		USA		UK		Germany	
	ADF	Lags	ADF	Lags	ADF	Lags	ADF	Lags
Stock ♦	-3.95***	5	-4.92***	4	-4.92***	4	-3.00**	12
Govt. bond ♦	-5.29***	7	-3.07**	5	-3.07**	5	-5.64***	3
Nominal effective exchange rate ♦	-4.05***	3	-4.80***	3	-4.55***	14	-3.97***	14
Stock	-3.93***	7	-9.47***	7	-4.92***	4	-4.54***	4
Government bond	-4.57***	8	-3.84***	8	-7.13***	12	-4.46***	11
Nominal effective exchange rate	-9.24***	9	-7.37***	9	-3.77***	11	-6.54***	11
Base money	-7.19***	12	-5.70***	9	-2.94**	11	—	—
Money supply	-5.27***	8	-5.57***	8	-6.10***	5	-3.75***	11
PPI	-2.98**	8	-2.17	9	-2.60	8	-4.06***	8
CPI	-1.89	8	-2.46	8	-7.26***	2	-7.82***	8
IP	-3.76***	9	-3.64***	9	-3.52***	8	-4.93***	10

Notes: 1. ♦ indicates volatility based on daily returns. Volatility of other variables is calculated from monthly data. 2. *** and ** indicate a rejection of null hypothesis of unit root at the 1% and 5% significance level respectively. 3. LR tests determine the number of lags.

3.1. Financial Market Volatility

Table 2 shows the results of VAR analysis for Japan. A basic VAR system of equations includes only three financial variables, corresponding to equations (3) through (5) in Table 2(1). This attempts to examine any relations (or contagion effects) within financial markets. Then, each macroeconomic variable is incorporated into this basic system of equations in Tables 2(2) through 2(6).[5] The F-tests indicate whether the lagged row variables can predict the column variable.[6] The larger the F-values are, the larger the predictive power is. The diagonal values of matrices are in general the largest since they represent the lagged values of the dependent variables and the off-diagonal values are smaller than the diagonal ones. For example, the lagged values of stock volatility are most important in predicting current stock volatility in Table 2(1). Lagged bond volatility is by far less important and lagged foreign exchange volatility

[5] This paper does not report the results of VAR analysis based on monthly financial return volatility calculated according to Schwert (1989) because most variables, including their own lagged values, correspond to very small F-values and hence are statistically insignificant.

[6] The LR test determines the number of lags for VAR equations.

contributes the least.

Due to the relatively small sample size, the model specifications in Table 2 may substantially reduce the degree of freedom.[7] For those variables that are statistically significant in Table 2, Table 3 shows the results of the bivariate VAR estimation. The relationship between stock and foreign exchange volatility and that between stock and industrial production volatility remain statistically significant. However, the relationship between stock and government bond volatility becomes insignificant. This may indicate that the small degree of freedom is actually problematic in Table 2(5) or that the specification of Table 2(5) is more appropriate than the bivariate specification of Table 3(2). Regardless of whether the problem arises from the degree of freedom or the model specification, the relationship between stock and bond volatility is not robust. Chart 3 depicts time series volatility for a pair of variables that are statistically significant in the bivariate VAR analysis. Stock volatility leads foreign exchange volatility in some periods and it is especially after 1993 that stock and foreign exchange volatility are closely moving together in Chart 3(1). Chart 3(2), on the other hand, shows that there are times when stock volatility leads industrial production volatility. It is obvious, however, that stock volatility can by no means explains all movements of industrial production volatility.

Tables 4 through 9 describe the results of the same VAR analysis for the other three countries. As far as financial markets – including Japan's – are concerned, by and large stock and bond return volatility can help to predict exchange rate volatility. This result is unsurprising since bond markets play an important role in determining foreign exchange movements through interest rate differentials. This relationship of the two markets may also reflect the importance of stock markets in affecting foreign exchange markets in recent years.[8] As in Japan, Charts 4 through 6 show time-series volatility for a pair of variables whose relationship is statistically significant for the United States, the United Kingdom and Germany.

3.2. Financial Market and Macroeconomic Volatility

As mentioned in Section 2, macroeconomic volatility may well be related to stock market volatility. Bond market volatility is also likely to be associated with volatility of macroeconomic measures. Monetary policy that is reflected in base money growth or money supply growth affects bond markets through interest rate changes. PPI inflation and CPI inflation should be related to bond markets through inflation expectations.

Tables 2 through 9 in fact show that macroeconomic volatility is related to financial market volatility. There is evidence that financial market volatility can help to explain macroeconomic volatility. Stock volatility in Japan can help to predict industrial production volatility in Table 3(3). In the United Kingdom, bond volatility

[7] Schwert (1989) and Anderson and Breedon (1996) exogenously set the number of lags to 12. But their sample size is substantially larger than this paper's. Schwert (1989) gathered data from 1859 to 1987 while Anderson and Breedon's data extends from 1945 to 1995.

[8] Since the US stock market is considered as important in affecting other countries' stock markets, this paper incorporate US stock market volatility into other countries' basic VAR specification of three financial variables. However, US stock volatility cannot help predict volatility of financial markets in other countries.

can explain CPI inflation volatility in Table 7(3), while exchange rate volatility leads money supply volatility in Table 7(2). There is also evidence of relationship in the reverse direction. Industrial production volatility can predict bond volatility in the United Kingdom in Table 7(6) and money supply volatility can explain stock volatility in Germany in Table 9(2). Moreover, there are pairs of variables that can help predict each other: bond and CPI inflation, and bond and industrial production in the United States in Tables 5(3) and 5(4), respectively; bond and PPI inflation in the United Kingdom in Table 7(5).[9]

4. Puzzles?

This paper finds some peculiar characteristics of bond and foreign exchange markets in Japan. Bond market volatility is relatively lower than other countries – except for Germany, where bond volatility is comparable to that in Japan. Furthermore, bond return volatility is not related to other financial return volatility or macroeconomic volatility.[10] This may be puzzling given that bond market volatility is related to macroeconomic volatility in the United States and the United Kingdom, and given that the relationship between bond market and macroeconomic activities at least in levels should exist.

Since it is likely that both financial and macroeconomic volatility increase during recessions, Charts 7 and 8 split the sample into recession and expansion periods and show the volatility of financial markets and macroeconomic measures for the respective periods. However, there is no significant difference in bond market volatility in Japan. If anything, volatility is slightly lower during recessions than during expansions.[11] On the contrary, it is remarkable that financial market volatility in the United States is substantially higher during recessions than during expansions. In fact, Schwert (1989) indicates that stock market volatility is higher during recessions than expansions.[12]

More formally, Hirata and Ueda (1998), who examined whether the term structure of interest rates could predict future recessions have found unusual characteristics in Japan's bond market. In theory, the expectations hypothesis of the term structure of interest rates states that the long-term rate is an average of current and

[9] These results are somewhat different from those of Schwert (1989) and Anderson and Breedon (1996). Among notable differences, Schwert found stock volatility is related to both money growth and industrial production, while he found no relationship between bonds and inflation. As for the United Kingdom, Anderson and Breedon reported the relationship among stock and industrial production volatility. These differences from this paper's findings may arise as a result of different sample periods and the smaller sample size of this paper.

[10] To the extent that bond return volatility is not related to macroeconomic volatility, Germany is similar to Japan.

[11] This paper also calculates the average value of volatility for six months before and after troughs and for six months before and after peaks for the four countries. This attempts to predict business cycles by examining whether the volatility of financial and macroeconomic measures changes during these two time periods. However, there is no substantial difference in any country.

[12] Similar to Schwert's specification, this paper formally tests the insensitivity of Japan's bond market by running a regression of bond volatility on a constant, a dummy variable for recessions, base money volatility, PPI inflation volatility and industrial production volatility. As expected from Chart 7, a dummy variable for recessions has a negative coefficient that is not statistically significant.

expected future short-term rates. A narrow yield spread between long-term and short-term interest rates could imply low expected short-term interest rates in the future. Expectations of low future interest rates could arise from expectations of future recessions. They found that although the yield spread can predict future recessions in Japan, its predictive power is smaller than in the United States and some European countries.[13] However, they attributed this relatively small predictive power to the small sample size rather than cross-country differences in bond markets.

The microstructure of Japanese bond market may offer a possible explanation for these puzzling results. Inoue (1999) compared Japan's government bond market with that of other industrialized countries and found that the Japanese market is less liquid than that of other countries. The lack of liquidity may well be attributed to the insensitive response of the bond market to macroeconomic activities in Japan.[14]

In contrast to the low bond market volatility, exchange market volatility in Japan is by far the highest of the four countries. Nevertheless, there appears to be no relationship between exchange rate volatility and macroeconomic volatility, although stock return volatility can explain exchange rate volatility. This may be puzzling given that exchange rates affect real economic activities in Japan at least in levels. Furthermore, Kimura and Nakayama (2000) found that exchange rate volatility has substantial negative effects on the level of Japan's exports.[15, 16]

5. Concluding Remarks

This paper attempts to investigate whether there are relationships in volatility among financial markets and whether financial market volatility is related to macroeconomic variability by utilizing a VAR. Having investigated four major industrialized countries during the 1980s and 1990s, this paper presents three findings. First, by and large stock and bond return volatility can help predict exchange rate volatility. Second, there is evidence that financial market volatility can help explain macroeconomic volatility. There is also evidence of relationship in the reverse direction. Finally, this paper finds some puzzling characteristics of financial markets in Japan. Compared with other major industrial countries, Japan has experienced lower bond market volatility and higher foreign exchange volatility, both of which are not related to macroeconomic volatility.

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[13] See, for instance, Estrella and Mishkin (1995, 1996a, 1996b) for studies on the United States and Europe.

[14] Another possible reason for the insensitive bond response arises from the unusual composition of market participants: there are only limited buyers (a few institutional investors), and many foreign sellers in the secondary bond market.

[15] One could, however, argue that it is not puzzling at all since this paper's methodology is nonstructural.

[16] Another puzzle is why stock volatility alone cannot explain the excessively volatile exchange rate.

Appendix: Data Description

A. Stock

Japan: TOPIX (Source: Datastream, Code: TOKYOSE)
United States: S&P 500 COMPOSITE (Source: Datastream, Code: S&PCOMP)
United Kingdom: FTSE 100 (Source: Datastream, Code: FTSE100)
Germany: DAX 30 (Source: Datastream, Code: DAXINDZ)

B. Government Bond

7-10 year maturity bond price index

Japan: (Source: Datastream, Code: AJPGVG4)
United States: (Source: Datastream, Code: AUSGVG4)
United Kingdom: (Source: Datastream, Code: AUKGVG4)
Germany: (Source: Datastream, Code: ABDGVG4)

C. Exchange Rates

Nominal Effective Exchange Rate

Japan: (Source: BIS Data Bank Series, Code: QSAAJP02)
United States: (Source: BIS Data Bank Series, Code: QSAAUS02)
United Kingdom: (Source: BIS Data Bank Series, Code: QSAAUK02)
Germany: (Source: BIS Data Bank Series, Code: QSAADE02)

D. Monetary Base

Japan: Seasonally adjusted (Source: Bank of Japan)
United States: Seasonally adjusted (Source: BIS Data Bank Series, Code: BBBBUS02)
United Kingdom: Seasonally adjusted (Source: BIS Data Bank Series, Code: BBBBUK02)

E. Money Supply

Japan: M2 + CD, seasonally adjusted (Source: Bank of Japan)
United States: M2, seasonally adjusted (Source: Federal Reserve Board)
United Kingdom: M4, seasonally adjusted (Source: OECD Main Economic Indicators)
Germany: M3, seasonally adjusted (Source: OECD Main Economic Indicators)

F. Producer Price Index

Japan: Wholesale price index, all commodities, seasonally adjusted (Source: Bank of Japan)
United States: Total, seasonally adjusted (Source: OECD Main Economic Indicators)
United Kingdom: Manufacturing output all products, seasonally adjusted (Source:

OECD Main Economic Indicators)
Germany: All items, seasonally adjusted (Source: OECD Main Economic Indicators)

G. Consumer Price Index

Japan: Excluding perishables, seasonally adjusted (Source: Management and Coordination Agency)
United States: Less food and energy, seasonally adjusted (Source: Department of Labor)
United Kingdom: Retail price index excluding mortgage interest payments, seasonally adjusted (Source: Office for National Statistics)
Germany: Less food, seasonally adjusted (Source: OECD Main Economic Indicators)

H. Industrial Production

Japan: Total, seasonally adjusted (Source: Ministry of International Trade and Industry)
United States: Total, seasonally adjusted (Source: Federal Reserve Board)
United Kingdom: Total, seasonally adjusted (Source: OECD Main Economic Indicators)
Germany: Total, seasonally adjusted (Source: OECD Main Economic Indicators)

References

Anderson, Nicola and Francis Breedon, 1996, “UK asset price volatility over the last fifty years,” in Financial Market Volatility: Measurement, causes and consequences (Bank for International Settlements, Basle, Switzerland), 396-428.

Engle, Robert, 1982, “Autoregressive conditional heteroskedasticity with estimates of the variance of United Kingdom inflation,” Econometrica, 50, 987-1007.

Estrella, Arturo and Frederic Mishkin, 1995, “The term structure of interest rates and its role in monetary policy for the European Central Bank,” NBER Working Paper, no. 5279.

Estrella, Arturo and Frederic Mishkin, 1996a, “Predicting U.S. recessions: Financial variables as leading indicators,” Federal Reserve Bank of New York, Research Paper, No. 9609.

Estrella, Arturo and Frederic Mishkin, 1996b, “The yield curve as a predictor of U.S. recessions,” Federal Reserve Bank of New York, Current Issues in Economics and Finance, Volume 2 Number 7.

Hirata, Hideaki and Kazuo Ueda, 1998, “The yield spread as a predictor of Japanese recessions,” Research and Statistics Department, Bank of Japan, Working Paper 98-3.

Inoue, Hirotaka, 1999, “Government bond markets in G7 countries: Characteristics of Japan’s market liquidity (*G7 shokoku no kokusai shijou: Shijouryuudousei no kanten kara mita nihonshijou no tokuiten*),” Financial Market Department, Bank of Japan, Working Paper Series 99-J-2.

Kimura, Takeshi and Kou Nakayama, 2000, “Foreign exchange volatility and firms’ export activities (*Kawasereito no boratiriti to kigyou no yushutsu koudou*), Bank of Japan Monthly Bulletin, March, 83-109.

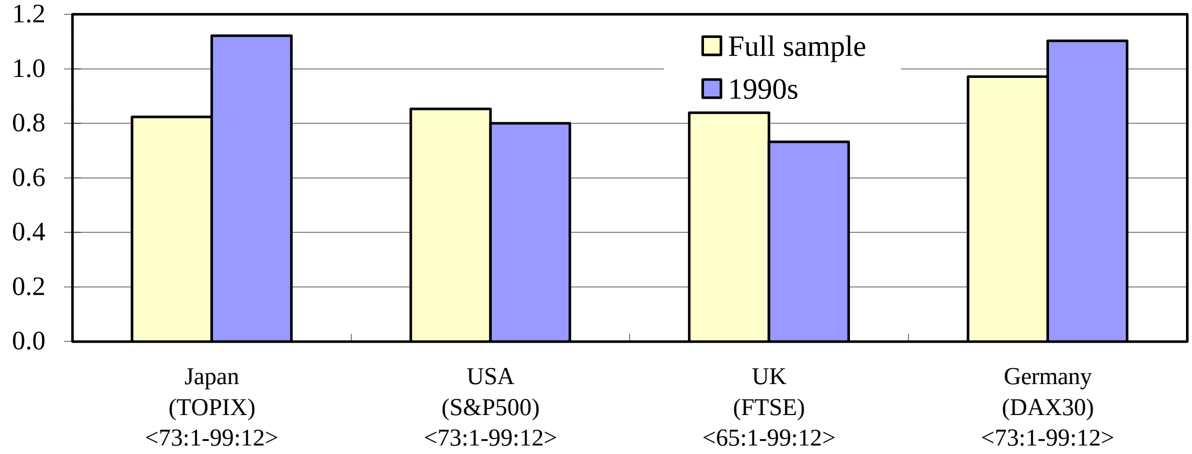
McKenzie, M., 1999, “The impact of exchange rate volatility on international trade flows,” Journal of Economic Surveys, 13, 77-106.

Schwert, G. William, 1989, “Why does stock market volatility change over time?” Journal of Finance, 44, 1115-1153.

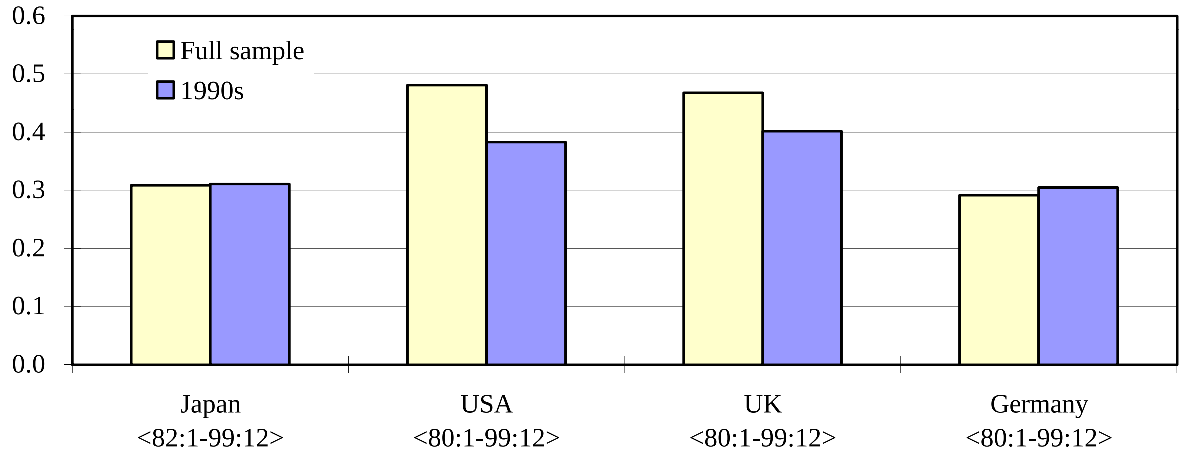
Chart 1

Financial Market Volatility

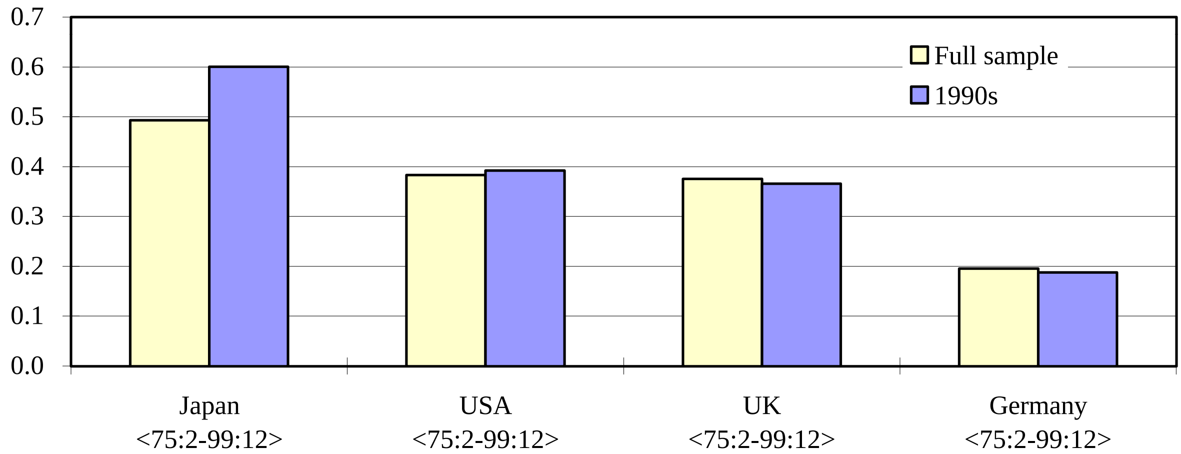
(1) Stock



(2) Government Bond (7-10 year maturity)



(3) Nominal Effective Exchange Rate

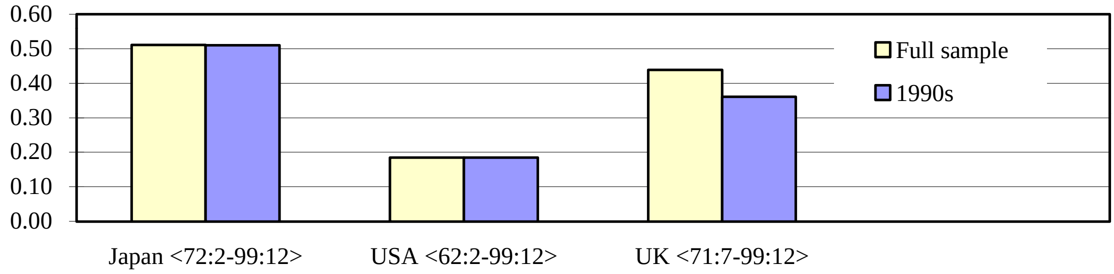


Notes: 1. Average value of monthly standard deviation calculated from daily return.
2. Numbers in angle brackets indicate sample periods.

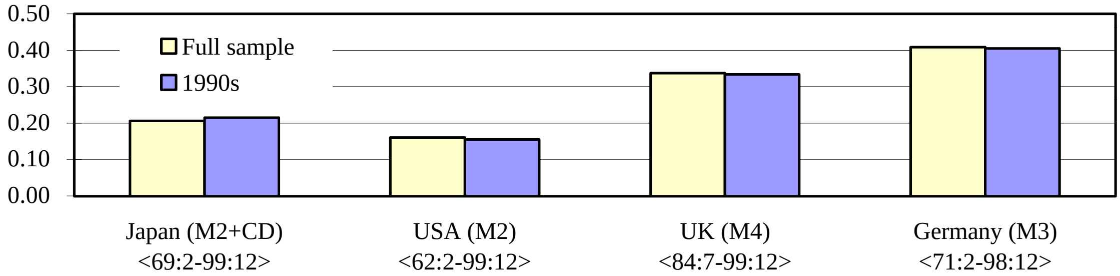
Chart 2

Macroeconomic Volatility

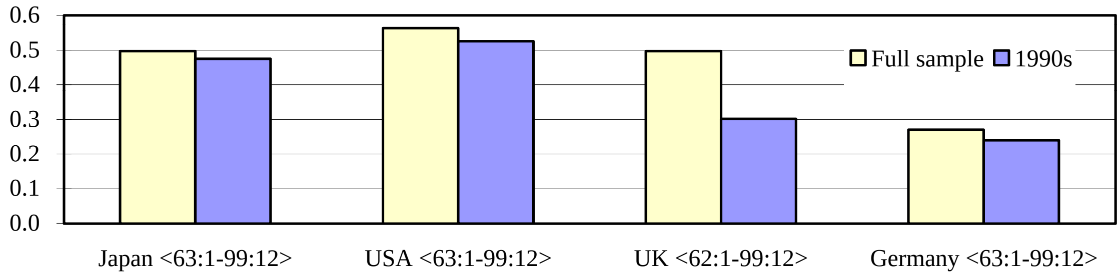
(1) Base Money



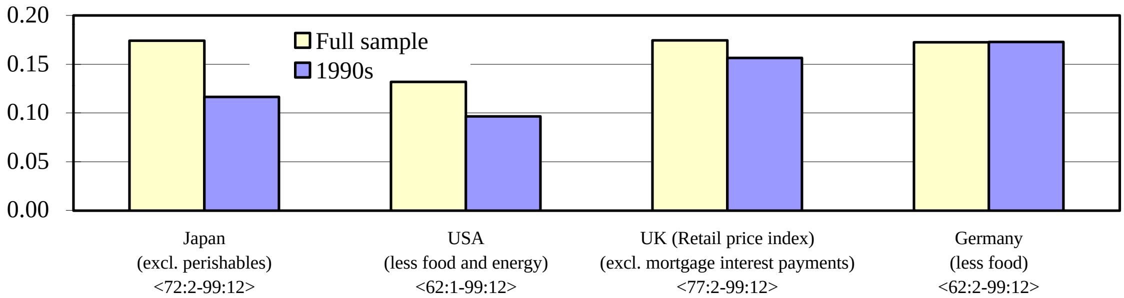
(2) Money Supply



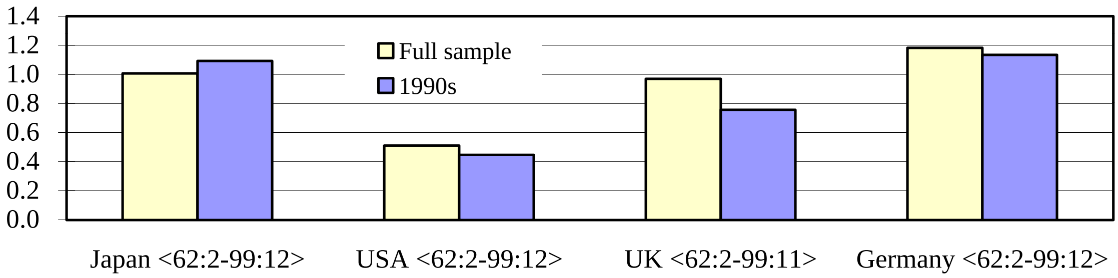
(3) Producer Price Index



(4) Consumer Price Index



(5) Industrial Production



Notes: 1. Average value of volatility calculated from monthly growth rate according to Schwert (1989).
2. Numbers in angle brackets indicate sample periods.

Japan

(1)

Independent Variable	*F*-Tests with Daily Volatility (L=4)		
	Stock	Govt. bond	Neer
Stock	18.7***	1.49	3.52***
Govt. bond	2.11	16.0***	0.71
Neer	1.20	0.98	23.7***

(2)

Independent Variable	*F*-Tests with Daily Volatility (L=4)			
	Stock	Gbond	Neer	Base
Stock	18.4***	1.32	3.18**	0.91
Govt. bond	1.94	16.2***	0.70	0.59
Neer	1.43	1.07	23.7***	2.44**
Base	1.32	0.57	0.64	0.58

(3)

Independent Variable	*F*-Tests with Daily Volatility (L=4)			
	Stock	Gbond	Neer	M2+CD
Stock	17.7***	1.45	3.49***	1.07
Govt. bond	2.00	15.3***	0.75	0.82
Neer	1.28	0.89	22.7***	0.93
M2+CD	0.52	0.16	1.09	3.84***

(4)

Independent Variable	*F*-Tests with Daily Volatility (L=4)			
	Stock	Gbond	Neer	WPI
Stock	18.3***	1.60	3.34**	0.64
Govt. bond	2.06	14.3***	0.56	0.61
Neer	1.11	0.69	20.3***	0.83
WPI	0.02	1.40	1.81	1.91

(5)

Independent Variable	*F*-Tests with Daily Volatility (L=4)			
	Stock	Gbond	Neer	CPI
Stock	17.68***	1.43	3.20**	0.22
Govt. bond	2.01	15.48***	0.77	0.76
Neer	1.00	0.90	22.91***	0.52
CPI	0.50	0.06	1.15	1.82

(6)

Independent Variable	*F*-Tests with Daily Volatility (L=4)			
	Stock	Gbond	Neer	IIP
Stock	18.7***	1.61	3.71***	3.24**
Govt. bond	1.97	14.7***	0.50	1.09
Neer	1.32	0.94	23.3***	0.17
IIP	0.97	0.36	1.50	2.12

Notes: 1. *** and ** indicate statistical significance at the 1% and 5% level respectively.
LR tests determine the number of lags.

2. Neer = Nominal effective exchange rate.
Base = Base money.
WPI = Wholesale price index.
CPI = Consumer price index excluding perishables.
IIP = Industrial production.

Table 3

Japan (Bivariate VAR)

(1) Stock → Neer (Sample = 75:5-99:12, No. of lags = 4)

	Stock	Neer
Stock	41.41***	4.60***
Neer	0.96	41.25***
D.W.	2.00	2.01

(2) Neer → Base (Sample = 75:5-99:12, No. of lags = 4)

	Neer	Base
Neer	49.87***	1.93
Base	1.79	1.17
D.W.	2.05	1.99

(3) Stock → IIP (Sample = 73:5-99:12, No. of lags = 4)

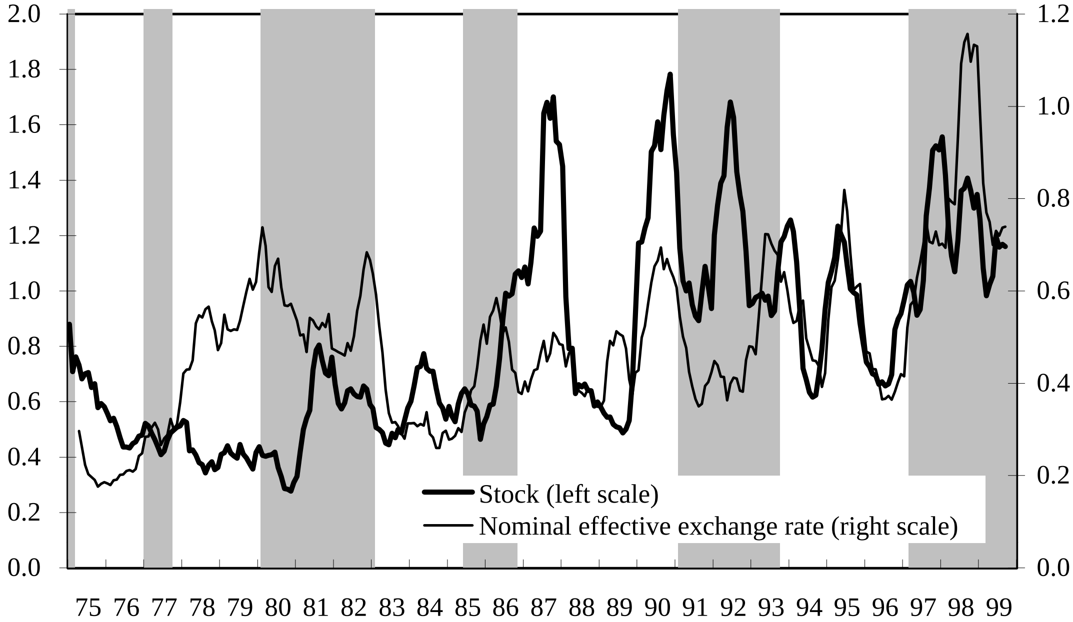
	Stock	IIP
Stock	47.11***	2.88**
IIP	0.81	2.95**
D.W.	2.00	2.01

Notes: 1. *** and ** indicate statistical significance at the 1% and 5% level respectively.
LR tests determine the number of lags.

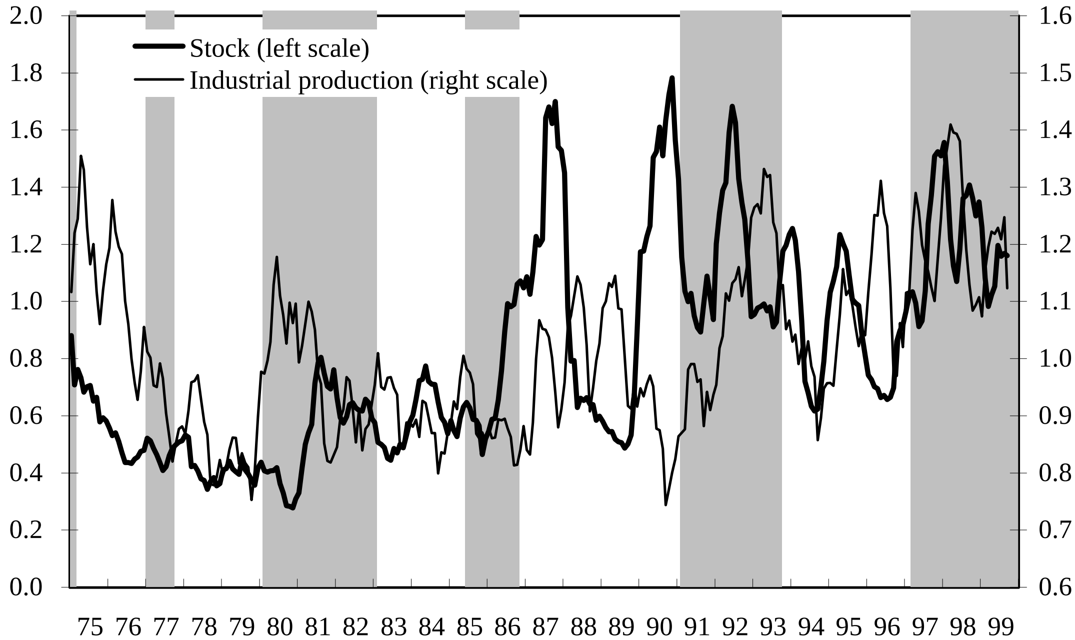
2. Neer = Nominal effective exchange rate.
Base = Base money.
IIP = Industrial production.

Bivariate Relationships (Japan)

(1) Stock and Exchange Rate



(2) Stock and Industrial Production*



Notes: 1. Six-month moving average.
2. Shaded areas indicate periods of recession.
3. * indicate volatility is calculated from monthly data (according to Schwert). Volatility of the other variables is based on daily returns (standard deviation).

Table 4

USA

(1)

Independent Variable	*F*-Tests with Daily Volatility (L=6)		
	Stock	Govt. bond	Neer
Stock	12.88***	0.82	1.92
Govt. bond	0.50	34.05***	1.93
Neer	0.69	0.72	8.86***

(2)

Independent Variable	*F*-Tests with Daily Volatility (L=6)			
	Stock	Gbond	Neer	Base
Stock	12.88***	0.92	1.97	0.57
Govt. bond	0.43	29.48***	1.97	0.01
Neer	0.77	0.79	9.51***	0.87
Base	0.62	0.70	1.87	6.17***

(3)

Independent Variable	*F*-Tests with Daily Volatility (L=6)			
	Stock	Gbond	Neer	M2
Stock	13.3***	0.98	1.89	1.12
Govt. bond	0.64	33.0***	1.92	2.13
Neer	0.77	0.98	8.86***	0.79
M2	0.90	1.84	0.29	1.52

(4)

Independent Variable	*F*-Tests with Daily Volatility (L=4)			
	Stock	Gbond	Neer	PPI
Stock	18.55***	1.02	2.93**	0.72
Govt. bond	0.79	42.19***	2.58**	1.52
Neer	0.83	0.15	12.17***	1.15
PPI	1.20	0.36	0.54	5.45***

(5)

Independent Variable	*F*-Tests with Daily Volatility (L=7)			
	Stock	Gbond	Neer	CPI
Stock	11.15***	0.87	1.94	0.35
Govt. bond	0.62	9.46***	1.28	2.59**
Neer	0.82	0.86	7.03***	1.23
CPI	1.02	4.06***	1.30	1.71

(6)

Independent Variable	*F*-Tests with Daily Volatility (L=6)			
	Stock	Gbond	Neer	IIP
Stock	12.60***	1.28	1.71	1.50
Govt. bond	0.54	23.21***	1.78	2.77**
Neer	0.71	1.10	8.57***	1.00
IIP	0.19	3.14***	0.74	1.22

Notes: 1. *** and ** indicate statistical significance at the 1% and 5% level respectively.
LR tests determine the number of lags.

2. Neer = Nominal effective exchange rate.
Base = Base money.
PPI = Producer price index.
CPI = Consumer price index less food and energy.
IIP = Industrial production.

Table 5

USA (Bivariate VAR)

(1) Stock → Neer
(Sample = 75:5-99:12, No. of lags = 4)

	Stock	Neer
Stock	23.33***	5.91***
Neer	0.93	38.66***
D.W.	1.99	2.02

(2) Govt. bond → Neer
(Sample = 80:7-99:12, No. of lags = 6)

	Govt. bond	Neer
Govt. bond	34.85***	3.33***
Neer	0.81	9.05***
D.W.	2.07	2.00

(3) Govt. bond ↔ CPI
(Sample = 80:8-99:12, No. of lags = 7)

	Govt. bond	CPI
Govt. bond	11.62***	3.31***
CPI	3.77***	1.83
D.W.	1.99	1.96

(4) Govt. bond ↔ IIP
(Sample = 80:7-99:12, No. of lags = 6)

	Govt. bond	IIP
Govt. bond	23.20***	2.36**
IIP	2.44**	1.24
D.W.	2.09	2.00

Notes: 1. *** and ** indicate statistical significance at the 1% and 5% level respectively.
LR tests determine the number of lags.

2. Neer = Nominal effective exchange rate.
CPI = CPI less food and energy.
IIP = Industrial production.

Table 6

UK

(1)

Independent Variable	*F*-Tests with Daily Volatility (L=6)		
	Stock	Govt. bond	Neer
Stock	11.20***	1.32	0.91
Govt. bond	0.78	19.71***	2.72**
Neer	0.83	1.05	13.80***

(2)

Independent Variable	*F*-Tests with Daily Volatility (L=6)			
	Stock	Gbond	Neer	Base
Stock	10.92***	1.48	0.90	1.82
Govt. bond	0.90	14.26***	2.79**	2.23**
Neer	0.78	1.36	13.98***	1.85
Base	0.94	1.90	0.74	2.99***

(3)

Independent Variable	*F*-Tests with Daily Volatility (L=5)			
	Stock	Gbond	Neer	M4
Stock	9.83***	0.66	1.51	1.04
Govt. bond	0.44	4.97***	3.45***	1.24
Neer	1.10	0.83	19.79***	3.05**
M4	0.63	0.11	0.79	0.58

(4)

Independent Variable	*F*-Tests with Daily Volatility (L=7)			
	Stock	Gbond	Neer	PPI
Stock	9.81***	0.64	1.15	1.04
Govt. bond	0.68	10.82***	2.12**	2.03
Neer	1.88	1.62	12.78***	0.77
PPI	0.65	3.00***	1.76	6.02***

(5)

Independent Variable	*F*-Tests with Daily Volatility (L=7)			
	Stock	Gbond	Neer	CPI
Stock	9.35***	0.92	1.07	0.37
Govt. bond	0.82	12.16***	2.54**	2.14**
Neer	1.56	1.59	12.90***	1.41
CPI	0.58	0.26	1.55	1.36

(6)

Independent Variable	*F*-Tests with Daily Volatility (L=9)			
	Stock	Gbond	Neer	IIP
Stock	6.61***	1.06	0.94	1.09
Govt. bond	1.14	14.14***	2.07**	2.00**
Neer	1.37	1.03	9.48***	0.72
IIP	0.90	2.33**	1.12	1.14

Notes: 1. *** and ** indicate statistical significance at the 1% and 5% level respectively.
LR tests determine the number of lags.

2. Neer = Nominal effective exchange rate.
Base = Base money.
PPI = Producer price index
CPI = Retail price index excluding mortgage interest payments.
IIP = Industrial production.

Table 7

UK (Bivariate VAR)

(1) Govt. bond → Neer
(Sample = 80:8-99:12, No. of lags = 7)

	Govt. bond	Neer
Govt. bond	19.35***	2.76***
Neer	1.87	12.42***
D.W.	2.02	1.99

(2) Neer → Money (M4)
(Sample = 83:10-99:12, No. of lags = 3)

	Neer	M4
Neer	31.85***	4.90***
M4	0.78	0.74
D.W.	2.00	2.00

(3) Govt. bond → CPI
(Sample = 80:7-99:12, No. of lags = 6)

	Govt. bond	CPI
Govt. bond	13.97***	2.66**
CPI	0.64	1.09
D.W.	1.95	2.00

(4) Govt. bond → Base money
(Sample = 80:7-99:12, No. of lags = 6)

	Govt. bond	Base
Govt. bond	13.39***	1.69
Base	1.51	2.35**
D.W.	1.92	1.74

(5) Govt. bond ← PPI
(Sample = 80:8-99:12, No. of lags = 7)

	Govt. bond	PPI
Govt. bond	11.05***	2.21**
PPI	3.82***	6.80***
D.W.	2.02	1.98

(6) Govt. bond ↔ IIP
(Sample = 80:10-99:12, No. of lags = 9)

	Govt. bond	IIP
Govt. bond	14.98***	1.83
IIP	2.74***	1.34
D.W.	1.94	2.01

Notes: 1. *** and ** indicate statistical significance at the 1% and 5% level respectively.
LR tests determine the number of lags.
2. Neer = Nominal effective exchange rate.
CPI = Retail price index excluding mortgage interest payments.
Base = Base money.
PPI = Producer price index.
IIP = Industrial production.

Table 8

Germany

(1)

Independent Variable	*F*-Tests with Daily Volatility (L=4)		
	Stock	Govt. bond	Neer
Stock	25.10***	1.20	1.33
Govt. bond	2.25	9.11***	0.44
Neer	1.97	0.74	6.92***

(2)

Data on base money are not available.

(3)

Independent Variable	*F*-Tests with Daily Volatility (L=4)			
	Stock	Gbond	Neer	M3
Stock	22.49***	0.74	1.26	0.25
Govt. bond	1.33	7.03***	0.28	1.47
Neer	1.91	0.60	6.55***	0.10
M3	3.43***	0.24	0.22	0.21

(4)

Independent Variable	*F*-Tests with Daily Volatility (L=4)			
	Stock	Gbond	Neer	PPI
Stock	24.60***	1.19	1.16	0.49
Govt. bond	2.11	9.07***	0.71	1.82
Neer	1.94	0.61	7.53***	1.94
PPI	0.66	0.77	2.14	3.25**

(5)

Independent Variable	*F*-Tests with Daily Volatility (L=4)			
	Stock	Gbond	Neer	CPI
Stock	25.48***	1.33	1.22	1.16
Govt. bond	2.08	7.89***	0.37	2.23
Neer	2.00	0.71	6.92***	0.99
CPI	0.93	0.69	0.22	2.96**

(6)

Independent Variable	*F*-Tests with Daily Volatility (L=4)			
	Stock	Gbond	Neer	IIP
Stock	24.93***	1.33	1.32	0.44
Govt. bond	2.42**	6.55***	0.40	1.99
Neer	1.82	0.69	6.79***	0.67
IIP	0.78	1.46	0.08	3.86***

Notes: 1. *** and ** indicate statistical significance at the 1% and 5% level respectively.
LR tests determine the number of lags.

2. Neer = Nominal effective exchange rate.
PPI = Producer price index.
CPI = Consumer price index less food.
IIP = Industrial production.

Table 9

Germany (Bivariate VAR)

(1) Stock ← Govt. bond (Sample = 80:5-99:12, No. of lags = 4)

	Stock	Govt. bond
Stock	30.02***	1.06
Govt. bond	2.20	8.96***
D.W.	2.02	1.99

(2) Stock ← Money <M3> (Sample = 73:3-98:12, No. of lags = 2)

	Stock	M_3
Stock	77.87***	0.01
M_3	8.77***	0.62
D.W.	2.02	2.00

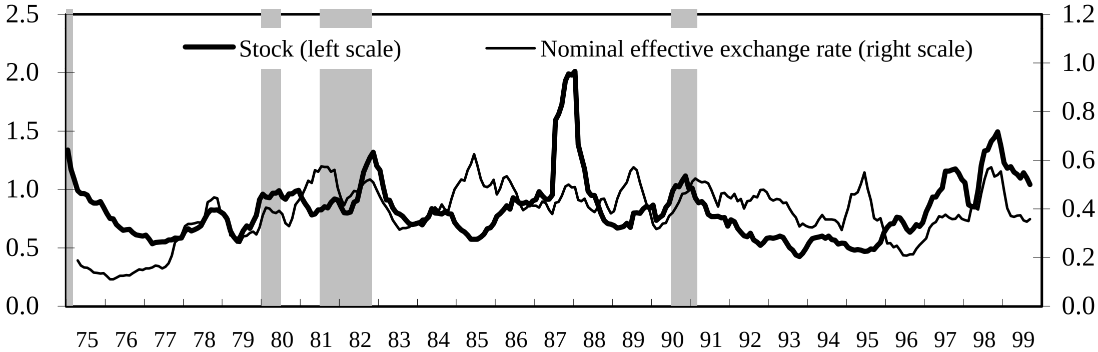
Notes: 1. *** and ** indicate statistical significance at the 1% and 5% level respectively.
LR tests determine the number of lags.

2. Neer = Nominal effective exchange rate.

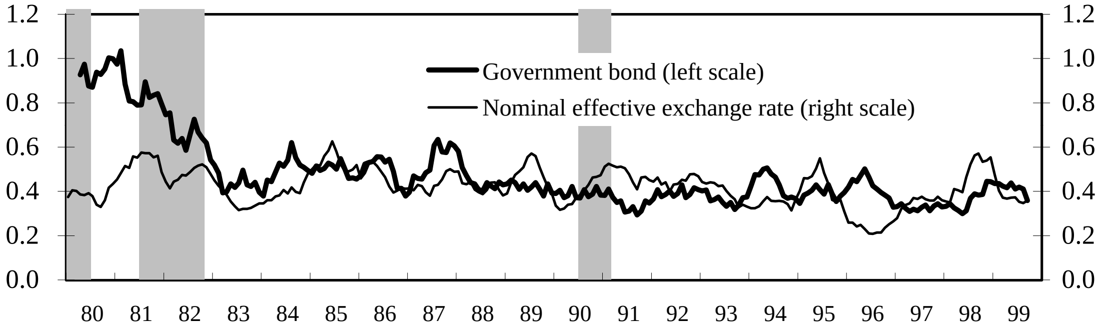
Chart 4

Bivariate Relationships (USA)

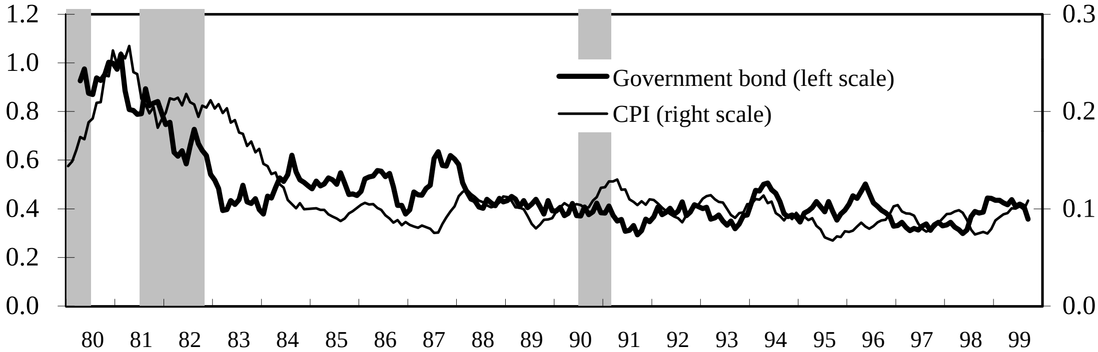
(1) Stock and Exchange Rate



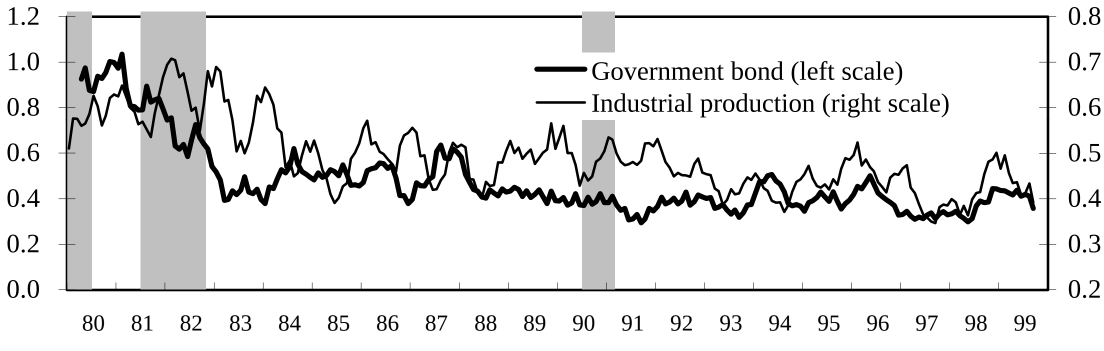
(2) Government Bond and Exchange Rate



(3) Government Bond and CPI*



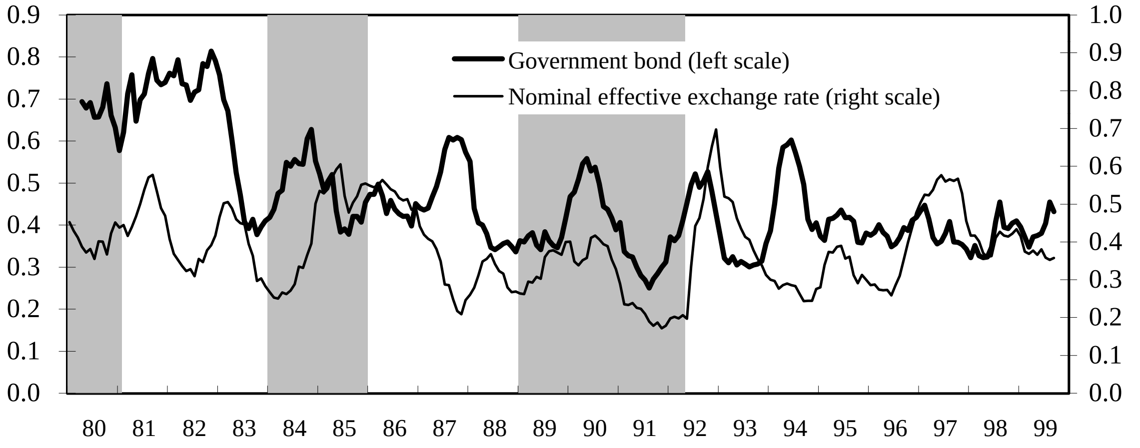
(4) Government Bond and Industrial Production*



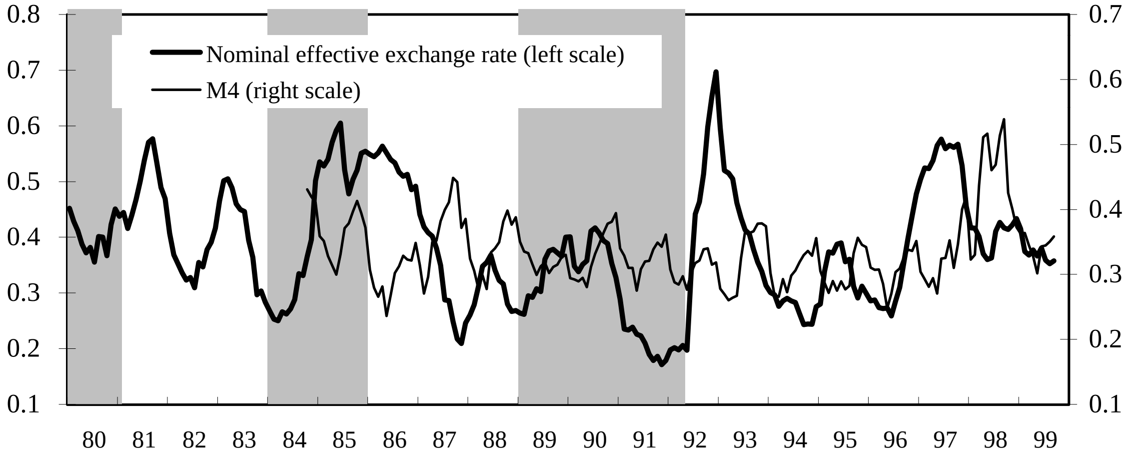
Notes: 1. Six-month moving average.
2. Shaded areas indicate periods of recession.
3. * indicate volatility is calculated from monthly data (according to Schwert).
Volatility of the other variables is based on daily returns (standard deviation).

Bivariate Relationships (UK)

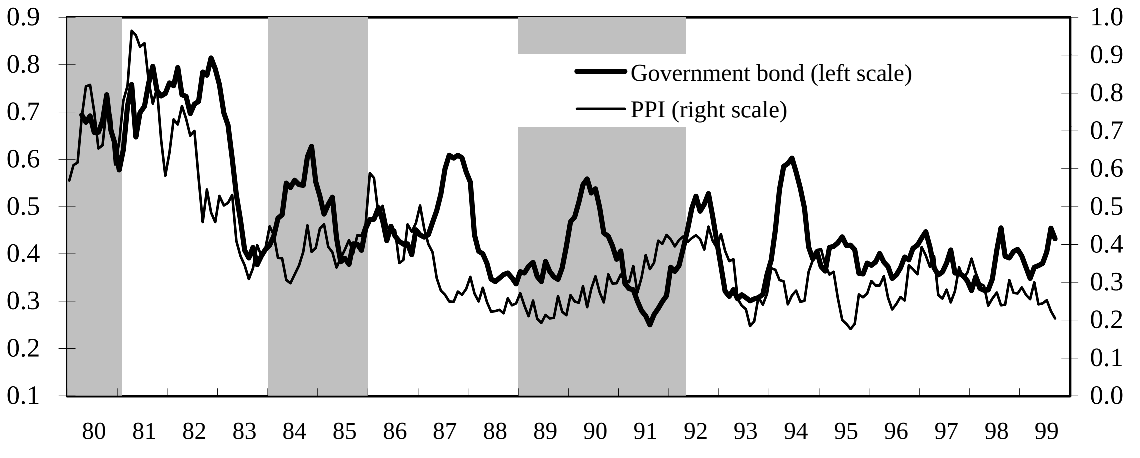
(1) Government Bond and Exchange Rate



(2) Exchange Rate and Money (M_4)*



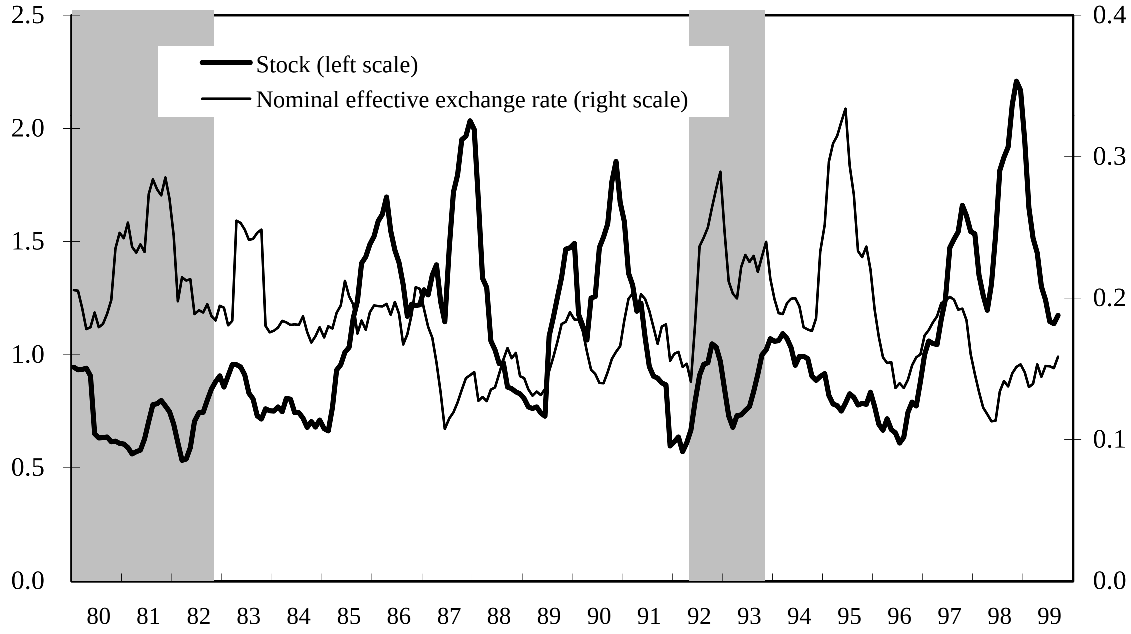
(3) Government Bond and PPI*



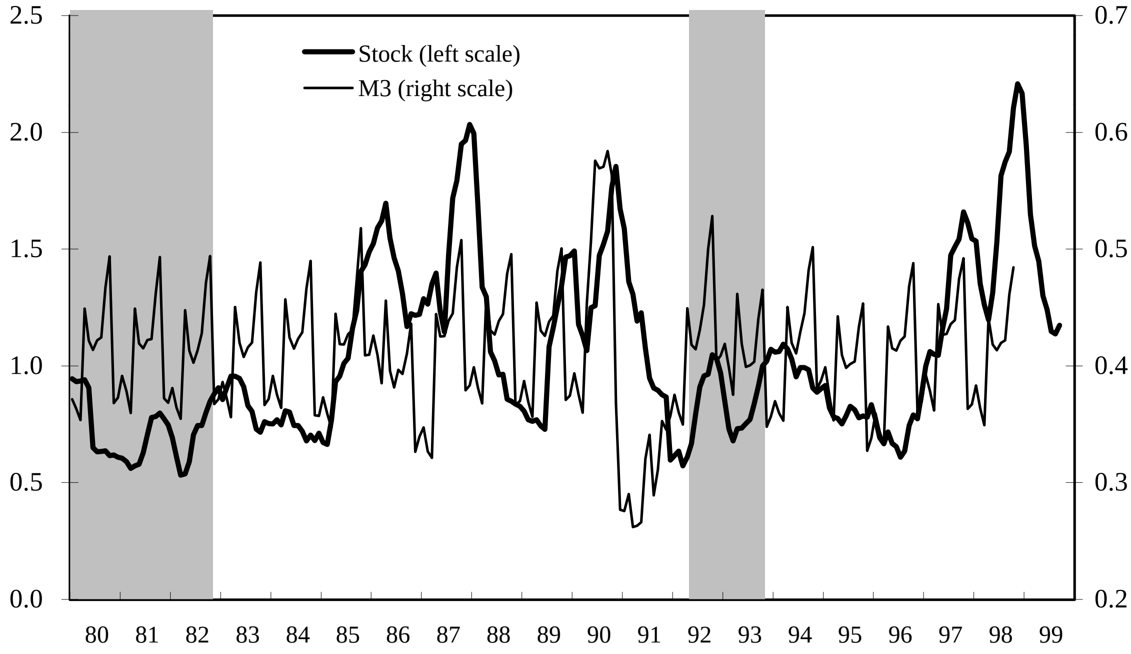
Notes: 1. Six-month moving average.
2. Shaded areas indicate periods of recession.
3. * indicate volatility is calculated from monthly data (according to Schwert).
Volatility of the other variables is based on daily returns (standard deviation).

Bivariate Relationships (Germany)

(1) Stock and Exchange Rate



(2) Stock and Money (M_3)*

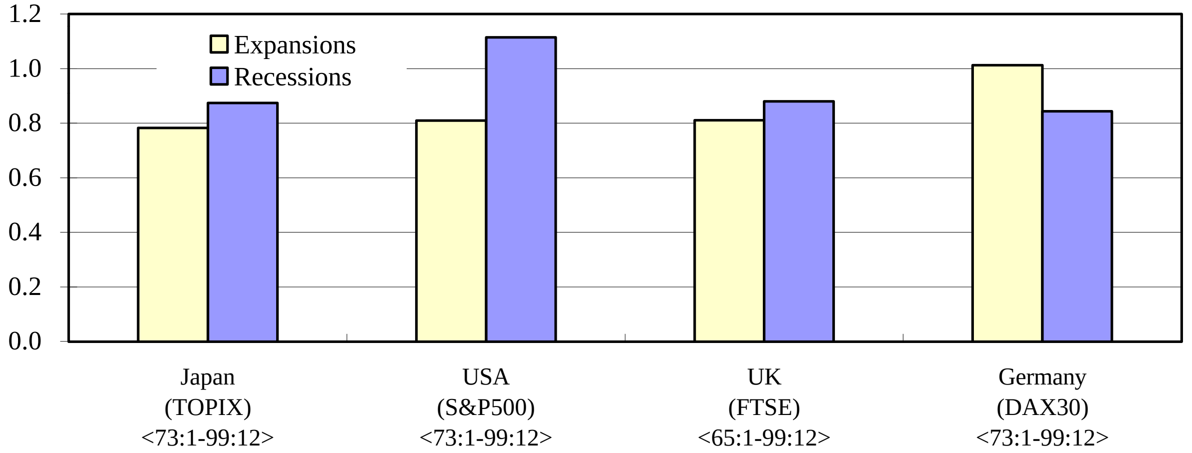


Notes: 1. Six-month moving average.
2. Shaded areas indicate periods of recession.
3. * indicate volatility is calculated from monthly data (according to Schwert).
Volatility of the other variables is based on daily returns (standard deviation).

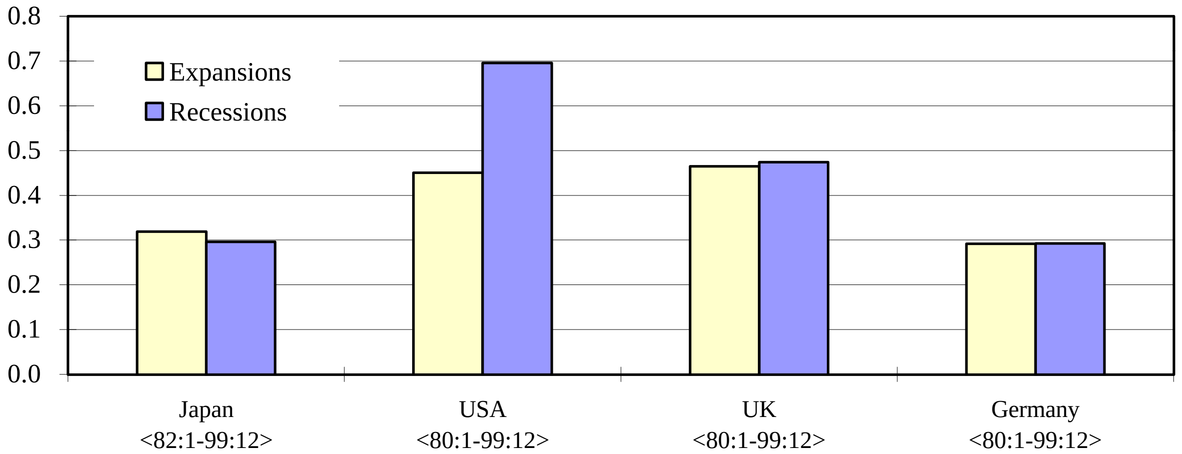
Chart 7

Financial Market Volatility

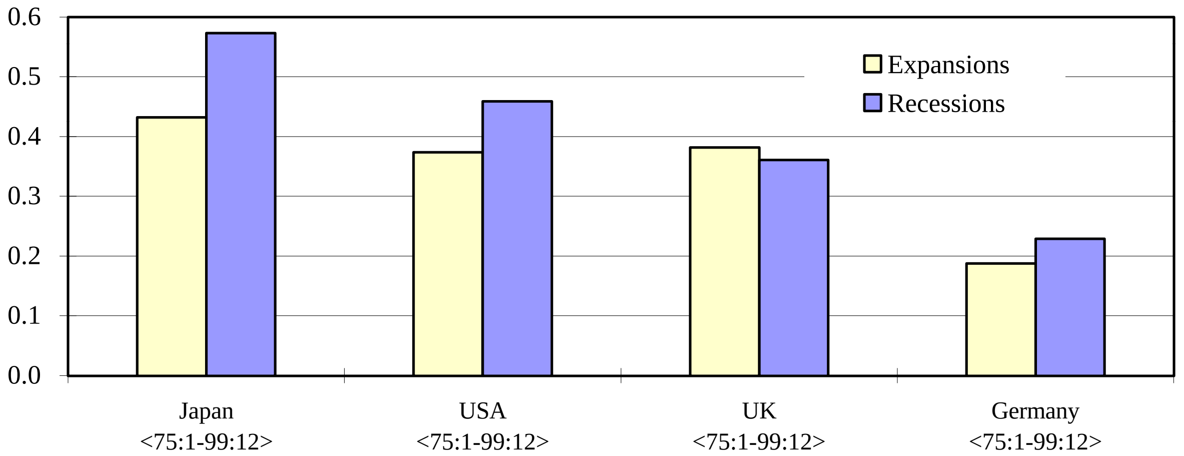
(1) Stock



(2) Government Bond (7-10 year maturity)



(3) Nominal Effective Exchange Rate

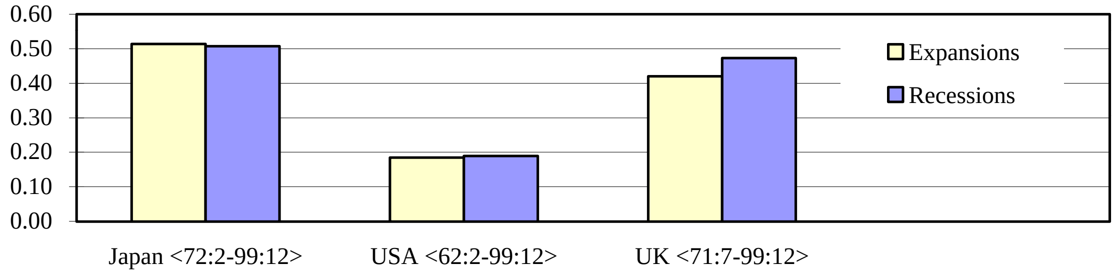


Notes: 1. Average value of monthly standard deviation calculated from daily return.
2. Numbers in angle brackets indicate sample periods.

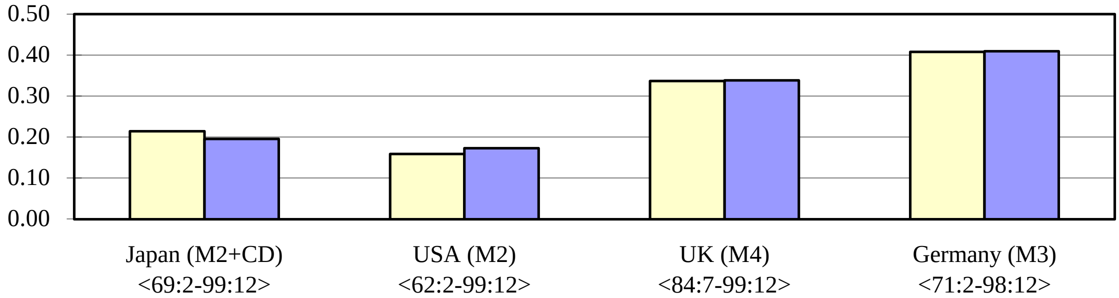
Chart 8

Macroeconomic Volatility

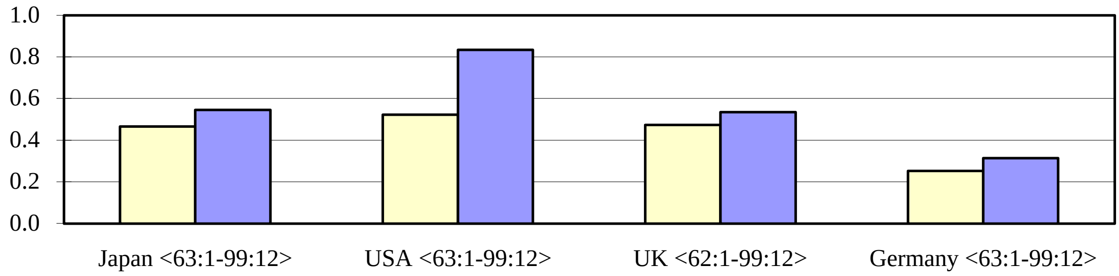
(1) Base Money



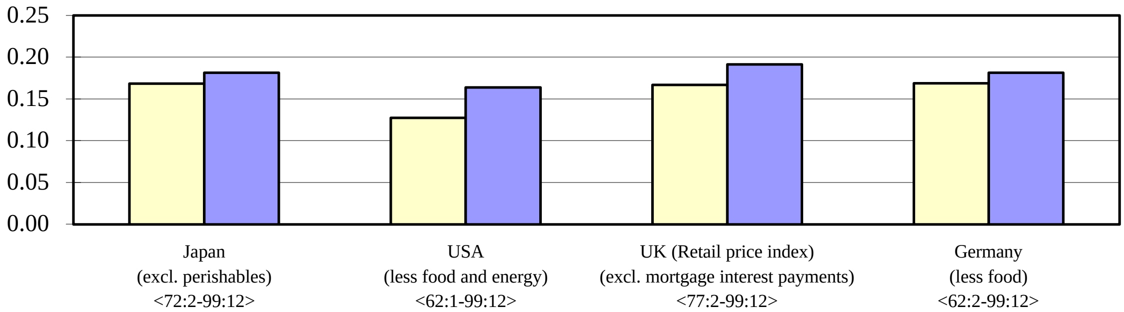
(2) Money Supply



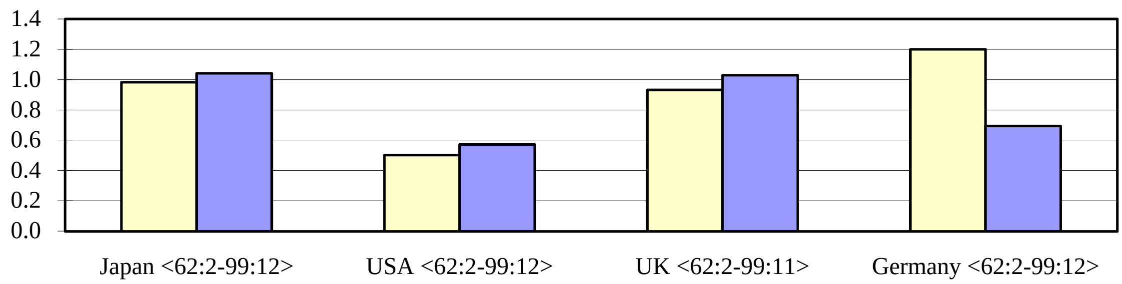
(3) Producer Price Index



(4) Consumer Price Index



(5) Industrial Production



Notes: 1. Average value of volatility calculated from monthly growth rate according to Schwert (1989).
2. Numbers in angle brackets indicate sample periods.