Macroeconomic Dynamics, **4**, 2000, 343–372. Printed in the United States of America.

STOCK RETURNS, TERM STRUCTURE, INFLATION, AND REAL ACTIVITY: AN INTERNATIONAL PERSPECTIVE

Fabio Canova
Universitat Pompeu Fabra

Gianni De Nicoló
Federal Reserve Board

This paper analyzes the empirical interdependecies among asset returns, real activity, and inflation from multicountry and international points of view. We find that innovations in nominal stock returns are not significantly related to inflation or real activity, that the U.S. term structure of interest rates predicts both domestic and foreign inflation rates and domestic future real activity, and that innovations in inflation do not significantly affect real activity. An interpretation of the dynamics and some policy implications of the results are provided.

Keywords: Transmission, Business Cycles, International Stock Returns, Financial Markets

1. INTRODUCTION

The relationship among asset returns, real activity, and inflation is at the center of the research agenda of financial economists [see, e.g., Fama (1981, 1990b) or Harvey (1988)], and of those branches of the macroeconomic literature attempting to reconcile modern business-cycle theory with empirical financial market regularities [see Cochrane and Hansen (1992), Boldrin et al. (1995), Danthine and Donaldson (1994)]. Yet, the empirical evidence regarding the dynamic interaction among these variables is incomplete in at least two respects: it is available primarily for the United States [one exception is Gerlach and Smets (1995)] and it concerns domestic variables taken in isolation from the rest of the world. By contrast, recent developments in the world economy are marked by the relative decline of the importance of the U.S. economy and by the fast pace of integration of the real, financial, and monetary sides of industrialized countries.

We would like to thank W. Barnett, an anonymous referee, M. Evans, B. Gerard, G. Hardouvelis, A. Weber, M. Wickens, and the participants of seminars at UPF, the CEPR workshop on Monetary Policy in Europe, the UK Macro Money Workshop and the 23rd European Finance Association annual meetings for comments and suggestions. Canova acknowledges the financial support of DGICYT and CNR grants. The first author is also associated with the University of Modena, the University of Southampton and the CEPR. The views expressed are solely those of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System.
Address correspondence to: Gianni De Nicoló, Federal Reserve Board, International Finance Division, Mail Stop 19, Washington, DC 20551, USA; e-mail: gianni.denicolo@fbr.gov.

 1365-1005/00 $9.50

In this paper we fill this gap by analyzing the empirical interdependencies among asset returns, real activity, and inflation from multicountry and international points of view. In previous work [Canova and De Nicoló (1995)], we have attempted to give a structural interpretation to the stock return–real activity relationship emerging from the reduced-form evidence popularized by Fama (1990a), both within and across countries. Here we study the interactions among real and financial aggregates across countries and their international linkages, with two goals in mind. First, we want to assess the robustness across countries of certain empirical regularities found in the United States. Second, we want to investigate how shocks originating in certain markets are propagated to the world economy. The task here is to sort out the links responsible for both the domestic and international propagation of disturbances and to assess the extent of cross-country heterogeneities both in terms of responsiveness of certain variables to shocks and of transmission. This information is of crucial importance for integrating financial markets into international models of the business cycle [see Ballabriga et al. (1999) and Canzonieri et al. (1996) for examples] and to effectively conduct international policy coordination activities.

Presentation of the empirical evidence is organized around three main questions.

First, we would like to know whether innovations in nominal stock returns affect real activity and inflation, and, in turn, whether and how nominal stock returns react to innovations in real activity and inflation. The issue at stake is to what extent the dynamics of equity returns reflect news regarding changes in economic and policy fundamentals and whether they anticipate such changes. Such a question has received substantial attention in the literature, primarily in an attempt to explain the negative contemporaneous correlation between real stock returns and inflation emerging in the United States. The explanation of the sign of this correlation proposed by Fama (1981) and Gerske and Roll (1983), based on the anticipatory movements of real stock returns for real activity and on a negative link between inflation and real activity, has been examined empirically for the United States by various authors with mixed results [see, e.g., James et al. (1985), Fama (1990b), Lee (1992)].

Second, we would like to assess whether, and to what extent, innovations in the slope of the term structure signal movements in real activity and/or inflation. The issue is whether the informational content of measures of the term structure is related more to changes in the monetary policy stance or to future developments in the real side of the economy. This question is tightly linked to those posed by the literature that studies whether measures of the term structure of interest rates are leading indicators for inflation and real activity [see, e.g., Harvey (1988), Stock and Watson (1989), Mishkin (1990), Estrella and Hardouvelis (1991), and Plosser and Rouwenhorst (1994)]. Common to the suggested interpretation of the key relationships is an implicit assessment of how monetary innovations and/or expectations about the future policy stance affect financial markets.

Third, we would like to study how inflation and real activity interact. There are two aspects that we are interested in investigating. First, we would like to examine whether inflation innovations affect real activity. Under a restrictive neoclassical interpretation or following recent literature, where inflation targets are used directly as policy instruments [see, e.g., Svensson (1997)], inflation innovations proxy for monetary policy surprises. Hence, we would like to find some new evidence on the old and unsolved question concerning the “real effects” of monetary policy. Second, we would like to know how innovations in real activity are translated to changes in inflation. Under a simply theoretical model of aggregate demand and supply, the responses of inflation to innovations in real activity may help us to unveil the type of structural source of disturbances driving these innovations. Our contribution is to analyze these two issues from explicit cross-country and international perspectives [see, for complementary efforts, Gerlach and Smets (1995) and Shijoi (1996a,b)].

Our findings suggest that there are interesting regularities but also important international asymmetries in the dynamics of the data. First, the informational content of innovations in nominal stock returns for inflation and real activity is negligible in all countries, but innovations in U.S. stock markets are rapidly incorporated in foreign nominal stock returns. Second, the link between financial markets and real activity, as indicated by the forecasting power of innovations in the slope of term structure for real activity, is important for the United States and almost absent for other countries. In addition, while innovations of the U.S. slope of the term structure have predictive power for domestic and foreign inflation, this is not the case for any other country’s term structure. Third, there is little evidence that inflation innovations affect real activity in all four countries; but however, there is a significant response of inflation to innovations in industrial production growth in the United States, but not in other countries. Finally, shocks to real activity appear to be driven by different sources of structural disturbances in the countries under consideration, both in domestic and international frameworks. We argue that these asymmetries are consistent with an interpretation of the international dynamics where innovations in U.S. real activity occur close to full capacity, influence nominal stock returns, and generate domestic inflationary expectations that are quickly incorporated in the slope of the term structure. Because foreign inflation increases following real U.S. shocks, probably via imported inflation effects, the U.S. term structure also predicts foreign movements in inflation. No such effects occur in the other countries because real shocks typically do not generate inflationary expectations.

The structure of the paper is as follows: In Section 2 we discuss the specification of the reduced form and the statistics that we use to summarize the results. Basic measures of volatility, persistence, and comovements of our dataset are discussed in Section 3. The dynamic interdependencies emerging from closed- and open-economy VAR models are described and discussed in Sections 4 and 5, respectively. Section 6 offers an interpretation of the international dynamics and Section 7 concludes.

2. SPECIFICATION OF THE EMPIRICAL MODEL

There are several problems connected with the specification of an empirical model that can be used to address the questions posed in the introduction. They concern the choice of a reduced form, the variables to include in the system, the question of how to appropriately describe the dynamics of the data, and the issue of stationarity. We address these questions in turn.

We choose to work with an unrestricted VAR. There are three basic reasons for our choice: first, it is well known that a VAR is a good approximation to the DGP of any vector of time series as long as enough lags are included [see, e.g., Canova (1995)]. Second, an unrestricted VAR is well suited to study interdependencies because it captures the dynamic feedbacks present in the model in an unconstrained fashion. Third, although there are alternative methodologies available in the literature, none of them allows us to study the questions of interest in this paper: the strength and the direction of the transmission of shocks across domestic and international real and financial markets.

Ideally, to study the overall set of interdependencies existing among the variables of interest one would like to include them all for all of the countries that we are interested in examining. Obviously, this is not feasible: large systems are hard to handle and to interpret. With a sample of limited size, the parameters of large VAR systems are poorly estimated and the extent of the dynamic interdependencies are obscured. Given these limitations, we proceed in two steps. First, we examine closed-economy VAR models for the United States, Japan, Germany, and the United Kingdom, including a measure of nominal stock returns (SR), of the slope of the nominal term structure (TERM), of real activity growth (IP), and of inflation (INF). Second we use a number of bilateral VAR models with the United States as one country and Germany, Japan, or the United Kingdom as the other country [as in Bekaert and Hodrick (1992)]. Within each system we include, for each of the two countries, a measure of nominal stock returns, of the slope of the nominal term structure, of real activity, of inflation, and the bilateral nominal exchange rate (E), measured in units of foreign currency per U.S. dollar, for a total of nine variables for each system. All models include a trend, seasonal dummies, and a 1987 crash dummy. The sources of the variables included in each system are provided in the Appendix. The sample that we use covers monthly data from 1973:1 to 1995:12. We choose to use monthly data to maximize the number of observations and the information contained in the series. There is clearly a trade-off in using monthly data because the noise can be substantial and heteroskedasticity may be a problem with financial time series. In Section 5, we discuss results obtained with data sampled at lower frequencies, where both of these problems are of minor importance. The sample is chosen with two considerations in mind. First, because of structural breaks or existing restrictions in financial markets, the pre-1973 data are likely to be incompatible with the post-1973 data. Second, the sample 1973–1995 is more likely to display the international interdependencies for which we are looking.

Reduced-form models, which include stock returns, real activity, inflation, and a measure of real interest rates, have been examined by many authors [e.g., Gerske and Roll (1983), James et al. (1985), or Lee (1992)]. Here, we maintain the same structure except that we employ a measure of the slope of the term structure in place of a measure of short-term interest rate.[1] We include nominal returns and an inflation rate instead of converting nominal returns into real ones using proxies for ex-post inflation or expected inflation prior to their use in the VAR, because the time path of real returns can be computed easily from estimated VAR coefficients.[2]

Although a VAR is a good approximation to any vector of time series when the sample size is unlimited, the degrees of freedom of the model are exhausted quickly if the lag length grows to make the approximation as accurate as possible in finite samples. To optimally trade off the quality of the approximation and the resulting overparameterization of the VAR, several criteria, which penalize overparameterized models adding little to the quality of the approximation, have been designed. Here we use the Akaike and the Schwarz criteria to determine how many lags should be included in each VAR model.

One issue of crucial importance in examining the structure of interdependencies across markets and countries over the business cycle is stationarity. To compute interesting statistics and interpret responses to shocks as short-term dynamics around a stationary (steady) state, the VAR system must be stationary, possibly around a deterministic trend. To ensure that this is the case, it is typical to examine the order of integration of each of the variables of the system, control for the number of common stochastic trends, and, finally, appropriately transform the system to achieve stationarity. Then, the effect of shocks on the level of the variables can be recovered using the inverse of the transformations originally employed.

As expected, unit roots are found in the nominal exchange rate and the industrial production index whereas for the other three variables the unit root hypothesis is rejected for all countries. Cointegration tests suggest the lack of a common trend between exchange rate and real activity. Therefore, we specify closed-economy VAR's with nominal stock returns, nominal slope of the term structure and inflation in levels, and industrial production index in percentage changes. For open-economy VAR models, the nominal exchange rate in percentage changes is added to these variables. Given this structure, both the Akaike and the Schwarz criteria indicate that the short-run dynamics of each of the models are well described by a VAR(1).

Because the VAR is a reduced-form model, inference concerning the transmission properties of the model in response to structural disturbances cannot be made unless a behavioral system is identified from the reduced-form evidence. Because the task here is to describe the interdependencies across markets and countries and suggest a tentative explanation for the linkages, rather then testing the validity of a particular model via the VAR, we proceed to identify innovations in a semiautomatic fashion. Let the VAR model be

$$\boldsymbol{Y}_t = A_0 + A(\ell)Y_{t-1} + e_t \qquad e_t \sim (0, \Sigma), \tag{1}$$

where $\boldsymbol{Y}_t$ is either a 4×1 or a 9×1 vector. Stationarity ensures that (1) is invertible so that we can compute the moving-average representation:

$$Y_t = (I - A(\ell))^{-1}A_0 + (I - A(\ell))^{-1}e_t. \tag{2}$$

Because the covariance matrix Σ of the VAR disturbances e_t is nondiagonal, it is impossible to decompose movements in the component of Y_t into innovations due to any particular variable of the system. Our approach is to note that for any positive semidefinite nonsingular Σ there always exists a decomposition $\Sigma = VV'$, where V is the lower triangular orthogonal matrix, so that (2) can be transformed to

$$\begin{aligned} Y_t &= (I - A(\ell))^{-1}A_0 + (I - A(\ell))^{-1}Vu_t \\ &= \mu_0 + \sum_{s=0}^{\infty} C_s u_{t-s} \qquad u_t \sim (0, I), \end{aligned} \tag{3}$$

where $u_t = V^{-1}e_t$ and $C(\ell) = (I - A(\ell))^{-1}V$. In (3), u_t are contemporaneously uncorrelated and it becomes possible to examine responses to innovation in each of the variables of the system. Note that whereas the contemporaneous (within 1 month) effects in the VAR are triangular, lagged dynamics are completely unrestricted. Therefore, the identification scheme is unlikely to induce distortions on the measures of the dynamic interdependencies that we are interested in examining.

There have been several criticisms in the literature to this semiautomatic approach [see, e.g., Canova (1995) for a summary]. Despite these criticisms, it has become standard to examine this type of system as a benchmark to compare the implications of more complicated structural systems. If the innovations in the reduced-form system are uncorrelated, all identification schemes that impose restrictions on the contemporaneous correlation of shocks will produce identical results. In the less-extreme event where innovations of the reduced-form system are nearly uncorrelated, results will be qualitatively robust to alternative identification schemes that impose restrictions on the covariance matrix of the shocks.

We summarize the dynamic interdependencies of the system using the impulse response and the variance decomposition. From equation (3) the coefficients C_s represent the matrix of demeaned responses s-periods ahead, $s = 0, 1, \ldots,$ following unitary shocks in the variables of the system. Also, since the unconditional variance of $\hat{Y}_t$ is $\sum_{j=0}^{\infty} C_s C_s'$, we can allocate the variance of each element in Y_t to sources in elements of u_t because the u_t's are both serially and contemporaneously uncorrelated, using

$$z^{\tau}(i, j) = \frac{\sum_{s=0}^{\tau-1}\left(C_s^{ij}\right)^2}{\sum_{j=1}^{m}\sum_{s=0}^{\tau-1}\left(C_s^{ij}\right)^2},$$

where $\sum_{j=1}^{m} z^{\tau}(i, j) = 1$ and $z_{i,j}^{\tau}$ is the component of error variance in the τ-step forecast of Y_i that is accounted for by innovations in Y_j. Here we report results for the 2-years-ahead variance decomposition (i.e., $\tau = 24$).

Although it is standard to report point estimates of the impulse response and of the variance decomposition, a meaningful interpretation of the dynamics is impossible unless measures of dispersion are attached to the point estimate obtained. We construct confidence bands, drawing from the posterior distribution of the

VAR coefficients.[3] We directly compute confidence intervals out of replications, instead of using an asymptotic normal approximation, to reduce the skewness and the asymmetries of the impulse response bands in small samples [see also Sims and Zha (1995)].

3. SUMMARY OF THE PROPERTIES OF THE DATA

An overview of the properties of our data appears in Table 1, which presents the mean, the standard error, the first four autocorrelations for each variable, and selected cross correlations. Figure 1 plots the time series for the four countries. The statistics show some cross-country variations, but the magnitude of the differences is small. On average over the sample period, nominal stock returns were approximately 1% per month; the term structure was slightly upward sloping; the dollar depreciated against the yen and the deutsche mark and appreciated with respect to the pound; the growth rate of industrial production was approximately 0.1–0.2% per month and the inflation rate was approximately 0.5% per month. Stock returns are significantly more volatile than any other series, followed by exchange-rate changes. The least volatile is the slope of the term structure, and this is true in all countries.

Autocorrelations typically are small. The exceptions are the slopes of the term structure, which are highly serially correlated and very persistent in all countries [see Plosser and Rouwenhorst (1994)]. Because their standard deviation is small, either the slope of the term structures must be approximately constant or its random component has a very small error relative to the level of the series for each of the four countries.

Nominal stock returns and inflation are negatively contemporaneously related in the United States, Japan, and Germany (contrary to a simple version of the Fisher hypothesis) and positively correlated in the United Kingdom, but the correlation is statistically insignificant except for the United States and the United Kingdom. Also, the correlation between nominal stock returns and current or future industrial production growth is small but significantly negative in the United States. Conversely, there is a comparatively stronger link between the slope of the nominal term structure and inflation in all countries [as in Fama (1990b) and Mishkin (1990)]. Correlations are significantly negative for the United States, Germany, and Japan, and significantly positive for the United Kingdom, with the United States exhibiting the largest correlation. In agreement with the findings of Stock and Watson (1989) and Estrella and Hardouvelis (1991), we find a small contemporaneous correlation between the slope of the term structure and industrial production growth. Such a correlation is significant only in the United States and Japan. This seems at variance with the findings of Plosser and Rouwenhorst (1994), especially for the two European countries, even though differences in sample periods and in the frequency of the data may account for the results. Exchange-rate changes are somewhat more correlated with domestic inflation rates than with industrial production growth, but differences are small and all correlations are insignificant. Finally, inflation rates

TABLE 1. Summary statistics 1973:1–1995:12

Variable	Mean	Standard deviation	Autocorrelations				Cross correlations with inflation					Cross correlations with IP growth					Selected cross correlations				
			1	2	3	4	2	1	0	−1	−2	2	1	0	−1	−2	2	1	0	−1	−2
USRET	0.97	4.49	0.00	−0.02	0.01	−0.01	−0.00	−0.12	−0.19	−0.07	−0.07	−0.12	−0.11	−0.08	−0.02	−0.01			with USRET		
JPRET	0.72	5.39	0.00	−0.00	0.01	0.02	−0.03	−0.07	−0.05	−0.05	−0.11	0.04	0.03	−0.04	0.00	0.07	0.04	0.18	0.31	−0.01	−0.02
GERET	0.85	5.21	0.04	−0.04	0.10	0.04	0.07	−0.08	−0.05	−0.06	0.01	0.00	0.07	0.01	−0.00	0.03	−0.01	0.17	0.37	−0.04	0.03
UKRET	1.38	6.80	0.10	−0.11	0.07	0.02	0.02	−0.03	0.12	0.00	−0.00	0.01	−0.00	0.00	0.03	−0.10	−0.03	0.03	0.57	0.05	−0.02
USTERM	0.11	0.14	0.95	0.87	0.81	0.76	−0.57	−0.61	−0.62	−0.63	−0.63	0.03	0.08	0.14	0.22	0.27			with USTERM		
JPTERM	0.03	0.11	0.94	0.88	0.81	0.74	−0.31	−0.25	−0.25	−0.26	−0.21	0.22	0.22	0.22	0.22	0.20	0.25	0.25	0.18	0.14	0.13
GETERM	0.06	0.14	0.97	0.93	0.88	0.82	−0.22	−0.22	−0.23	−0.25	−0.25	0.06	0.08	0.09	0.08	0.09	0.31	0.30	0.28	0.26	0.25
UKTERM	0.03	0.22	0.96	0.93	0.89	0.86	0.13	0.13	0.13	0.11	0.11	0.03	0.03	0.06	0.07	0.07	0.13	0.12	0.11	0.10	0.09
JPAEG	−0.35	3.31	0.10	0.03	0.06	0.01	0.13	0.00	0.04	0.06	−0.04	0.03	−0.03	0.01	−0.01	−0.07					
GEAEG	−0.22	3.51	0.04	0.05	0.01	−0.00	0.04	0.10	0.09	0.12	0.04	−0.08	0.06	−0.00	−0.07	0.05					
UKAEG	0.21	3.33	0.10	0.02	−0.02	0.01	0.00	−0.01	−0.04	0.01	0.03	−0.05	0.08	0.01	−0.00	−0.03					
USIPG	0.19	0.82	0.44	0.31	0.21	0.06	−0.20	−0.12	−0.03	0.02	0.00								with USIPG		
JPIPG	0.20	1.59	−0.30	0.13	0.25	−0.10	−0.14	−0.01	−0.05	0.00	0.04						0.18	0.23	0.14	0.14	0.07
GEIPG	0.12	2.02	−0.43	0.09	−0.00	0.05	0.03	−0.16	0.00	−0.11	0.04						0.10	0.04	0.09	0.06	0.14
UKIPG	0.11	1.63	−0.17	−0.02	0.04	−0.02	−0.02	−0.07	−0.06	−0.03	0.00						0.03	0.08	0.22	0.06	0.05
USINF	0.47	0.35	0.59	0.52	0.46	0.41													with USINF		
JPINF	0.36	0.76	0.31	0.07	0.15	0.21											0.30	0.29	0.33	0.36	0.19
GEINF	0.29	0.29	0.41	0.25	0.20	0.18											0.20	0.22	0.39	0.35	0.25
UKINF	0.70	0.75	0.46	0.33	0.30	0.24											0.42	0.38	0.37	0.40	0.38

Notes: Acronyms for countries are US for USA, JP for Japan, GE for Germany, and UK for United Kingdom. RET refers to 1-month stock returns, TERM to the term premium between 5-year bonds and 3-month bills, AEG to 1-month changes in the US dollar exchange rate, IPG to 1-month industrial production growth, and INF to 1-month inflation rate. The standard deviations for autocorrelations, under the null of no serial correlation, is $\sqrt{\frac{1}{276}} \approx 0.06$.

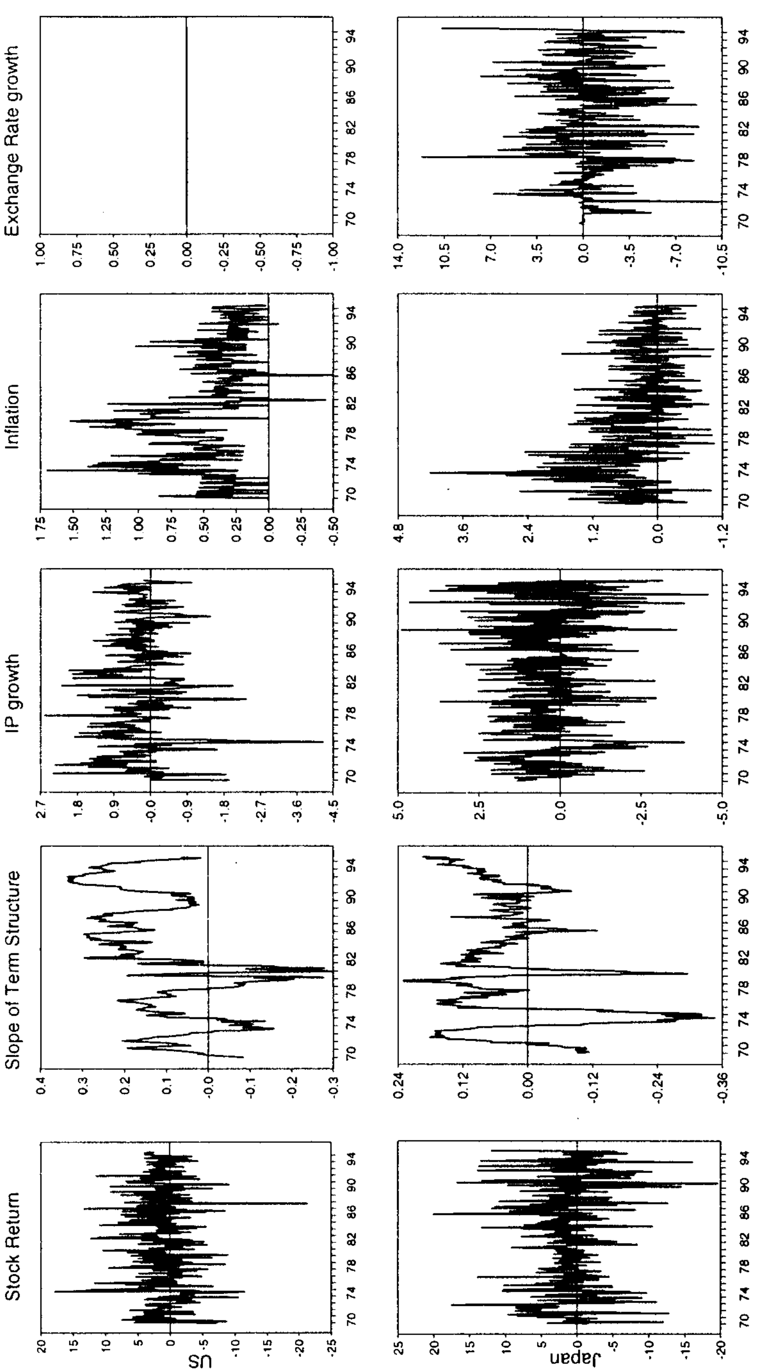

FIGURE 1. Time-series plots.

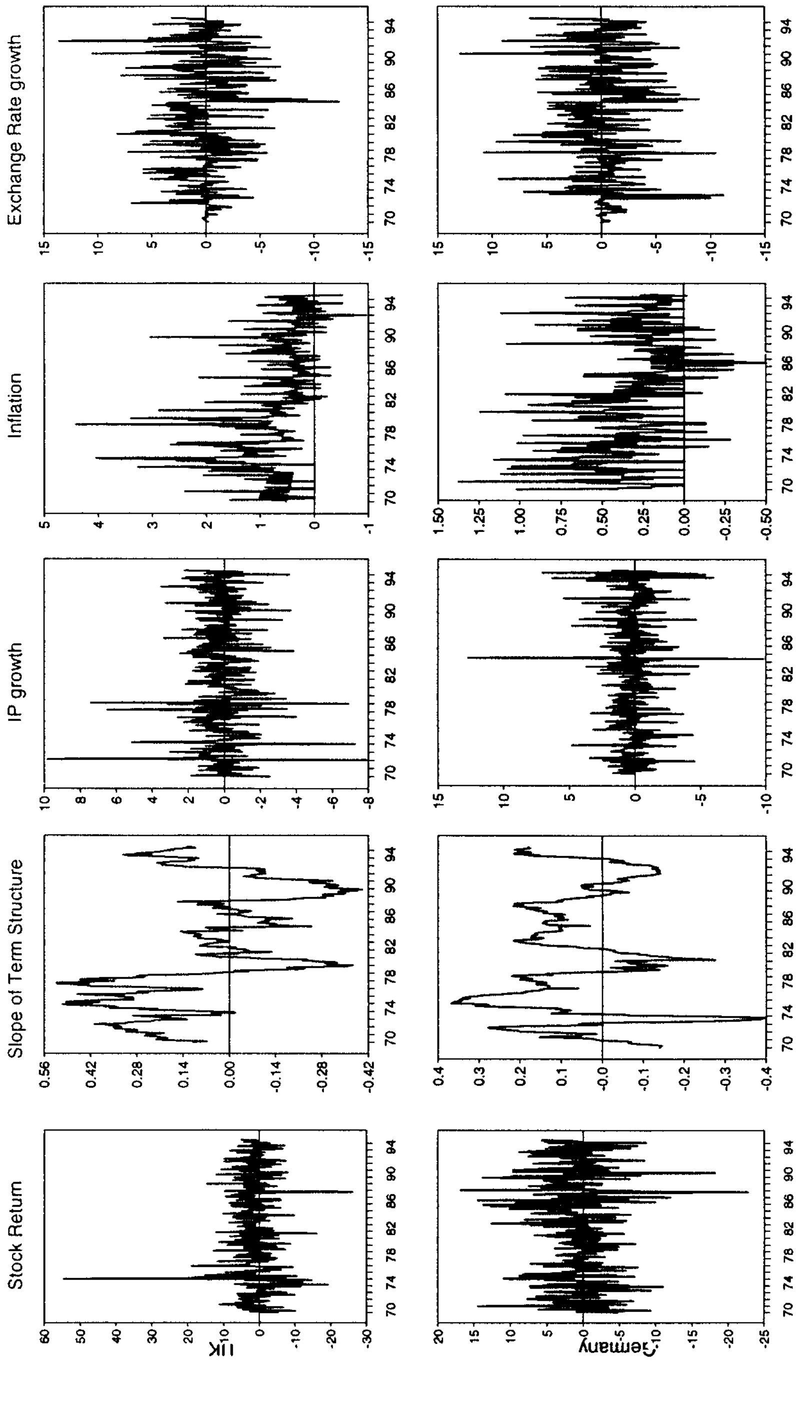

FIGURE 1. (Continued.)

are negatively associated with subsequent growth in industrial production in all countries, but the relationship is statistically weak.

International comovements in stock returns and inflations are much more synchronous than cross-country comovements in the slopes of the term structures and industrial production growth. Stock returns in the United States are somewhat related to lagged values of stock returns in Japan and Germany but not vice versa. Surprisingly low are the cross-country correlations of industrial production growth, which contrast with the relatively larger cross-country correlations of quarterly GNPs [see, e.g., Backus et al. (1992, p. 752)]. Also notice the strong persistence of cross-country correlations of the slope of the term structures and of inflation.

4. CLOSED-ECONOMY INTERDEPENDENCIES

Our discussion of closed-economy interdependencies is based on Table 2 and on Figure 2. Table 2 reports median values of the variance decomposition for each of the four single-country VARs and an asterisk indicates that the 90% band around the median is entirely above 0.05. Figure 2 presents median responses and 90% confidence bands.

Consider first the relationship among stock returns, inflation, and real activity. Figure 2A indicates that nominal stock returns respond negatively to inflation innovations in Japan and Germany, where the responses are significant for a few months, but in the other two countries responses are always insignificant. The responses of inflation to stock-return innovation are insignificant in all countries. Furthermore, nominal stock-return responses to shocks in real activity are negligible (at least 96% of the variance of stock returns is explained by its own innovations) and, conversely, stock-return innovations have extremely low predictive power for future real activity (the variance of industrial production growth explained by stock-return innovations is negligible).

These results are puzzling in two ways. First, the literature has documented that stock returns, inflation, and real activity are significantly related in the United States [see, e.g., Gerske and Roll (1983), James et al. (1985), Fama (1990a), and Lee (1992)]. After all, rational investors should adjust nominal returns to changes in inflation, in the dividend process and in the discount factor. The lack of a dynamic relationship among these variables seems at variance with any theory that maintains that developments in financial markets are rational. Second, the finding that cross-country dynamics differ somewhat suggests that the transmission mechanism of shocks is heterogeneous across countries.

There are many ways to reconcile our findings with those in the existing literature. First, the sample and the frequency of the data here are different from those used in previous work. Second, we are using measures of industrial production as opposed to GDP (for which monthly data do not exist) and this may account for the limited predictive power of stock-return innovations. More generally, it is sufficient to recall that here we are considering the dynamic response of variables

Table 2. Percentage of the 24-month forecast error variance explained by innovations in a four-variable VAR, 1973:1–1995:12

Innovations in	Variance of RET	TERM	IPG	INF
	U.S. variables			
RET	96.7*	0.6	0.5	1.9
TERM	1.3	91.7*	9.5	28.3*
IPG	1.2	5.0	89.0*	2.9
INF	0.3	1.6	0.4	66.5*
	Japanese variables			
RET	97.7*	0.6	0.5	1.7
TERM	0.6	93.3*	6.3	4.0
IPG	0.1	0.1	92.2*	0.6
INF	1.1	5.4	0.6	93.1*
	German variables			
RET	99.1*	0.4	0.5	1.4
TERM	0.1	97.1*	1.8	1.8
IPG	1.8	0.2	96.0*	0.7
INF	0.2	0.5	1.2	95.4*
	UK variables			
RET	99.1*	0.4	0.5	1.4
TERM	0.1	97.1*	1.8	1.8
IPG	1.8	0.2	96.0*	0.7
INF	0.2	0.5	1.2	95.4*

Notes: RET refers to 1-month stock returns, TERM to the term premium between 5-year bonds and 3-month bills, AEG to 1-month changes in the US dollar exchange rate, IPG to 1-month industrial production growth, and INF to 1-month inflation rate. The forecast error variance is computed using a four-variable VAR model with a constant and one lag. The table shows the median percentage of the 24-month forecast error variance in variable i explained by innovations in variable j, computed as $(1/Q)\Sigma_{q=1}^{Q}\{100 * [\Sigma_{s=0}^{23}C_s^{ij} / \Sigma_{j=1}^{4}\Sigma_{s=0}^{23}C_s^{ij}\}$, where C_s^{ij} is obtained from the orthogonalized moving-average representation of $\hat{y}_t = y_t - \mu_0 = \Sigma_{s=0}^{\infty}C_s u_{t-s}$, where $\hat{y}_t$ is a 4×1 vector and Q is the number of Monte Carlo replications. A asterisk indicates that a 90% band around the median is entirely above 0.05.

to *innovations* and not static correlations on the *level* of the variables; that the estimated predictable component of nominal stock returns is highly correlated with both current inflation (up to 0.72 in the United Kingdom) and current industrial production in all countries and that it is also highly correlated with future inflation because, as we have seen in Section 3, inflation is very persistent.

The hetereogeneities in cross-country dynamics can be interpreted in several ways. First, it is possible that the responses of stock markets in Japan and Germany to monetary or real news are more interpretable because they are less exposed to “destabilizing” speculation since they are comparatively thinner and less affected by international capital flows, at least for the first part of the sample. Alternatively, it could be that inflation innovations negatively affect nominal stock

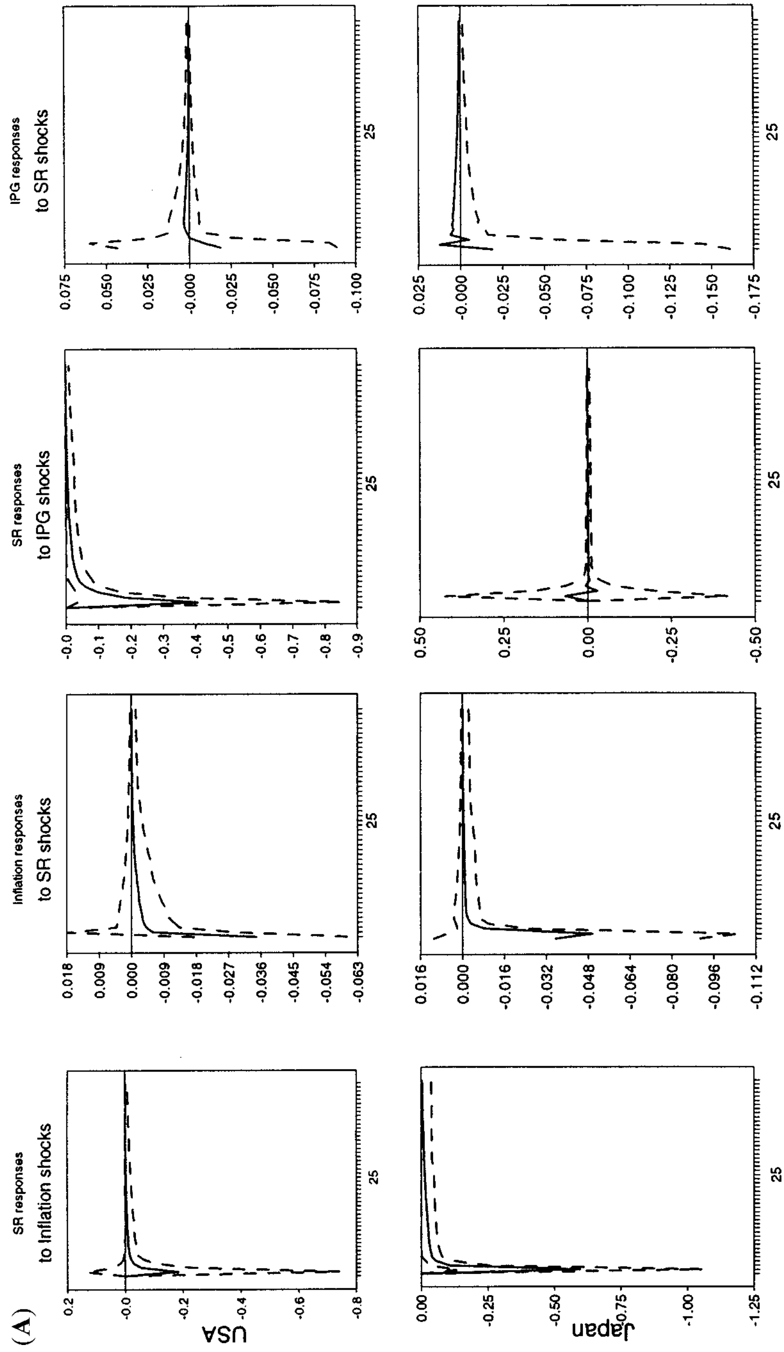

FIGURE 2. Impulse responses, 1970:1–1995:1

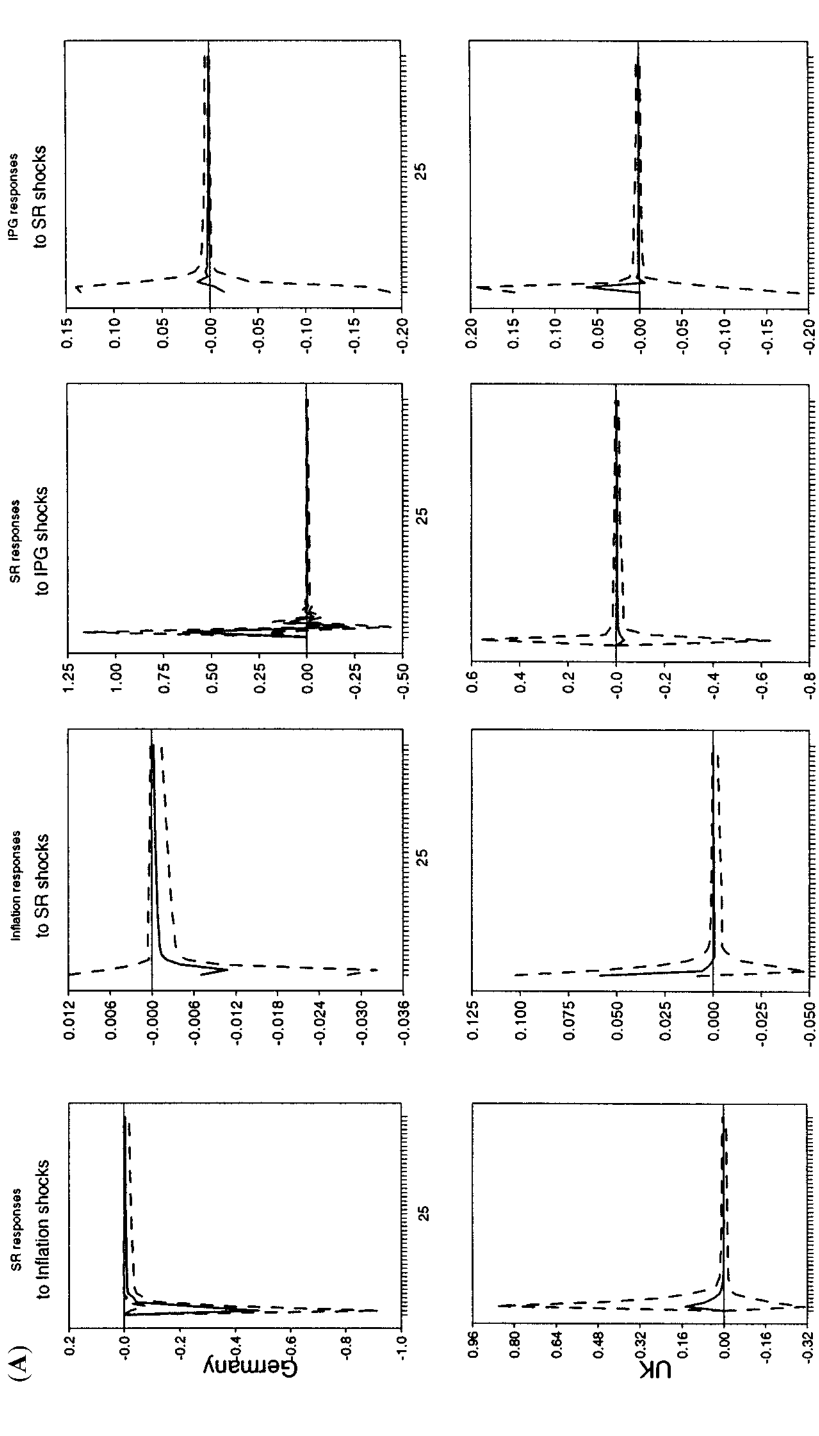

FIGURE 2. (Continued.)

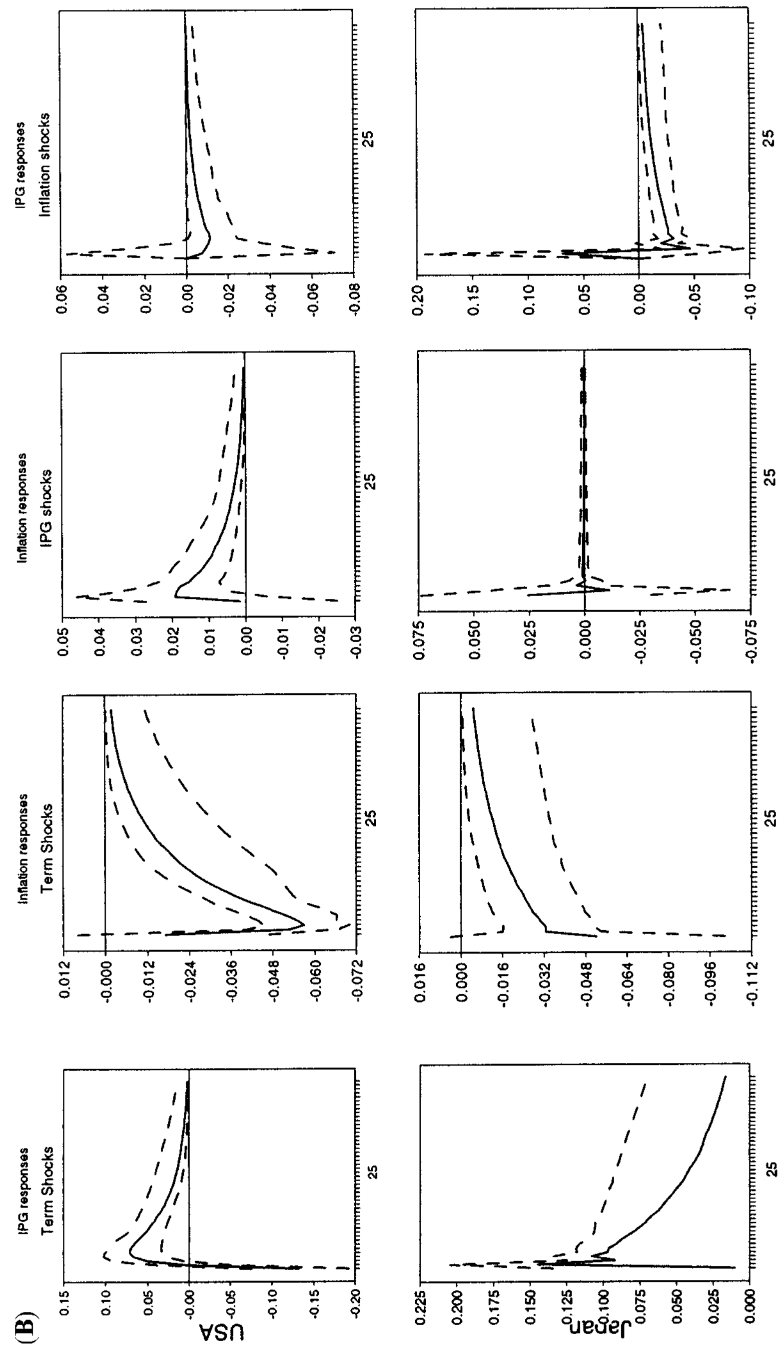

FIGURE 2. (Continued.)

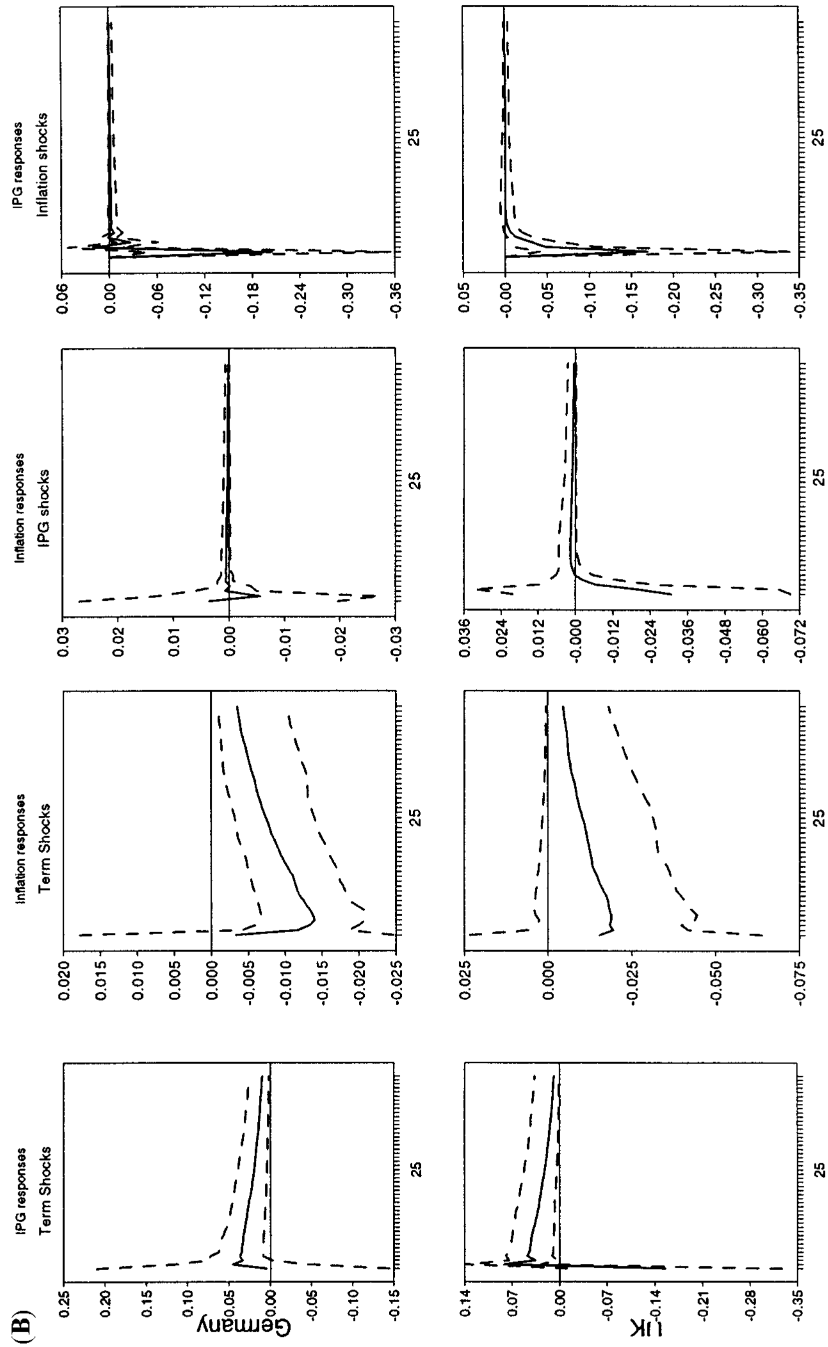

FIGURE 2. (Continued.)

returns and industrial production innovations positively influence them in all four countries but that these responses are masked by contemporaneous movements in government-controlled short-term interest rates. It has been documented [see, e.g., Clarida et al. (1998)] that central banks in some countries tend to lean against the wind in response to innovations in inflation and real activity. These actions may induce movements in nominal stock returns that cancel out or taper off those induced by innovations in real activity or inflation. The fact that innovations in stock returns do not have predictive power for inflation or real activity, on the other hand, suggests that the noise in monthly returns may be substantial and that measurement error could be largely responsible for the results (we will come back on this issue in a later section).[4]

In all four countries, innovations in the slope of the term structure clearly dominate stock returns as the leading indicator for inflation and real activity and have higher predictive power for inflation than for the growth rate of real activity (see Figure 2B). Innovations in the term structure have the largest predictive power in the United States, where, in the median, they explain 28.3% and 9.5% of inflation and industrial production growth, respectively, and the smallest in the United Kingdom, where, in the median, they explain 1.8% and 0.9% of the variance of inflation and industrial production growth, respectively. Hence, surprise movements in the slope of the term structure capture more expectations about the future state of the monetary policy stance than future developments in the real side of the economy. Notice that innovations that generate a steeper term structure are typically associated with higher future growth of industrial production and lower inflation. Within this general tendency, there are diversities across countries. In the United States and Japan, these changes are economically sizeable and statistically significant, but this is not the case in the United Kingdom and Germany.

Finally, the relationship between inflation and real activity is fairly stable across countries. Inflation innovations induce median responses in industrial production growth that are, in general, negative but their predictive power for real activity at the 24-month horizon is small in all four countries. More interesting is the response of inflation to innovations in real activity, which is somewhat heterogeneous across countries. Innovations in industrial production growth produce positive median responses of inflation in the United States, Japan, and Germany but negative ones in the United Kingdom. In all cases, however, the magnitude is small and responses are significant only in the United States. In general, shocks to the growth rate of industrial production explain a small fraction of the variability of the other three variables in all countries except the United States.

4.1. Summary

Given the cross-country heterogeneities that are present in the data, we next summarize the answer to our three questions from a cross-country perspective.

- In the United States, term-structure innovations predict real activity and inflation better than nominal stock-return innovations. The forecasting power of the slope of the term structure is stronger for inflation, but the proportion of the variance of industrial production growth explained by its innovations is nonnegligible. Nominal (and real) stock returns and industrial production growth negatively react to inflation innovations, even though the response is small and insignificant. Finally, positive innovations in industrial production growth generate significant positive responses of inflation, supporting the view that demand shocks may drive industrial production-growth innovations.

- In the United Kingdom and Germany, the interdependencies between financial markets, real activity, and inflation are negligible. Consequently, movements in financial markets have little forecasting power for both real activity and inflation at the 24-month horizon; there is no significant dynamic relationship between nominal stock returns and inflation, whereas real stock returns respond negatively to inflation innovations. The median estimate of the dynamic correlation between stock returns and industrial production growth is positive but small. Finally, the median estimate of the response of industrial production growth to inflation innovations, and the response of inflation to industrial production innovations, is small but negative in both cases.
- The dynamic interdependecies in Japan are intermediate between the preceding two cases. There is a significant relationship between innovations in the slope of the term structure, the growth rate of industrial production, and inflation, but the forecasting content of the term structure is small. The dynamic relationship between innovations in nominal stock returns and inflation is negative but barely significant, and innovations in inflation have little predictive power for nominal stock returns. The response of real activity and inflation to each other's innovations is negative but insignificant.

5. INTERNATIONAL DYNAMIC INTERDEPENDENCIES

We next turn to study interdependencies among the countries we previously considered in isolation. Because the four economies we have considered have become more interdependent over the past 15 years, we expect the international propagation of domestic shocks to be significant in some instances. In this exercise, we take the United States a pivot country because, for a large part of the sample, it played a bandwagon role for the world economy. Moreover, Plosser and Rowenhorst (1994) and Harris and Opler (1990) have shown that the level of financial variables in the United States have some predictive power for future values of foreign inflation and foreign real activity, whereas there is little evidence of direct transmission among the other three countries.

Median values for the variance decomposition results are in Table 3 where, again, an asterisk indicates that a 90% standard error band around the median value is above 0.05.

The presence of international linkages does not change the features of the relationship among stock returns, inflation, and real activity. Domestically, nominal

Table 3. Percentage of the 24-month forecast error variance explained by innovations in a nine-variable VAR, 1973:1–1995:12

Innovations in	Variance of								
	USRET	GERET	USTERM	GETERM	GEAEG	USIPG	GEIPG	USINF	GEINF
				U.S. and Japanese variables					
JPINF									
USRET	94.3*	11.0*	0.6	1.0	0.8	0.5	0.7	1.5	0.9
JPRET	0.2	81.2*	0.9	0.7	0.7	0.8	0.7	0.9	0.8
USTERM	1.0	1.6	80.9*	23.1*	3.7	12.6*	2.6	25.1*	5.5
JPTERM	0.3	0.5	5.2	60.5*	1.0	4.3	4.4	1.7	1.8
JPAEG	0.3	1.7	2.5	2.0	89.8*	0.9	0.8	1.4	0.9
USIPG	0.7	0.3	4.5	1.6	0.5	76.9*	2.7	3.1	0.7
JPIPG	0.5	0.2	0.7	0.1	0.5	0.3	84.6*	0.3	0.7
USINF	0.2	0.1	1.3	3.6	0.2	0.9	1.0	61.7*	0.9
JPINF	0.6	0.6	0.6	5.2	1.2	0.8	0.8	2.2	84.6*
				U.S. and German variables					
USRET	92.3*	10.0*	0.6	0.6	1.4	0.6	0.7	1.5	0.7
GERET	0.5	82.7*	1.3	2.0	0.5	1.9	0.6	0.9	0.9
USTERM	1.1	0.9	82.1*	18.3*	1.4	7.3	0.8	24.8*	5.6
GETERM	0.4	0.4	1.0	67.3*	0.4	1.7	0.9	0.8	2.8
GEAEG	0.5	0.3	3.3	0.7	93.4*	2.4	1.1	2.6	2.0
USIPG	1.7	0.4	6.4	6.6	0.3	82.6*	1.9	2.8	2.5
GEIPG	1.2	2.1	0.2	0.1	0.3	0.1	91.2*	0.5	0.5
USINF	0.2	0.3	1.5	0.4	0.1	0.3	0.3	62.1*	3.1
GEINF	0.4	0.9	0.4	0.5	0.3	0.5	1.2	1.1	79.1*

Table 3. (Continued.)

Innovations in	Variance of USRET	GERET	USTERM	GETERM	GEAEG	USIPG	GEIPG	USINF	GEINF
	U.S. and UK variables								
UKINF									
USRET	93.4*	25.3*	0.7	2.1	0.5	0.5	0.7	1.8	2.0
UKRET	0.4	67.4*	0.5	0.9	0.6	0.7	0.5	0.9	1.0
USTERM	1.7	1.9	79.7*	7.7	0.8	7.5*	0.7	23.5*	7.6*
UKTERM	0.5	0.2	5.4	80.8*	3.6	1.0	1.7	1.6	1.1
UKAEG	0.3	0.3	2.3	0.7	91.5*	2.2	0.6	1.4	1.0
USIPG	1.2	3.3	5.8	1.2	0.2	84.9*	3.7	3.2	1.5
UKIPG	0.3	0.2	0.2	1.1	0.3	0.2	89.6*	1.3	0.6
USINF	0.3	0.2	1.1	0.8	0.4	0.5	0.2	60.3*	4.9
UKINF	0.2	0.2	0.4	0.3	0.2	0.5	0.8	2.4	78.5*

Notes: The acronyms for countries are U.S. for USA, JP for Japan, GE for Germany, and UK for United Kingdom. RET refers to 1-month stock returns, TERM to the term premium between 5-year bonds and 3-month bills, AEG to 1-month changes in the US dollar exchange rate, IPG to 1-month industrial production growth and INF to 1-month inflation rate. Forecast error variance is computed using a nine-variable VAR model with a constant and one lag. The table shows the median percentage of the 24-month forecast error variance in variable i explained by innovations in variable j, computed as $(1/Q)\Sigma_{q=1}^{Q}\{100*[\Sigma_{s=0}^{23}C_s^{ij}/\Sigma_{j=1}^{9}\Sigma_{s=0}^{23}C_s^{ij}\}$, where C_s^{ij} is obtained from the orthogonalized moving-average representation of $\hat{y}_t = y_t - \mu_0 = \Sigma_{s=0}^{\infty}C_s u_{t-s}$, where $\hat{y}_t$ is a 9×1 vector and Q is the number of Monte Carlo replications. An asterisk indicates that the 90% confidence interval around the median is entirely above 0.05.

stock-return surprises induce positive median responses of industrial production growth and, with some qualifications, negative median responses of inflation, but the link is weak and insignificant in all countries. In general, the explanatory power of stock-return innovations for the variance of domestic industrial production growth or domestic inflation is always very small. On the other hand, the median responses of nominal and real stock returns are negative and insignificant in response to inflation surprises and positive and insignificant in response to industrial production-growth surprises.

Innovations in U.S. nominal stock returns are instantaneously transmitted across the world and induce a statistically significant and positive median response in nominal foreign stock returns. In fact, a significant portion of the variability of foreign stock returns is explained by U.S. stock-return innovations (from 10% to 25.3% in the median). However, there is no evidence that innovations in U.S. stock returns predict inflation or industrial production growth in any of the other three countries or that shocks in foreign stock returns predict U.S. variables. Hence, stock markets appear to be sufficiently well integrated internationally with causality running from the U.S. to foreign stock markets and with the transmission mechanism being almost identical in the three systems. However, innovation stock returns have little connections with real activity or inflation: The responses of all variables are economically interpretable but statistically insignificant.

The predictive power of term-structure innovations is somewhat altered in international contexts. Although it is still the case that innovations in the slope of the term structure generate a drop of domestic inflation in all countries and an increase in domestic IP growth, it is only in the United States that innovations of the term structure retain significant predictive power, explaining about 25% of the variability in domestic inflation and 7–12% of the variability of domestic industrial production growth. Interestingly, innovations in the U.S. slope of the term structure also predict foreign inflation rates but they have negligible predictive power for foreign industrial production growth. Surprise movements in the slope of the U.S. nominal term structure are also transmitted across world bond markets and they account for a significant proportion of the Japanese and German slopes of term structure at the 24-month (about 23% and 18%, respectively). The sign of the median response of U.S. variables to shocks to the foreign slope of the term structure depends on the country where they originate but the proportion of the variance of U.S. variables explained by shocks in foreign term structures is close to zero.

Hence, as in closed-economy setups, the informational content of innovations in the slope of term structure for domestic inflation and IP growth differs across countries. However, once movements in the slope of the U.S. term structure are taken into account, innovations in the foreign slope contain very little information for foreign inflation and IP growth. Surprise movements in the slope of the term structure in Japan, which previously had predictive power for domestic variables, appear to be generated by surprise movements in the slope of the U.S. term structure. U.S. and European slopes, on the other hand, do not show strong feedbacks and appear to be linked only indirectly through comovements of inflation rates.

Next, we turn to the final question of interest, that is, the relationship between inflation and real activity. Consistent with the closed-economy characterization, surprise movements in domestic inflation generate median responses in domestic IP growth that are negative but insignificant. Also, although no direct effect of U.S. inflation innovations on foreign inflation exists, inflationary pressures in the United States indirectly influence the variability in foreign inflation rates via term structure effects. The sign of dynamic responses to shocks to foreign inflation depend on the country where they originate. In general, they induce small responses in U.S. variables and explain a statistically insignificant proportion of their variability.

Innovations to industrial production growth produce domestic adjustments that are very similar to those found in the closed-economy case, but U.S. industrial-production innovations also have important repercussions in the world economy. In particular, they significantly influence foreign industrial production growth, increase domestic but not foreign inflation, and induce a decline in the slope of the domestic term structure. Shocks to foreign industrial production growth, on the other hand, generate insignificant international repercussions.

To summarize, in agreement with closed-economy results, nominal stock-return innovations have no predictive content for developments in the real side of the economies under consideration. Also, consistent with findings by Plosser and Rouwenhorst (1994), innovations in the slope of the U.S. term structure carry information about future U.S. inflation even in open-economy frameworks. The information, however, is not entirely nominal because movements in the slope also signal future movements in U.S. IP growth. Moreover, because, as noted in Section 3, inflation rates comove across countries, innovations in the slope of the U.S. term structure also carry information about future movements in foreign inflation rates. This predictive power is, however, a prerogative of innovations in the U.S. term structure. Once the effect of innovations in the slope of the U.S. term structure is taken into account, innovations in the three foreign slopes have no predictive power for domestic or foreign inflation. Inflation surprises have negligible influences on the growth rate of real activity in all countries, and small international repercussions. Finally, shocks to IP growth induce statistically significant domestic responses only if they originate in the United States in which case they also are transmitted to the real sectors of other countries.

5.1. Sensitivity Analysis

To examine the robustness of our results we have run a number of sensitivity checks on various aspects of the empirical model. For example, the ordering of the variables is unlikely to matter in domestic frameworks, due to the near orthogonality of VAR innovations, but the correlation between innovations in international stock returns is higher and the ordering of the two variables may matter in studying cross-country transmisssion. Also, there is a literature [see Fama (1990a)] that claims that the predictive power of financial variables for real activity depends on the forecasting horizons. Furthermore, the sample that we consider is unlikely to be completely homogeneous and structural breaks may bias our results and change the interpretation of the dynamics. Finally, industrial production is, in general, a poor proxy for real activity and a more comprehensive measure such as GDP may give somewhat different conclusions.

We have run these sensitivity checks (results are in an appendix available on request) and found that our major qualitative conclusions are unchanged. Switching the order of U.S. and foreign stock returns does not matter because stock-return innovations appear to be unrelated to the developments in the other markets in the economy. Varying the forecasting horizon from 12 to 48 months does not alter our conclusions because shocks are almost completely absorbed by the variables of the system after 12 months. Consequently, the predictive power of innovations in the slope of the term structure for real activity and inflation in each of the four countries is independent of the forecasting horizon and is always superior to that of stock returns. This should be contrasted with the findings by Mishkin (1990), who shows that the predictive power of the *level* of the term structure in the United States depends on the forecasting horizon, and with the findings by Fama (1990a), who claims that the *level* of stock returns has predictive power for future activity 2 years in the future. Changing the sample does alter the magnitude of the entries in the variance decompositions, in particular, if we consider the post-1982 sample. However, none of our qualitative results is affected. Finally, we have used the interpolated U.S. monthly series of GDP employed by Leeper et al. (1996) in place of industrial production, with no changes in the major features of the dynamics.

We have further examined the robustness of our results along two dimensions. First, we have considered quarterly VAR (both domestic and international) to examine whether the use of lower-frequency data affects the predictive power of innovations in financial variables for real activity and inflation. Fama (1990a) argued that, at least in the United States, real stock market returns predict industrial production growth better when low-frequency data are used because monthly stock returns may contain a large amount of noise. Second, we have run bilateral VAR's with stock returns expressed in one currency (the U.S. dollar) to assess whether returns uncovered for exchange-rate risk might have different informational content. Although we found no relevant changes in this latter case, we noticed some interesting differences when quarterly data are used. In particular, three results stand out. First, changes emerge for the United States but not for the other three countries. Second, nominal stock returns have a larger predictive power for the variance of industrial production growth and they now account for 15% of the variance in the median. Conversely, industrial production-growth innovations now explain 9% of variance of nominal stock returns. Finally, the level of dynamic interdependencies in the United States increases substantially when we consider either domestic or international systems. Although these results are comforting because they confirm what was obtained in the literature, the use of lower-frequency data may create time aggregation problems, which results in substantial bias. In particular, as Hansen and Sargent (1994) have shown, innovations in quarterly data are likely to be a combination of the innovations in monthly data, for months outside the quarter under consideration. Moreover, for certain data-generating processes, it is possible that this combination includes innovations from months that are in the future relative to the quarter under consideration.

6. INTERPRETATION OF THE INTERNATIONAL DYNAMICS

Although our analysis is based on a semistructural identification scheme, we next provide an economic interpretation of the national and international interdependencies. Because the covariance matrix of the VAR residuals is almost diagonal (except for the correlation between stock returns across countries), more or less structural identification schemes are unlikely to produce dramatically different results. Clearly, our proposed interpretation is not the only possible rationalization of structural evidence that we have presented, but is one that seems to be consistent with all of the empirical regularities that we have found.

Our explanation for the evidence we have collected is the following: demand-driven innovations in the growth rate of industrial production in the United States have little real domestic expansionary effects, probably because they occur close to full capacity, and typically are expected to generate inflationary pressures that are transmitted across countries. The domestic slope of the term structure anticipates these effects, with short-term interest rates reacting more than long-term ones, therefore acquiring predictive content for future inflation but not for future industrial production growth because of the relatively small persistence of these innovations. Nominal and real stock returns, on average, decline, probably in expectation of declines in future inflation. None of these effects appears in countries other than the United States: Innovations in IP growth appear to occur at less than full capacity, induce dynamics primarily in IP growth, and typically do not generate inflation. Innovations to the growth rate of U.S. IP are transmitted with a small lag to IP growth of other countries but the magnitude of the responses depends on the country considered. For example, the German IP growth is practically unaffected by developments in the real side of the U.S. economy. U.S. inflationary pressures, however, do not directly affect foreign IP growth, probably because of neutralizing responses of local monetary authorities. In general, international inflation rates appear to be passively reacting to the developments of the real side of the U.S. economy, and do not have any predictive content for cyclical movements in the real side of the domestic economies. Clearly, this interpretation of the evidence does not imply that monetary policy has no effects on the real side of the economy. It simply states that, over the past 20 years, neutralization of unexpected imported inflation has been one of the major goals of monetary policy in Japan, the United Kingdom and Germany, and that the real effects due to unexpected movements in the monetary policy stance have been negligible.

Restating the conclusion in another way, monetary policy has been sufficiently "credible" and there had been little attempts to deviate from the proposed monetary goals.

The role of financial markets in terms of transmission is limited to the links that the innovations in industrial production growth in the United States have on the domestic term structure. Stock markets appear to be well integrated across the world but their unexpected movements seem to have very little relationship to information about dividend flows, discount factors, or inflation. Bond markets appear to be less integrated than stock markets, but we uncovered a significant one-way relationship between the U.S. and the Japanese slopes of the term structure, which accounts for the predictive power that innovations in the Japanese slope of the term structure have for inflation in that country.

7. CONCLUSIONS

This paper analyzes the interdependencies among financial markets, real activity, and inflation from multicountry and international points of view. The goal was to examine the dynamics in response to particular disturbances and construct a set of stylized facts that could be used to evaluate the robustness of key relationships documented in the United States and to assess the quality of the outcomes of international business-cycle models with money and financial assets.

Our findings suggest that there are interesting regularities but also important international asymmetries in the dynamics of the data. First, the informational content of innovations in nominal stock returns for inflation and real activity is negligible in all countries, but innovations in U.S. stock markets are rapidly incorporated in nominal foreign stock returns. Second, the link between financial markets and real activity, as indicated by the forecasting power of innovations in the slope of term structure for real activity, is important for the United States and almost absent for other countries. In addition, although the U.S. slope of the term structure has major predictive power for domestic and foreign inflation, this is not the case for any other country's term structure. Third, there is little evidence that inflation innovations affect real activity in all four countries, whereas there is a significant response of inflation to innovations in industrial production growth in the United States, but not in other countries. Finally, shocks to real activity appear to be driven by different sources of structural disturbances in the countries under consideration, both in domestic and international frameworks. We argue that these asymmetries are consistent with an interpretation of the international dynamics in which innovations to the growth rate of industrial production in the United States appear to occur close to full capacity, influence nominal stock returns, and generate domestic inflationary expectations that are quickly incorporated in the slope of the term structure. Because foreign inflation increases following real U.S. shocks, probably via imported inflation effects, the U.S. term structure also predicts foreign movements in inflation. No such effects occur in the other countries because real shocks typically do not generate inflationary expectations.

We believe that our findings might be useful in designing effective international policy coordination activities in the context of a tightly integrated world economy, issues that are high on the policymaking agenda. First, notwithstanding the relative decline in the weight of the United States in the world economy over the past 20 years, it is still true that shocks originating in the United States have important real and informational effects that shocks generated in other economies do not possess. If designing common policies in the face of cyclical fluctuations is considered one of the goals of international policy coordination, this fact suggests that the United States is still a key counterpart that any country, including the European Union, should confront. Second, the primary source of disturbances at national and international levels appear to be shocks originating in real activity, whereas those originating in financial markets or attributable to a restrictive view of monetary policy have an insignificant role in generating significant cyclical fluctuations. These findings should be kept in mind both in discussing convergence indicators and in formulating feasible international policy objectives. Third, the responses of domestic inflation to shocks in both domestic and international real activity are consistent with the idea that monetary policy, in European countries, in particular, has been effective in neutralizing both domestic and imported inflation. In addition, our results indicate that over the past 20 years monetary policy may have been an effective tool, devoid of real effects, in controlling inflation.

NOTES

1. We do this because of recent results by Stock and Watson (1989), Estrella and Hardouvelis (1991), and Plosser and Rowenhorst (1994), demonstrating the superior predictive power of the term structure for real activity, relative to a single measure of short-term interest rates, both in the United States and in some European countries. In principle, a VAR could be better specified if both a short- and a long-term nominal rate are included. However, as argued by Bekaert and Hodrick (1992), this creates problems in handling nonstationarities. These problems are reduced, if not solved, by directly taking a measure of the slope of the term structure as a basic variable of the system.

2. As Lee (1992) and others have stressed, the rate of inflation is very highly correlated with the growth rate of the monetary base (on average, for the countries under consideration, the contemporaneous correlation is about 0.7): by including them directly we can interpret inflation surprises as proxies for monetary surprises. In addition, we include a measure of nominal exchange rates in the VAR to convert foreign nominal returns into domestic currency.

3. To do this, write (1) as

$$y_t = (I \otimes \boldsymbol{x}_t)\boldsymbol{\beta} + e_t \qquad \textbf{(4)}$$

where $\otimes$ is the Kroneker delta, $\boldsymbol{x}_t$ is a vector of lagged y_{it}, $i = 1, \ldots, m$, and $\boldsymbol{\beta}$ is a vector containing the stacked version of the $A(\ell)$ and of the A_0 matrices. Denote the OLS estimates of β and Σ as b and S. If we assume that the prior on β and Σ is $f(\beta, \Sigma) \propto |\Sigma|^{[(m+1)/2]}$, the posterior distribution for β, conditional on Σ, is normal with mean b and covariance matrix $\Sigma \otimes (x'x)^{-1}$ and the distribution of Σ^{-1} is Wishart((TS)$^{-1}$, T), where T is the sample size. Confidence intervals for C_s and $z^{\tau}(i, j)$ can be computed by drawing Q times from the above distributions for β and Σ, inverting the VAR and finding the matrix V, computing $[C_s]^q$ and $[z^{\tau}(i, j)]^q$, $q = 1, 2, \ldots, Q$, and appropriately ordering the replications.

4. Note also that the mechanism through which the negative correlation between nominal stock returns and inflation emerges for the United States is direct, without any intermediate effect via industrial production growth [as was suggested originally by Fama (1981)].

REFERENCES

Backus, D., P. Kehoe & F. Kydland (1992) International business cycles. *Journal of Political Economy* 100, 745–775.

Ballabriga, F., M. Sebastian & J. Valles (1999) European asymmetries. *Journal of International Economics* 48, 233–253.

Bekaert, G. & R. Hodrick (1992) Characterizing predictable components in excess returns on equity and foreign exchange markets. *Journal of Finance* 47, 467–509.

Boldrin, M., L. Christiano and J.D.M. Fisher (1995) Asset Pricing Lessons for Modelling Business Cycles. NBER working paper 5262.

Canova, F. (1995) VAR: Specification, estimation, testing and forecasting. In H. Pesaran & M. Wickens (eds.), *Handbook of Applied Econometrics*, pp. 31–65.

Canova, F. & G. De Nicoló (1995) Stock returns and real activity: A structural approach. *European Economic Review* 39, 981–1015.

Canzonieri, M., J. Valles & J. Vinals (1996) Do Exchange Rates Move to Address Regional Imbalances? Manuscript, Bank of Spain.

Clarida, R., J. Gali & M. Gerlter (1998) Monetary policy rules in practice: Some international evidence. *European Economic Review* 43, 1178–1203.

Cochrane, J. & L.P. Hansen (1992) Asset pricing explorations for macroeconomics. *NBER Macroeconomics Annual, 1992* 7, 115–165.

Danthine, J.P. & J.B. Donaldson (1994) Asset Pricing Implications of Real Market Frictions. Working paper 9504, Université de Lausanne.

Estrella, A. & G. Hardouvelis (1991) The term structure as predictor of real economic activity. *Journal of Finance* 46, 555–576.

Fama, E. (1981) Stock returns, real activity, inflation and money. *American Economic Review* 25, 59–76.

Fama, E. (1990a) Stock returns, expected returns and real activity. *Journal of Finance* 45, 1089–1108.

Fama, E. (1990b) Term structure forecasts of interest rates, inflation and real returns. *Journal of Monetary Economics* 25, 59–76.

Gerlach, S. & F. Smets (1995) The Monetary Transmission Mechanism: Evidence from the G-7 Countries. Mimeo, Bank for International Settlements.

Gerske, R. & R. Roll (1983) The monetary linkage between stock returns and inflation. *Journal of Finance* 38, 1–33.

Hansen, L. & T. Sargent (1994) Two difficulties in interpreting vectorautoregressions. In L. Hansen & T. Sargent (eds.), *Rational Expectations Econometrics*. Boulder, Co & London: Westview Press.

Harris, M. & T. Opler (1990) Stock Market Returns and Real Activity: International Evidence. Manuscript.

Harvey, C. (1988) The real term structure and consumption growth. *Journal of Financial Economics* 22, 305–333.

James, C., S. Koreisha & M. Partch (1985) A VARMA analysis of the causal relation among stock returns, real output and nominal interest rates. *Journal of Finance* 40, 1375–1384.

Lee, B.S. (1992) Causal relations among stock returns, interest rates, real activity, and inflation. *Journal of Finance* 47, 1591–1603.

Leeper, E., C. Sims & T. Zha (1996) What does monetary policy do? *Brookings Papers on Economic Activity* 2, 1–78.

Mishkin, R. (1990) What does the term structure tell us about future inflation? *Journal of Monetary Economics* 25, 77–95.

Plosser, C. & G. Rouwenhorst (1994) International term structure and real economic growth. *Journal of Monetary Economics* 33, 133–155.

Shijoi, E. (1996a) External Shocks and Spanish Monetary Policy. Mimeo, Universitat Pompeu Fabra.

Shijoi, E. (1996b) Identifying Monetary Policy in Japan. Mimeo, Universitat Pompeu Fabra.

Sims, C. & C. Zha (1995) Error Bands for Impulse Responses. Working paper 95-6, Federal Reserve Bank of Atlanta.

Stock, J. & M. Watson (1989) New indexes of coincident and leading economic indicators. *NBER Macroeconomic Annual 1989* 4, 351–393.

Svensson, L. (1997) Inflation forecast targetting: Implementing and monitoring inflation targets. *European Economic Review* 41, 1111–1146.

APPENDIX

A.1. DEFINITION OF VARIABLES

The basic series employed in this study are share price indexes for national stock markets (SH), dividend yields on stock market indexes (DY), nominal yields on short- and long-term government bonds (IRS) and (IRL), consumer price indexes (CPI), industrial production indexes (IP), and nominal exchange rates vis-à-vis the U.S. dollar (EX). Sources are OECD or IFS (IMF) unless indicated otherwise.

The dervied series are nominal stock returns, obtained using the ratio of stock price index (SR) and dividend yields at time (t):

$$RET_t = \frac{SH_{t+1} - SH_t}{SH_t} + DY_t;$$

slope of nominal term structure, obtined as the difference between yields on long-term and short-term government bonds:

$$TERM_t = IRL_t - IRS_t.$$

A.2. DATA SOURCES

A.2.1. United States

SH. Monthly Standard & Poor 500 industrial share price index (1985 = 100), daily averages (Morgan Stanley).

IRS. Monthly interest rate on 3-month treasury bills, average of daily auction rates during the week of the last Monday of the month (OECD).

IRL. Monthly interest rate on long-term government bonds, 10 years or over, daily averages (OECD).

DY. Monthly Standard & Poor 500 dividend yield, MF1431 (Datastream International).

CPI. Consumer prices, all items, not seasonally adjusted, 1985 = 100 (OECD).

IP. Industrial production, seasonally adjusted, 1985 = 100 (OECD).

A.2.2. Japan

SH. Monthly Tokyo stock exchange share price index, end-of-period data, 1985 = 100 (Morgan Stanley).

IRS. Monthly 3-month Genaski rate (OECD).

IRL. Monthly interest rate on long-term central government bonds, 5 years or more, end of the period (OECD).

DY. Monthly Tokyo Stock Exchange dividend yield, Topix (Datastream International).

CPI. Consumer prices, all items, not seasonally adjusted, 1985 = 100 (OECD).

IP. Industrial production, seasonally adjusted but not adjusted for unequal number of working days in the month, 1985 = 100 (OECD).

EX. Market exchange rate vis à vis the U.S. dollar (IMF, IFS database 1994).

A.2.3. United Kingdom

SH. Monthly F.T. Actuaries (500 shares) share price index, end-of-period data, 1985 = 100 (Morgan Stanley).

IRS. Monthly interest rate on 3-month treasury bills, average rate of allotment on last issue of month (OECD).

IRL. Monthly interest rate on long-term government bonds, 5 years or more, last Friday of the month (OECD).

DY. Monthly F.T. Actuaries dividend yield (FTUKALY) (Datastream International).

CPI. Consumer prices, all items, not seasonally adjusted, 1985 = 100 (OECD).

IP. Industrial production, seasonally adjusted, 1985 = 100 (OECD).

EX. Market exchange rate vis à vis the U.S. dollar (IMF, IFS database 1994).

A.2.4. Germany

SH. Monthly Federal Statistical Office industrial share price index, daily averages, 1985 = 100 (Morgan Stanley).

IRS. Monthly interest rate on 3-month loans, average of daily rate (OECD).

IRL. Monthly interest rate on long-term government bonds, 5 years or more, end of the period (OECD).

DY. Monthly dividend yield (Datastream International Total Market Return index).

CPI. Consumer prices, all items, not seasonally adjusted, 1985 = 100 (OECD).

IP. Industrial production, seasonally adjusted, 1985 = 100 (OECD).

EX. Market exchange rate vis à vis the U.S. dollar (IMF, IFS database 1994).