International Spillover of Risk and Return among Major Banking Institutions: A Bivariate GARCH Model

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Using the bivariate GARCH methodology, this study examines bank stock sensitivities to market, interest rate, and exchange rate, and investigates the spillover effects of interest rate volatility and unsystematic risk among the banking sectors of the United States and Japan, and the United States and Germany. Empirical results show that return-generating processes of the banking sectors considered can be properly described by GARCH models. Within this framework, banks are found to be highly sensitive to macroeconomic shocks such as the exchange rate and interest rate, with the latter exerting its impact at the volatility level. Moreover, stock volatilities in the banking sectors of the three countries are found to be highly interdependent. The direction and magnitude of the effects from interest rate volatility and unsystematic shocks in one country on other countries are sensitive to the origin of the shock, with the United States playing a leadership role. The findings have serious implications on international financial stability, international portfolio diversification, and policy formulation by central banks and fiscal authorities.

1. Introduction

In recent decades, the world of banking has witnessed a rapid proliferation of telecommunication technology, globalization of business activity, and increased

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policy and regulatory coordination among the central banks of the industrialized countries. These phenomena are likely to have strengthened the interdependence of the banking sectors across these countries, heightened bank sensitivity to outside shocks, and exposed the international banking system to greater risks. Contagion among the banking markets and the resulting “domino effect” have been especially manifested at times of crisis, such as the crash of 1987, the Asian crisis of 1997, and the Russian crisis of 1998.

Although there is a substantial body of literature that examines the return and risk interdependence among financial markets using aggregated market indices, investigation of risk and return transmission across the banking sectors of different countries has received inadequate attention. The study of interdependence at the disaggregate (sectoral) level is of importance and interest for several reasons. First, the use of aggregate indices makes it impossible to disentangle the changes in the spillover effect of the specific industries embedded in the aggregate market from those of the market mix. Hence, the use of an aggregate market measure may distort the findings and render them inapplicable to the banking sector.

Second, academics and policymakers concur that banks are “distinct” from other industries due to their influential role in the transmission of monetary policy, administration of the payment system, and allocation of credit to favored sectors such as housing and agriculture (Saunders [2000]). Treatment of banks as “special” has led to pervasive regulation of banking activities and has introduced considerable friction in the information transmission process. As a consequence, banks are likely to display responses to received shocks, which are dissimilar in character to those exhibited by markets in general. It is commonly believed that, in comparison with other industries, bank contagion occurs faster, spreads more broadly within the industry, and permeates far beyond the banking sector to cause substantial damage to the financial system and the economy.1

Third, the relation between financial institutions and financial markets has changed over time and has done so at differential rates across countries. In recent decades, financial markets in the United States have presented a serious challenge to financial institutions in their traditional functions of “intertemporal smoothing” and asset transformation (Allen and Santomero [2001]). Indeed, U.S. capital markets have practically replaced banks as the primary source of funds for large and mid-sized corporations, forcing the latter to seek other sources of revenue such as fee-based services and off balance sheet activities. This phenomenon has been much less intense in Japan and Germany, whose financial intermediaries continue to man-

1. See Kaufman (1994) for a review of the theory and evidence of bank contagion. Historically, the worldwide great contraction of 1929 started with—and was sharply deepened by—the contagion across the largest banks in the industrialized countries.

2. Intertemporal smoothing entails building up reserves in safe, low-yielding assets at a time when returns are high, and drawing on these reserves at a time when the returns are low, in order to shield bank customers from risk (Allen and Santomero [2001]). This is a multiperiod optimization framework, while the more competitive banking markets, such as that in the United States, tend to adopt a shorter optimization span.
age risk principally through intertemporal smoothing. Indeed, Allen and Gale (1997) have suggested that this distinction represents a fundamental difference between risk management approaches of the intermediaries in Japan and Germany and their counterparts in the United States. This issue raises a major question on how the differences among banking sectors of different countries influence the way information is transmitted across banks. In particular, one implication of this dissimilarity is that since the Japanese and German banks have to absorb shocks and not pass them on to their customers, they may display a wider return volatility than the U.S. banks.

The banking sectors of different countries are also dissimilar in terms of structure and regulatory constraints and, hence, they may not respond similarly to various shocks. The banking systems of the G-10 nations can be categorized as either universal, thin firewall, or thick firewall. The German banking system, which is considered to be a prime example of the universal system, allows banks to conduct investment and mortgage banking, to engage in mutual fund activity, and to own equity stakes in commercial firms, besides the traditional banking business. The thin firewall system provides for some product diversification by banks but maintains a degree of separation between traditional banking and other operations. The Japanese banking system, which allows the securities firms discount window and payment system privileges but maintains a separation between banking and securities business, is characterized as a thin firewall system. The U.S. banking system, the most restrictive among the G-10 nations, is categorized as a thick firewall system.

Moreover, it is noteworthy that the largest U.S. banks are affiliated with bank holding companies (BHC), many of Japan’s largest banks belong to Keiretsu organizations, and some German banks are a part of the Hausbank System, with some being largely owned by the state. The extent of product diversification and organizational structure, within which a bank operates, can potentially exert a significant degree of influence on the bank’s profitability and risk exposure. Although the intent of the thick firewall system (e.g., Glass-Steagall Act) was to limit risk by restricting activities, the actual effect is in dispute. In this paper, differential sensitivities of the banking systems in the United States, Japan, and Germany to macroeconomic and financial shocks—and the spillover of these shocks among the three banking sectors—are examined. More specifically, this paper has a twofold objective: First, to examine and contrast the behavioral patterns and shock sensitivities of commercial bank stock returns under the three divergent banking systems in the United States, Japan, and Germany in a generalized framework. To this end, the effect of changes in the equity market,

3. For a discussion of markets and the banking structure in Japan, see Genay (1998) and Peek and Rosengren (1997). For Germany, see Gorton and Schmid (2000). The Gramm-Leach-Bliley Act of 1999 relaxed some of the restrictions on cross-industry activity imposed by the Glass-Steagall Act. The law creates a new “financial holding company” that can engage in a statutorily provided list of activities, including insurance and securities underwriting, merchant banking, agency services, and insurance company portfolio investment services. Activities complementary to financial services are also permitted.
interest rate, and exchange rate on the return generating process of bank stocks in the United States, Japan, and Germany will be investigated within the context of a generalized autoregressive conditionally heteroscedastic (GARCH) model. Second, to investigate the effect of interest rate volatility and unsystematic risk in the banking sector of one country on the bank stock return volatility in its own and foreign countries. The pattern of these effects highlights the role of volatility in determination of bank stock return behavior and, more importantly, it allows the nature of the volatility spillover between the banking sectors of the countries considered to be delineated, both in terms of direction and magnitude of the contagion effect.

The current study extends the existing literature by incorporating the effect of interest rate volatility, inter-country return interdependence, and spillover of unsystematic risk across national borders, within a generalized bivariate GARCH model. The finding that bank stock return volatility in one country is systematically influenced by interest rate volatility and unsystematic risk in its own and/or another country has serious implications on international financial stability, international portfolio diversification, trading strategies, hedging practices, regulatory decisions, and policy formulation by central banks and fiscal authorities (Fleming et al. [1998]). The remainder of the paper is organized as follows. Section two provides a brief literature review, section three discusses the model and methodology, and section four describes the data sources and diagnostics. Empirical results are presented in section five, and conclusions are contained in section six.

2. Bank Stock Return Behavior

Most existing studies of bank stock returns are based on the assumptions of linearity, returns independence, and constant conditional variance of returns over time. The former two assumptions are challenged by Tinic and West (1986), Carroll and Wei (1988), and Akgiray (1989), while the latter is inconsistent with evidence presented by Pindyck (1984), Poterba and Summers (1986), Akgiray and Booth (1988), and Carroll et al. (1992), among others. Kane and Unal (1988), Kwan (1991), Yourougou (1990), Choi et al. (1992), and Wetmore and Brick (1994) have shown that market and interest rate risks are time dependent and need to be modeled in a general framework. It is noteworthy that the use of the traditional linear model in the presence of heteroscedastic and leptokurtic residuals can lead to parameter standard errors which are too large, possibly leading to an erroneous conclusion that a parameter is not significantly different from zero.

Since the basic studies on bank stock return sensitivities are discussed elsewhere, the review here will be limited to recent studies based on non-linearity and return interdependence.4 Bessler and Booth (1994), Song (1994), and Elyasiani and Mansur (1998) all employ the ARCH-type methodology to model bank stock return

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behavior. Bessler and Booth (1994) use a two-factor GARCH model to examine the sensitivity of bank stock returns to the innovations in interest rates for the German universal banks and the U.S. money center banks. In contradiction to the previous findings, these authors report that allowing bank ownership of commercial firms is not likely to lower the interest rate risk exposure of the banks. Song (1994), using a two-factor ARCH model, finds that the market and interest rate risk measures of banks are time variant. Specifically, although these measures are found to have remained basically unchanged around October 1979, when the Federal Reserve switched to controlling monetary aggregates, they do show an increase in 1982 in response to the Fed’s shift in strategy in favor of targeting borrowed reserve.

Elyasiani and Mansur (1998) employ the GARCH-M methodology to investigate the effect of interest rate and its volatility on the bank stock return generating process. Using monthly data from January 1970 to December 1992, they analyze the U.S. money center bank, large bank, and regional bank portfolios and determine that the ARCH, GARCH, and the volatility feedback effects are all statistically significant. In addition, interest rate and interest rate volatility are found to directly impact the first and the second moments of the bank stock return distribution, respectively, with the latter also affecting the risk premia indirectly. Furthermore, the degree of persistence in shocks is found to be substantial for all the three bank portfolios, and sensitive to the nature of the portfolio and the prevailing monetary regime.

Studies of risk and return spillover at the sectoral level are almost non-existent in banking. Peek and Rosengren (1997) is an exception. These authors examine the transmission of the domestic financial shocks in Japan to the United States through the Japanese banking sector. Using data from September 1988 through September 1995, they find that shocks to the Japanese parent banking institutions’ capital resulted in substantial loan shrinkage at their U.S. branches, though not at their U.S. subsidiaries. Application of ARCH-type models to banking, particularly those outside the United States, remains limited. More importantly, no study has investigated the inter-country transmission of shocks across the world markets within a general GARCH framework. The current study intends to fill this void by investigating the bank stock behavior and the spillover effects among the banking sectors of the United States, Japan, and Germany.

3. Model and Methodology

3.1 Theories of Contagion

Engle et al. (1990) have put forward two hypotheses concerning the behavior of shock waves introduced to financial markets. The “heat wave” hypothesis pos-

tulates that volatility has only country-specific autocorrelation, and shocks introduced into one market remain restricted to that market. This kind of shock may be classified as "local" or "competitive" and has a tendency to redistribute wealth from one market to another. According to the "meteor shower" hypothesis, shock wave behavior is similar to a meteor shower, which rains down on earth as it turns. In other words, shocks spillover across markets. Shocks of this category may be labeled "global" shocks because they affect multiple markets. Empirical tests carried out by Engle et al., based on intra-daily data, support the latter hypothesis. Along the same lines, Jeong (1999) examines the transmission pattern of intra-daily volatility among the United States, United Kingdom, and Canadian markets during their overlapping trading hours using high frequency data (five-minute interval). The Jeong study also supports volatility spillover across countries.

King and Wadhwani (1990) offer an alternative theory of contagion across financial markets, which may be labeled the "private information" hypothesis. According to this theory, contagion across markets occurs as a result of attempts by rational economic agents to infer the valuable proprietary "private" information available to other agents by observing the price and trading patterns in other markets. In this framework, idiosyncrasies and mistakes in one market have a tendency to be transmitted to other markets, engendering a channel of interdependence and contagion. King and Wadhwani report that the degree of interdependence among markets is sensitive to the extent of market volatility; as volatility heightens, contagion strengthens in magnitude.

Harvey and Huang (1991) contend that interdependence does prevail among markets and can be partially explained by the information extraction attempts of the investors, as indicated by the "private information" hypothesis. They propose, however, that it is the "public announcement" of news rather than "private information" that is the prime motivator and the likely force behind the price changes in the market place. This may be dubbed the "public information" hypothesis. In this scenario, announcement of news will engender a contemporaneous movement across all markets and, hence, a co-movement or interdependence across these markets. If this view is valid, volatilities are likely to be concentrated at points of time when macroeconomic and other relevant news is announced. Gradual dissemination of private information and public announcement of news can both serve as the source of "meteor shower" and geographic spillover of volatility. In addition, if policy shocks in one country lead to stochastic responses by policymakers of other countries, they, too, can bring about volatility spillover and shock persistence (Ito, et al. [1992]).

3.2 Model Specification

The appropriate methodology for testing the prevalence of market contagion and shock persistence is an extended version of the generalized autoregressive conditionally heteroscedastic (GARCH-p, q) model proposed by Bollerslev (1986). Laux and Ng (1993) have proposed the "mixture of distributions" hypothesis as the theoretical explanation of the GARCH family of models. According to this hypothesis, the presence of autocorrelation in the rate of information arrival induces volatility dependencies, which can be adequately modeled by GARCH. Moreover, De Santis and Gerard (1997) have pointed out that since conditional Capital Asset Pricing Model (CAPM) fails to impose restrictions on the dynamics of the conditional variances, a GARCH specification can be used to remedy this limitation and to obtain a testable version of the model. The GARCH family of models is also consistent with the International Capital Asset Pricing Model (ICAPM), has many desirable econometric properties, and is widely used to study the behavior of the financial markets.7

The extended bivariate GARCH model employed here is similar to that used by Baillie and Bollerslev (1990), Kroner and Sultan (1993), Grier and Perry (1996), and Jeong (1999). For a pair of countries 1 and 2 (1 = Japan [JP] or Germany [GE], and 2 = the United States), the model can be presented by the following system of equations:

\[ R_{1,t} = \beta_{10} + \beta_{11} R_{M1,t-1} + \beta_{12} \Delta I_{1,t-1} + \beta_{13} F_{X1,t-1} + \beta_{14} R_{2,t-1} + \epsilon_{1,t} \]

\[ h_{1,t} = \nu_{10} + \alpha_{11} h_{1,t-1} + \lambda_{12} \epsilon_{1,t-1}^2 + \delta_{13} \epsilon_{2,t-1}^2 + \varphi_{14} CVI_{1,t-1} \]

\[ \epsilon_{1,t} | \Omega_{t-1} \sim N(0, h_{1,t}) \]  

\[ R_{2,t} = \beta_{20} + \beta_{21} R_{M2,t} + \beta_{22} \Delta I_{2,t-1} + \beta_{23} F_{X2,t-1} + \beta_{24} R_{1,t-1} + \epsilon_{2,t} \]

\[ h_{2,t} = \nu_{20} + \alpha_{21} h_{2,t-1} + \lambda_{22} \epsilon_{2,t-1}^2 + \delta_{23} \epsilon_{1,t-1}^2 + \varphi_{24} CVI_{2,t-1} \]

\[ \epsilon_{2,t} | \Omega_{t-1} \sim N(0, h_{2,t}) \]  

\[ h_{12,t} = \rho_{12} \sigma_{1,t} \sigma_{2,t} (-1 < \rho_{12} < 1) \]

In this model, \( R_{1,t} \) is the return on the bank portfolio, \( R_{M1,t} \) is the return on the market index, \( \Delta I_{1,t} \) is the change in the long-term interest rate (ten-year government bonds), and \( F_{X_{i,t}} \) is the percentage change in the foreign exchange index for country \( i (i = 1,2) \). The variable \( CVI_{i,t-1} \) is the lagged conditional variance of the interest rate, used as a proxy for interest rate volatility, and \( \epsilon_{i,t} \) is the random error term.

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7. See Bollerslev et al. (1992) for a review of the theory and empirical evidence of ARCH modeling in finance.
with conditional mean zero and conditional variance \( h_{t|T} \), where the conditioning variable is the information set \( \Omega_{t-1} \).  

Equation (1) in this model describes the bank portfolio return \( R_{t,1} \) of country 1 as a function of own-market portfolio return \( R_{M,t,1} \), changes in interest rate \( (\Delta I_{t,1}) \), change in the foreign exchange index \( (FX_{t,1}) \), and the foreign bank stock return \( R_{t,2} \). This specification allows for the effect of these factors on \( R_{t,1} \) to be examined in the context of the same model. Inclusion of the foreign bank stock return \( R_{t,2} \) also provides a framework for testing the interdependence in return levels between the two countries.

The volatility equation (equation [2]) extends the GARCH (1,1) formulation to include the conditional volatilities of interest rates in the domestic \( (CVI_{1,t-1}) \) and foreign markets \( (CVI_{2,t-1}) \), as well as the unsystematic risk in the two countries \( (\varepsilon_{1,t-1}^2 \text{ and } \varepsilon_{2,t-1}^2) \). Formulation of equations (4–6) is similar to equations (1–3). This specification is a constant correlation bivariate GARCH model. It allows the variances of returns \( (h_{t|T}) \) to change over time but requires the correlation \( (\rho_{12}) \) between the series to remain the same (equation [7]). The parameter \( \rho_{12} \) needs to be estimated along with other parameters \( (\beta, \alpha, \lambda, \delta, \varphi, \phi) \). Transmission of risk from country 2 to country 1 can occur through two channels; unsystematic shocks \( (\varepsilon_{2,t-1}^2) \) and interest rate volatility \( (CVI_{2,t-1}) \). Presence of these sources of spillover in the model allows the long-term contagion between each two countries to be measured in terms of both direction and magnitude of the effect.

Inclusion of interest rate uncertainty can be defended both theoretically and empirically. On theoretical grounds, as Flannery et al. (1997) point out, although the effect of interest rate uncertainty on stock returns has received little attention, it stands to reason that if this variable influences bonds or, for that matter, any group of assets, it must also impact all other assets, including stocks. Thus, incorporation of conditional variance of interest rate as an argument in the volatility equation is a step toward a more complete model of asset pricing.

Elyasiani and Mansur (1998) present three other reasons for inclusion of this variable. First, Deshmukh et al. (1983) have demonstrated that an intermediary’s choice of risk is affected by interest rate uncertainty. Second, this variable reflects the uncertainty in the stance of monetary policy, and effectiveness of the Fed in hitting its target. Hence, it exerts an influence on bank risk exposure. Third, the objective of avoiding personal risk motivates bank managers to limit other cate-

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8. All variables are tested for stationarity. All variables, except the interest rate series, are found to be stationary (1(0)). The first difference of the interest rate series is found to be stationary and is used throughout this study. The issue of whether to employ interest rates or the orthogonalized variable is still unresolved. However, Giliberto (1987) shows that regressing the stock market index on the interest rate index may produce biased estimates for the regression coefficient of the interest rate variable. Similarly, regressing interest rate index on stock return index creates the opposite bias. Unal and Kane (1988) argue that it is not apparent which index is the driving index and which is the driven index and that the parameter space spanned is the same whether or not the indices are orthogonalized. Choi et al. (1992) also support this conclusion. Hence, the indices in this study are not orthogonalized.
gories of bank risk in response to increased interest rate uncertainty. On empirical grounds, inclusion of this variable can be defended on the basis of the work by Engle et al. (1987) and Mansur and Elyasiani (1995) who, respectively, find that bond values and bank stock returns are sensitive to the conditional variance of interest rates. Inclusion of own-market uncertainty (unsystematic risk) in the volatility equation is consistent with French et al. (1987) who demonstrate that returns are positively correlated with anticipated market volatility, and with Akgiray (1989) who confirms this relationship.

The bivariate specification offers several advantages. First, it accounts for inter-country transmission of stock returns, interest rate volatility, and unsystematic risk. This property allows tests of significance of the “heat wave” and the “meteor shower” hypotheses to be carried out and the relative explanatory power of the two forces in determining the volatility patterns to be determined. Second, this model allows asymmetry of the spillover effects across countries to be tested, and tests of linear relationships among the parameters within and across equations to be implemented. This property is highly convenient for testing, for example, the equality of bank stock return sensitivities to macroeconomic variables across different banking regimes such as universal banking, thin firewall, and thick firewall regulatory systems. Finally, the joint estimation of a bivariate system has an advantage over the single variate GARCH as it permits the errors in the mean equations to interact and allows a more efficient set of estimates to be obtained.

Bivariate GARCH also receives support from the extant empirical literature. For example, Karolyi (1995) reports that bivariate GARCH is an empirically successful framework for delineating stock price linkages between the United States and Canada. Laux and Ng (1993) also state that, based on their empirical results, multivariate GARCH models dominate their univariate counterparts. The Broyden, Fletcher, Goldfarb, and Shanno (BFGS) algorithm with robust errors option is used to carry out the estimation. This option, under fairly weak conditions, estimates coefficients that are consistent even when the conditional distribution of the residuals is non-normal.

4. Data and Diagnostics

4.1 Data Sources

The data on the banking firms contained in the Global Vantage data set for the United States, Japan, and Germany are utilized for this study. The sample consists of forty-seven, eighty-five, and seven large banking institutions for the United States, Japan, and Germany, respectively. Monthly bank portfolio returns, including dividend yields, are generated as the simple average returns of the in-

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individual banking institutions. The time period for bank portfolio returns encompasses January 1986 through November 1995. The market returns data are the Capital International series composed of capital gains and the dividend yield constructed by Morgan Stanley. The interest rate and exchange rate indices are extracted from the International Financial Statistics (IFS) tapes. Interest rate volatility is measured by the conditional variance of the interest rate and is generated using a GARCH-M process.\(^{10}\)

The choice of the monthly data can be defended on the grounds that it allows a longer historical period to be included in the sample, it is less affected by noise, and it is unaffected by settlements and clearing delays. The longer horizon permits the long-term movements in volatility to be more effectively manifested. Similarly, settlements and clearing delays are significant determinants of returns in the daily data and may distort the findings in the higher frequency data (Baillie and De-Gennaro [1990]).

4.2 Diagnostics

To investigate the appropriateness of the GARCH framework, the white noise, skewness, and kurtosis properties of the data have to be examined. The summary statistics for the data (mean, variance, maximum, minimum, skewness, and kurtosis) are reported in Table 1. According to the figures in this table, the Lagrange multiplier test for normality rejects the joint hypotheses of zero skewness and zero excess kurtosis for each of the portfolios, with much of the non-normality being due to leptokurtosis. The null hypothesis of white noise is also rejected by the Box-Pierce-Ljung portmanteau statistics. Rejection of the normality feature is similar to the finding in the extant literature and may be an indication of non-linearity in the return generating process. The model regressors are also checked for multicollinearity. The correlation coefficients among these variables are found to be low to moderate, indicating lack of collinearity.

5. Empirical Results

The parameter estimates based on joint estimation of the bivariate GARCH models of United States–Japan and United States–Germany are reported in Tables

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10. A detailed discussion of the interest rate volatility estimation procedure and the maximum likelihood estimation results can be obtained from the authors. Monthly data from January 1965 through December 1995 is utilized. The optimal lag structure for the mean equation for the United States, Japan, and Germany is determined to be 5, 2, and 1, respectively. The \( \chi^2 \) values for Q(12), Q(18) and Q(24) for the (United States), (Japan), and (Germany) are (12.06, 19.99, 28.49), (2.93, 3.78, 4.14) and (9.19, 12.51, 15.78), respectively. For the United States, Japan, and Germany, the skewness values are 5.53, 13.94, and 3.66, respectively, and for kurtosis the values are 36.75, 209.64, and 15.99, respectively. The Jarque-Bera (1987) Lagrange Multiplier values for the United States, Japan, and Germany (18874, 650410, and 3331.64, respectively) are all significant. All ARCH, GARCH, and GARCH-M parameters are significant. The values of the log likelihood functions are 1174, 167627, and 1040 for the United States, Japan and Germany, respectively.
### TABLE 1
Sample Statistics on Monthly Bank Portfolio Returns

<table>
<thead>
<tr>
<th>No. of Observations</th>
<th>United States</th>
<th>Japan</th>
<th>Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>118</td>
<td>118</td>
<td>118</td>
</tr>
<tr>
<td>Mean</td>
<td>0.016</td>
<td>0.022</td>
<td>0.007</td>
</tr>
<tr>
<td>Variance</td>
<td>0.004</td>
<td>0.004</td>
<td>0.005</td>
</tr>
<tr>
<td>Minimum</td>
<td>-0.193</td>
<td>-0.136</td>
<td>-0.183</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.189</td>
<td>0.260</td>
<td>0.191</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.074</td>
<td>0.540**</td>
<td>-0.196</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>0.725</td>
<td>0.999**</td>
<td>0.589</td>
</tr>
<tr>
<td>LM(x^2)</td>
<td>25.11***</td>
<td>24.998***</td>
<td>28.838***</td>
</tr>
<tr>
<td>Q(8)</td>
<td>12.57**</td>
<td>5.24</td>
<td>19.42***</td>
</tr>
<tr>
<td>Q(16)</td>
<td>18.79</td>
<td>16.27</td>
<td>23.94**</td>
</tr>
<tr>
<td>Q(24)</td>
<td>34.65**</td>
<td>23.82</td>
<td>37.65**</td>
</tr>
</tbody>
</table>

LM is a Lagrange multiplier test for normality under the null hypothesis that the coefficients of skewness and kurtosis are jointly equal to zero and three, respectively. This statistic is distributed as $\chi^2$ with two degrees of freedom. Q is the Ljung-Box statistic at a lag of n. ** and *** represent significance at the .10, .05, and .01 levels, respectively.

2 and 3, respectively. The description of the hypotheses and the corresponding Likelihood Ratio (chi-square) and t-test statistics are reported in Tables 4 and 5. Three categories of test results will be discussed: model specification, macro shocks, and spillover effects.\(^{11}\)

#### 5.1 Model Specification

Banking studies generally include the capital asset pricing model (CAPM) as a maintained hypothesis, and carry out tests concerning bank stock sensitivities within this framework. An advantage of the generalized GARCH specification adopted here is that it includes the simpler models, such as the CAPM, as special

\(^{11}\) Several other versions of GARCH were also estimated but dropped in favor of the current model. In terms of convergence, log likelihood values, reasonableness of the signs and magnitude of the estimates, and stability conditions, the model used here showed the best performance. In particular, the GARCH-M model produced negative risk-return tradeoff values. This feature is found also in other papers but it is difficult to justify. The EGARCH specification was not chosen for two main reasons. First, EGARCH imposes additional a priori restrictions on the functional form, whose validity is not well-documented. Second, EGARCH is used to test for asymmetry of response to positive and negative return shocks. In our model, volatility shocks, rather than return shocks, are the focus. It is noteworthy that there exists no well-established procedure for model selection within the context of bivariate GARCH. In a general context, model selection tests can be carried out using both nested and non-nested procedures (Elyasiani and Nasseh [2000]). Since GARCH and EGARCH models are not nested within a more general model and non-nested tests are limited to single equation models, a formal test of validity of GARCH versus EGARCH models could not be carried out.
cases and allows a test of their validity. Three hypotheses concerning the form of the model are tested: a traditional constant variance CAPM (H₁), a constant variance extended CAPM (H₂-H₃), and a CAPM with GARCH errors (H₄). The t-statistics, reported in Tables 2 and 3, for the null of zero values for extended ARCH and GARCH parameters (α, λ, δ, φ, ϕ) indicate that the return generating processes for bank portfolios of all three countries follow a GARCH specification with autoregressive and/or moving average representation. The Likelihood Ratio test results for the null of basic CAPM, extended CAPM, and CAPM with GARCH errors, produced in Panel II of Tables 4 and 5, also strongly reject these restricted models for all three countries.

These findings cast doubt on the validity of the models frequently used in the existing literature and the reliability of the parameter estimates and inferences based on these models. More specifically, the omitted variable problem in these models is likely to result in biased and inconsistent parameter estimates and erroneous inferences. Moreover, the significance of the exchange rate in the mean equation and the interest rate volatility and unsystematic risk in the volatility equation indicate that these arguments do play a significant role in determining the overall return and volatility of bank stocks and have to be included in the model. This issue will be discussed further below.

5.2 Domestic Macroeconomic Factors

The coefficient estimates and the t-statistics for the macroeconomic parameters (β₁₁, β₁₂, β₁₃, β₂₁, β₂₂, and β₂₃) are produced in Tables 2 and 3. According to these estimates, market and exchange rate factors exert positive and statistically significant effects on the bank portfolios of all three countries, while the effect of the long-term interest rate is negative and insignificant in all cases. The null hypothesis of zero-effect from domestic interest rate volatility is rejected in the Japanese case (φ₁₃), but not for the German and U.S. bank portfolios (φ₁₅, φ₂₅).

Composite hypotheses of zero macroeconomic effects include the following: H₅ is a test of joint non-significance of interest rate level and interest rate volatility for the United States and Japan/Germany; H₆ and H₇ are tests of non-significance, for both countries, of interest rate level and interest rate volatility, respectively; and H₈-H₁₀ and H₁₁-H₁₃ contain tests for each of the three above hypotheses for each country separately. Finally, H₁₄-H₁₆ formulate tests of zero exchange rate effect, jointly, and for each country alone.

The chi-square test statistics in Tables 4 and 5 confirm and reinforce the findings based on simple t-tests in Tables 2 and 3. In the U.S.–Japanese case, the joint test of zero effect from changes in the level and volatility of the domestic interest rate for the two countries (H₈) is rejected. This result, however, is due to the significance of the interest rate volatility effect (H₉), as opposed to the effect of changes in the level of interest rate (H₈). Separate tests of interest rate level and interest rate volatility for each country (H₉-H₁₃) also corroborate the finding of significance due to the second moment of the interest rate distribution, rather than
TABLE 2
Bivariate GARCH (1,1) Model of the U.S. and Japanese Bank Stock Returns

Panel I: U.S. and Japanese Bank Portfolios

<table>
<thead>
<tr>
<th></th>
<th>Japanese Bank Portfolio</th>
<th>U.S. Bank Portfolio</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta_{10} )</td>
<td>0.013 (3.65)***</td>
<td>( \beta_{20} )</td>
</tr>
<tr>
<td>( \beta_{11} )</td>
<td>0.757 (14.56)***</td>
<td>( \beta_{21} )</td>
</tr>
<tr>
<td>( \beta_{12} )</td>
<td>-0.013 (-0.11)</td>
<td>( \beta_{22} )</td>
</tr>
<tr>
<td>( \beta_{13} )</td>
<td>0.733 (8.22)***</td>
<td>( \beta_{23} )</td>
</tr>
<tr>
<td>( \beta_{14} )</td>
<td>-0.031 (-0.66)</td>
<td>( \beta_{24} )</td>
</tr>
<tr>
<td>( \nu_{10} \times 10^2 )</td>
<td>0.072 (7.32)***</td>
<td>( \nu_{20} \times 10^2 )</td>
</tr>
<tr>
<td>( \alpha_{11} )</td>
<td>0.312 (4.22)***</td>
<td>( \alpha_{21} )</td>
</tr>
<tr>
<td>( \lambda_{12} )</td>
<td>0.017 (0.42)</td>
<td>( \lambda_{22} )</td>
</tr>
<tr>
<td>( \delta_{13} )</td>
<td>-0.061 (-3.50)***</td>
<td>( \delta_{23} )</td>
</tr>
<tr>
<td>( \psi_{14} )</td>
<td>0.797 (4.46)***</td>
<td>( \psi_{24} )</td>
</tr>
<tr>
<td>( \phi_{10} \times 10^2 )</td>
<td>-0.065 (-2.80)***</td>
<td>( \phi_{20} \times 10^2 )</td>
</tr>
</tbody>
</table>

Panel II: Diagnostic Test Results

<table>
<thead>
<tr>
<th></th>
<th>( \epsilon_{yt} )</th>
<th>( \epsilon_{yt}^2 )</th>
<th>( \epsilon_{yt} )</th>
<th>( \epsilon_{yt}^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.066</td>
<td>-0.026</td>
<td>1.011***</td>
<td>0.900***</td>
</tr>
<tr>
<td>Variance</td>
<td>1.015</td>
<td>0.907</td>
<td>2.482</td>
<td>2.323</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.185</td>
<td>0.451*</td>
<td>3.795***</td>
<td>3.745***</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>0.432</td>
<td>0.986**</td>
<td>21.159***</td>
<td>18.936***</td>
</tr>
<tr>
<td>Q(8)</td>
<td>9.552</td>
<td>2.062</td>
<td>0.289</td>
<td>0.302</td>
</tr>
<tr>
<td>Q(16)</td>
<td>22.398**</td>
<td>8.733</td>
<td>0.440</td>
<td>0.611</td>
</tr>
<tr>
<td>Q(24)</td>
<td>30.011*</td>
<td>15.003</td>
<td>1.069</td>
<td>1.293</td>
</tr>
</tbody>
</table>

Log Likelihood Value 634.95

The bivariate GARCH(1,1) models estimated are as follows:

\[
\begin{align*}
R_{yt} & = \beta_{t0} + \beta_{11} R_{yt-1} + \beta_{12} \Delta l_{yt} + \beta_{13} F_{yt} + \beta_{14} R_{yt} + \epsilon_{yt} \\
\epsilon_{yt} & = \nu_{10} + \alpha_{11} \epsilon_{yt-1} + \alpha_{12} \epsilon_{yt-1}^2 + \delta_{13} \epsilon_{yt-1}^2 + \psi_{14} C V I_{yt-1} + \phi_{10} \epsilon_{yt-1} \Omega_{yt-1} \sim N(0, \sigma_{yt}^2) \\
\sigma_{yt} & = \beta_{21} + \beta_{22} R_{yt} + \beta_{23} \Delta l_{yt} + \beta_{24} F_{yt} + \beta_{25} R_{yt} + \epsilon_{yt} \\
\epsilon_{yt} & = \nu_{20} + \alpha_{21} \epsilon_{yt-1} + \alpha_{22} \epsilon_{yt-1}^2 + \delta_{23} \epsilon_{yt-1}^2 + \psi_{24} C V I_{yt-1} + \phi_{20} \epsilon_{yt-1} \Omega_{yt-1} \sim N(0, \sigma_{yt}^2)
\end{align*}
\]

Where,

- \( R \) = the return on bank portfolios
- \( R M \) = the return on the Morgan Stanley market index
- \( \Delta l \) = the change in long-term interest rate (ten-year Treasury Composite yield)
- \( F X \) = the percentage change in foreign index value
- \( \epsilon \) = the error term which is dependent on the information set \( \Omega_{yt-1} \)
- \( h \) = the conditional variance of returns
- \( C V I \) = the conditional variance of long-term interest rates
- \( j p \) = Japan
- \( u s \) = United States
- \( t \) = time subscript

Values in parentheses are those of t statistic.

*, **, and *** represent significance at the .10, .05 and .01 levels, respectively.
### TABLE 3

**Bivariate GARCH (1,1) Model of U.S. and German Bank Stock Returns**

#### Panel I: German and U.S. Bank Portfolios

<table>
<thead>
<tr>
<th></th>
<th>German Bank Portfolio</th>
<th>U.S. Bank Portfolio</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta_{10} )</td>
<td>-0.001 (-0.28)</td>
<td>0.007 (2.15)**</td>
</tr>
<tr>
<td>( \beta_{11} )</td>
<td>0.833 (14.87)**</td>
<td>0.948 (13.84)**</td>
</tr>
<tr>
<td>( \beta_{12} )</td>
<td>-0.164 (-0.76)</td>
<td>-0.314 (-1.25)</td>
</tr>
<tr>
<td>( \beta_{13} )</td>
<td>0.795 (5.16)**</td>
<td>0.571 (2.64)**</td>
</tr>
<tr>
<td>( \beta_{14} )</td>
<td>0.049 (1.12)</td>
<td>0.033 (0.85)</td>
</tr>
<tr>
<td>( \gamma_{10} \times 10^2 )</td>
<td>0.100 (3.33)**</td>
<td>( \gamma_{20} \times 10^2 )</td>
</tr>
<tr>
<td>( \alpha_{11} )</td>
<td>0.218 (2.25)**</td>
<td>( \alpha_{21} )</td>
</tr>
<tr>
<td>( \lambda_{12} )</td>
<td>0.050 (0.46)</td>
<td>( \lambda_{22} )</td>
</tr>
<tr>
<td>( \delta_{13} )</td>
<td>-0.076 (-2.99)**</td>
<td>( \delta_{23} )</td>
</tr>
<tr>
<td>( \phi_{14} )</td>
<td>0.608 (2.39)**</td>
<td>( \phi_{24} )</td>
</tr>
<tr>
<td>( \phi_{15} )</td>
<td>0.176 (0.36)</td>
<td>( \phi_{25} )</td>
</tr>
</tbody>
</table>

#### Panel II: Diagnostic Test Results

<table>
<thead>
<tr>
<th></th>
<th>( \varepsilon_{p,t}/h )</th>
<th>( \varepsilon_{w,t}/h )</th>
<th>( \varepsilon_{p,t}^2 )</th>
<th>( \varepsilon_{w,t}^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.021</td>
<td>-0.003</td>
<td>0.973***</td>
<td>0.991***</td>
</tr>
<tr>
<td>Variance</td>
<td>0.982</td>
<td>1.000</td>
<td>1.997</td>
<td>2.638</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.010</td>
<td>0.274</td>
<td>3.013***</td>
<td>3.246***</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>0.145</td>
<td>0.748</td>
<td>12.727***</td>
<td>13.076***</td>
</tr>
<tr>
<td>( Q(8) )</td>
<td>7.824</td>
<td>2.438</td>
<td>0.212</td>
<td>0.459</td>
</tr>
<tr>
<td>( Q(16) )</td>
<td>16.977</td>
<td>9.041</td>
<td>0.529</td>
<td>0.808</td>
</tr>
<tr>
<td>( Q(24) )</td>
<td>18.959</td>
<td>16.892</td>
<td>0.887</td>
<td>1.417</td>
</tr>
</tbody>
</table>

Log Likelihood Value 611.70

The bivariate GARCH(1,1) models estimated are as follows:

\[
R_{gt} = \beta_{10} + \beta_{11} R_{M,t} + \beta_{12} \Delta I_{ct} + \beta_{13} F_{X,t} + \beta_{14} R_{w,t} + \epsilon_{p,t} \\
\h_{gt} = \gamma_{10} + \alpha_{11} \h_{1,t-1} + \lambda_{12} \epsilon_{p,t-1}^2 + \delta_{13} \epsilon_{w,t-1}^2 + \phi_{14} CVI_{w,t-1} + \phi_{15} CVI_{p,t-1} + \epsilon_{p,t} \\
R_{w,t} = \beta_{20} + \beta_{21} R_{M,t} + \beta_{22} \Delta I_{ct} + \beta_{23} F_{X,t} + \beta_{24} R_{p,t} + \epsilon_{w,t} \\
\h_{w,t} = \gamma_{20} + \alpha_{21} \h_{w,t-1} + \lambda_{22} \epsilon_{w,t-1}^2 + \delta_{23} \epsilon_{p,t-1}^2 + \phi_{24} CVI_{p,t-1} + \phi_{25} CVI_{w,t-1} + \epsilon_{w,t} \\
\h_{p,t} = \rho_{p} = \sigma_{p,t} \sigma_{w,t}
\]

Where
- \( R \) = the return on bank portfolios
- \( RM \) = the return on the Morgan Stanley market index
- \( \Delta I \) = the change in long-term interest rate (ten-year Treasury Composite yield)
- \( F_X \) = the percentage change in foreign index values,
- \( \epsilon \) = the error term which is dependent on the information set \( \Omega_{t-1} \)
- \( h \) = the conditional variance of return
- \( CVI \) = the conditional variance of long-term interest rates
- \( ge \) = Germany
- \( us \) = United States
- \( t \) = time subscript

Values in parentheses are those of \( t \) statistic.

** and *** represent significance at the .10, .05 and .01 levels, respectively.
### TABLE 4

Results of Hypotheses Tests: The U.S.–Japan Model

<table>
<thead>
<tr>
<th>Panel I: Hypotheses Description</th>
<th>Panel II: Test Values</th>
</tr>
</thead>
</table>

**Model Specification**

The Basic Market Model (constant variance) holds simultaneously for both U.S. and JP banks:

\[ H_1: \beta_{12} = \beta_{14} = \alpha_{11} = \lambda_{12} = \delta_{13} = \varphi_{14} = \varphi_{15} = \beta_{22} = \beta_{23} = \beta_{24} = \beta_{25} = \varphi_{25} = 0 \]

The Extended Model (constant variance) holds individually for U.S. and JP banks:

\[ H_2: \alpha_{11} = \lambda_{12} = \delta_{13} = \varphi_{14} = \varphi_{15} = 0 \text{ for Japan} \]

\[ H_3: \alpha_{21} = \lambda_{22} = \delta_{23} = \varphi_{24} = \varphi_{25} = 0 \text{ for U.S.} \]

The Basic Market Model with GARCH errors holds simultaneously for both U.S. and JP banks:

\[ H_4: \beta_{12} = \beta_{14} = \delta_{13} = \varphi_{14} = \varphi_{15} = \beta_{22} = \beta_{23} = \beta_{24} = \delta_{23} = \varphi_{24} = \varphi_{25} = 0 \]

**Macroeconomic Shocks**

No own-interest rate (level and volatility) effects for JP and U.S. banks:

\[ H_5: \beta_{12} = \varphi_{14} = \beta_{22} = \varphi_{24} = 0 \]

No own-interest rate level effects for JP and U.S. banks:

\[ H_6: \beta_{12} = \beta_{22} = 0 \]

No own-interest rate volatility effects for JP and U.S. banks:

\[ H_7: \varphi_{14} = \varphi_{24} = 0 \]

No own-interest rate effects on JP banks:

\[ H_8: \beta_{12} = \varphi_{14} = 0 \]

No own-interest rate level effects on JP banks:

\[ H_9: \beta_{12} = 0 \]

No own-interest rate volatility effects on JP banks:

\[ H_{10}: \varphi_{14} = 0 \]

No own-interest rate effects on U.S. banks:

\[ H_11: \beta_{22} = \varphi_{24} = 0 \]

No own-interest rate level effects on U.S. banks:

\[ H_{12}: \beta_{22} = 0 \]

No own-interest rate volatility effects on U.S. banks:

\[ H_{13}: \varphi_{24} = 0 \]

No exchange rate effect for U.S. and JP banks:

\[ H_{14}: \beta_{14} = \beta_{23} = 0 \]

No exchange rate effect on JP banks:

\[ H_{15}: \beta_{14} = 0 \]

No exchange rate effect on U.S. banks:

\[ H_{16}: \beta_{23} = 0 \]

**Spillover Effects**

No spillover in mean returns of JP and U.S. banks:

\[ H_{17}: \beta_{14} = \beta_{24} = 0 \]

No unidirectional spillover in mean returns from U.S. to JP banks:

\[ H_{18}: \beta_{14} = 0 \]

No unidirectional spillover in mean returns from JP to U.S. banks:

\[ H_{19}: \beta_{24} = 0 \]

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TABLE 4 (continued)

No spillover between JP and U.S. banks:
\[ H_{26}: \beta_{26} = \delta_{26} = \varphi_{14} = \beta_{24} = \delta_{23} = \varphi_{23} = 0 \]

No interest rate spillover between JP and U.S. banks:
\[ H_{27}: \varphi_{14} = \varphi_{24} = 0 \]

No unidirectional interest rate spillover from U.S. to JP banks:
\[ H_{28}: \beta_{24} = \varphi_{14} = 0 \]

No unidirectional interest rate spillover from JP to U.S. banks:
\[ H_{29}: \beta_{24} = \varphi_{23} = 0 \]

No risk spillover between JP and U.S. banks:
\[ H_{30}: \delta_{13} = \delta_{23} = 0 \]

No unidirectional risk spillover from U.S. to JP banks:
\[ H_{31}: \delta_{13} = 0 \]

No unidirectional risk spillover from JP to U.S. banks:
\[ H_{32}: \delta_{23} = 0 \]

Equality of Cross-Country Effects

Symmetry of interest rate volatility spillover between U.S. and JP banks:
\[ H_{33}: \varphi_{14} = \varphi_{23} \]

Symmetric spillover effects in unsystematic risk between U.S. and JP banks:
\[ H_{34}: \delta_{13} = \delta_{23} = 0 \]

Identical systematic risk between U.S. and JP banks:
\[ H_{35}: \beta_{11} = \beta_{21} \]

\[ \chi^2_6 = 32.18^{***} \]

\[ \chi^2_2 = 23.81^{***} \]

\[ \chi^2_2 = 20.22^{***} \]

\[ \chi^2_2 = 4.43^* \]

\[ \chi^2_2 = 12.43^{***} \]

\[ t = 3.50^{***} \]

\[ t = 1.15 \]

\[ \chi^2_2 = 4.53^{**} \]

JP = Japan

the first. Contrary to the interest rate level, the exchange rate effect shows universal significance (\( H_{14} - H_{16} \)). In the U.S.–German case, the macroeconomic variables play a weaker role than in the U.S.–Japanese model. In this case, all hypotheses denoting zero effect from changes in the level and/or volatility of the domestic interest rate fail to be rejected by the data. Nevertheless, as in the Japanese case, the exchange rate does exert a significant influence on the German bank stock returns.

The findings on the interest rate variable in the extant literature are mixed but in general the magnitude of the interest rate effect is small and the direction of the effect is negative. For example, Booth and Officer (1985) and Chance and Lane (1980), among others, have found that interest rates have little impact on U.S. bank stock returns. The lack of significance of the interest rate variable uncovered here, though consistent with much of the literature, may have been contributed to by several factors. First, since BHCs included in the data set may have conflicting sensitivities to interest rates (due to positive versus negative duration gaps between assets and liabilities), the net (average) interest rate sensitivity of the portfolio appears insignificant. Second, insignificance of the interest rate may result from the hedging activity of the banks in the form of matched duration gaps, securitization, and holding positions in options, futures, and swaps. Third, banks in the sample
TABLE 5
Results of Hypotheses Tests: The U.S.–Germany Model

<table>
<thead>
<tr>
<th>Model Specification</th>
<th>Panel I: Hypotheses Description</th>
<th>Panel II: Test Values</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model Specification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Basic Market Model (constant variance) holds simultaneously for both U.S. and GE banks:</td>
<td>$H_1: \beta_{12} = \beta_{13} = \beta_{14} = \alpha_{11} = \lambda_{12} = \delta_{13} = \phi_{14} = \phi_{15} = \beta_{22} = \beta_{23} = \beta_{24} = \alpha_{21} = \lambda_{22} = \delta_{23} = \phi_{24} = \phi_{25} = 0$</td>
<td>$\chi^2_{16} = 108.65^{***}$</td>
</tr>
<tr>
<td>The Extended Model (constant variance) holds individually for U.S. and GE banks:</td>
<td>$H_2: \alpha_{11} = \lambda_{12} = \delta_{13} = \phi_{14} = \phi_{15} = 0$ for Germany</td>
<td>$\chi^2_3 = 19.72^{***}$</td>
</tr>
<tr>
<td></td>
<td>$H_3: \alpha_{21} = \lambda_{22} = \delta_{23} = \phi_{24} = \phi_{25} = 0$ for U.S.</td>
<td>$\chi^2_3 = 27.88^{***}$</td>
</tr>
<tr>
<td>The Basic Market Model with GARCH errors holds simultaneously for both U.S. and GE Banks:</td>
<td>$H_4: \beta_{13} = \beta_{14} = \delta_{13} = \phi_{14} = \phi_{15} = \beta_{22} = \beta_{23} = \beta_{24} = \delta_{23} = \phi_{24} = \phi_{25} = 0$</td>
<td>$\chi^2_{12} = 100.74^{***}$</td>
</tr>
<tr>
<td>Macroeconomic Shocks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No own-interest rate (level and volatility) effects for GE and U.S. banks:</td>
<td>$H_5: \alpha_{11} = \lambda_{12} = \delta_{13} = \phi_{14} = \phi_{15} = \beta_{22} = \beta_{23} = \beta_{24} = \beta_{25} = 0$</td>
<td>$\chi^2_4 = 1.90$</td>
</tr>
<tr>
<td>No own-interest rate level effects for GE and U.S. banks:</td>
<td>$H_6: \beta_{12} = \beta_{13} = \beta_{14} = \phi_{14} = \phi_{15} = \beta_{22} = \beta_{23} = \beta_{24} = \phi_{24} = \phi_{25} = 0$</td>
<td>$\chi^2_2 = 1.64$</td>
</tr>
<tr>
<td>No own-interest rate volatility effects for GE and U.S. banks:</td>
<td>$H_7: \phi_{14} = \phi_{24} = \phi_{25} = 0$</td>
<td>$\chi^2_2 = 0.19$</td>
</tr>
<tr>
<td>No own-interest rate effects on GE banks:</td>
<td>$H_8: \beta_{12} = \beta_{13} = \beta_{14} = \phi_{14} = \phi_{15} = \beta_{22} = \beta_{23} = \beta_{24} = \phi_{24} = \phi_{25} = 0$</td>
<td>$\chi^2_2 = 0.69$</td>
</tr>
<tr>
<td>No own-interest rate level effects on GE banks:</td>
<td>$H_9: \beta_{12} = \beta_{13} = \beta_{14} = \phi_{14} = \phi_{15} = \beta_{22} = \beta_{23} = \beta_{24} = \phi_{24} = \phi_{25} = 0$</td>
<td>$t = 0.76$</td>
</tr>
<tr>
<td>No own-interest rate volatility effects on GE banks:</td>
<td>$H_{10}: \phi_{14} = \phi_{24} = \phi_{25} = 0$</td>
<td>$t = 0.36$</td>
</tr>
<tr>
<td>No own-interest rate effects on U.S. banks:</td>
<td>$H_{11}: \alpha_{11} = \lambda_{12} = \delta_{13} = \phi_{14} = \phi_{15} = \beta_{22} = \beta_{23} = \beta_{24} = \phi_{24} = \phi_{25} = 0$</td>
<td>$\chi^2_2 = 1.74$</td>
</tr>
<tr>
<td>No own-interest rate level effects on U.S. banks:</td>
<td>$H_{12}: \beta_{12} = \beta_{13} = \beta_{14} = \phi_{14} = \phi_{15} = \beta_{22} = \beta_{23} = \beta_{24} = \phi_{24} = \phi_{25} = 0$</td>
<td>$t = 1.25$</td>
</tr>
<tr>
<td>No own-interest rate volatility effects on U.S. banks:</td>
<td>$H_{13}: \phi_{24} = \phi_{25} = 0$</td>
<td>$t = 0.24$</td>
</tr>
<tr>
<td>No exchange rate effect for U.S. and GE banks:</td>
<td>$H_{14}: \beta_{13} = \beta_{23} = \beta_{24} = \beta_{25} = 0$</td>
<td>$\chi^2_2 = 32.85^{***}$</td>
</tr>
<tr>
<td>No exchange rate effect on GE banks:</td>
<td>$H_{15}: \beta_{13} = \beta_{23} = \beta_{24} = \beta_{25} = 0$</td>
<td>$t = 5.16^{***}$</td>
</tr>
<tr>
<td>No exchange rate effect on U.S. banks:</td>
<td>$H_{16}: \beta_{23} = \beta_{24} = \beta_{25} = 0$</td>
<td>$t = 2.64^{***}$</td>
</tr>
<tr>
<td>Spillover Effects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No spillover in mean returns of GE and U.S. banks:</td>
<td>$H_{17}: \beta_{14} = \beta_{24} = \beta_{25} = 0$</td>
<td>$\chi^2_2 = 1.79$</td>
</tr>
<tr>
<td>No unidirectional spillover in mean returns from U.S. to GE banks:</td>
<td>$H_{18}: \beta_{14} = 0$</td>
<td>$t = 1.12$</td>
</tr>
<tr>
<td>No unidirectional spillover in mean returns from GE to U.S. banks:</td>
<td>$H_{19}: \beta_{24} = 0$</td>
<td>$t = 0.85$</td>
</tr>
</tbody>
</table>
TABLE 5 (continued)

| No spillover between GE and U.S. banks:                           | $\chi^2 = 31.07^{***}$ |
| No interest rate spillover between GE and U.S. banks:             | $\chi^2 = 5.93^{**}$   |
| No unidirectional interest rate spillover from U.S. to GE banks: | $\chi^2 = 7.42^{**}$   |
| No unidirectional interest rate spillover from GE to U.S. banks: | $\chi^2 = 0.80$        |
| No risk spillover between GE and U.S. banks:                     | $\chi^2 = 20.79^{***}$|
| No unidirectional risk spillover from U.S. to GE banks:          | $t = 2.99^{***}$       |
| No unidirectional risk spillover from GE to U.S. banks:          | $t = 3.80^{***}$       |

Equality of Cross-Country Effects

| Symmetry of interest rate volatility spillover between U.S. and GE banks: | $\chi^2 = 0.59$ |
| Symmetric spillover effects in unsystematic risk between U.S. and GE banks: | $\chi^2 = 0.47$ |
| Identical systematic risk between U.S. and GE banks: | $\chi^2 = 1.60$ |

GE = Germany

are part of a large, diversified organization with both banking and non-banking activities whose banking business is focused on fee-based and off balance sheet contracts, rather than the intermediation. Finally, our results on interest rate effects may also differ from some of the existing literature because of the GARCH methodology employed here.

The finding of insignificant interest rate sensitivity of the Japanese banks is particularly curious because these banks hold a substantial amount of government bonds. However, during the mid-1990s the Japanese interest rates hovered around the 2 percent level. It is likely that the very low level of interest rates narrowed the interest rate changes and made them rather ineffective. State ownership of some of the German banks and the universal nature of their banking activity are also likely to have contributed to the weak interest rate sensitivity of these banks.\(^{12}\)

Empirical tests of the exchange rate effect available in the extant literature are limited. Choi et al. (1992) is the first published study to examine the bank exchange rate sensitivity. These authors report that exchange rate sensitivity is significant when bank returns are aggregated but not when individual bank data are used.

\(^{12}\) Thanks are due, without implications, to Tony Saunders who brought this point to our attention.
Similarly, Choi and Elyasiani (1997) find that the exchange rate coefficients for banks in their sample are more often and more rigorously significant than the interest rate variable. Chamberlain et al. (1997) report that the exchange rate variable is more frequently significant for U.S. banks than Japanese banks and, indeed, few of the latter show sensitivity to the exchange rate variable. Martin and Mauer (2000) also find that internationally-oriented and domestically-oriented U.S. banks are both exposed to a significant level of exchange rate risk. The finding of strongly significant exchange rate effects in the current study for all three countries stands in contrast with much of the extant literature, which by and large assumes away or fails to uncover evidence in favor of exchange rate sensitivity. Increased globalization of banking markets and deregulation are contributory factors to this finding. In particular, exposure to foreign exchange risk of the Japanese banks increased when the government relaxed the exchange rate and capital controls, which served as a major source of market segmentation, in the 1980s.

It is interesting to also contrast the effect of increased interest rate volatility on the banking sectors of the three countries considered. In the United States, financial markets are much more developed and play a more crucial role in the lending process in the form of direct financing. As a result, U.S. banks can no longer engage in intertemporal smoothing; they simply pass on the risk to their customers. In Japan and Germany, however, intertemporal smoothing by banks is the common practice. In such an environment, banks must absorb the added volatility in order to shield their customers. This distinction in the role of the market may provide an explanation as to why increased domestic interest rate volatility affects bank stock return volatility in Japan but not the United States. The lack of significance of interest rate volatility effect in Germany may be due to the fact that some of their large banks are government-owned and that they are generally sheltered by vast cross-holdings across corporate sectors and close monitoring by the affiliated firms.

5.3 Spillover Dynamics

5.3.1 Spillover Sources and Mean Effects

Cross-country effects between the United States and Japan/Germany of interest rate volatility and unsystematic shocks in the banking sector are of considerable interest because of the potential for chain reactions and diffusion of financial crises, impact on risk diversification and asset pricing, and setting of regulatory policy (Fleming et al. [1998]). Inclusion of the conditional volatility of own and foreign interest rate and own and foreign unsystematic risk in the model is a novelty of the current study and allows the effect of these variables on the distribution of the bank portfolio stock returns to be investigated.

Interest rate volatility shocks may originate from central bank policy decisions, changes in central bank policy strategy, government debt management actions, or international debt repudiation. Examples include changes in the frequency of in-
terest rate tightening (easing) by the Fed, the strategy of targeting interest rates as opposed to monetary aggregates, the U.S. Treasury’s massive buy-back of its outstanding long-term bonds in recent years, and less-developed countries’ (LDC) debt repudiation. Similarly, unsystematic shocks in the banking sector include events such as the announcement of mergers between large financial institutions (e.g., Chemical Bank and Chase; Citicorp and Travelers), deregulation or re-regulation, major loan losses by a group of large banks, and technology shocks.

In the current study, spillover can occur through bank portfolio return interdependence, foreign interest rate volatility shocks, and foreign unsystematic risk channels. Theoretically, each of these channels may feature mutual interdependence, unidirectional effects, or non-dependence. Empirical measures of spillover can be derived from the coefficients in Tables 2 and 3. The corresponding significance test results are given in Tables 4 and 5. According to the results in Tables 2 and 3, the bank stock returns in the United States and Japan/Germany are not related at the mean level as the cross-country coefficients $\beta_{14}, \beta_{24}$ are statistically insignificant. The chi-square tests of spillover effects at the mean level ($H_{17} - H_{19}$) also indicate the lack of mutual interdependence ($\beta_{14} = \beta_{24} = 0$). This finding at the industry level stands in contrast to Koutmos (1995), who reports a significant price spillover from the United States to Japan at the aggregate market level. This conflict highlights the need for sectoral disaggregation in order to obtain reliable results.

5.3.2 Spillover of Interest Rate Volatility

Contrary to the finding at the return level, the cross-effects at the volatility level are frequently significant, establishing volatility interdependence across the national borders. This result is consistent with Jeong (1999), who finds that the information contained in the volatility surprises of each national market is clearly transmitted to other national markets. In the U.S.–Japan model the interest rate volatility spillover is found to be bidirectional ($\varphi_{14}, \phi_{25}$ are both significant), while in the U.S.–German model it is primarily unidirectional from the United States to Germany ($\varphi_{14}$ significant, $\phi_{25}$ not significant). Moreover, increased interest rate volatility in the United States heightens bank riskiness in both Japan and Germany, indicating a transmission of risk from the United States to the latter countries ($\varphi_{14} > 0$). Dissimilar to this, however, larger interest rate volatility in Japan is followed by volatility moderation in the U.S. markets ($\phi_{25} < 0$).

Increased volatility in the U.S. interest rates heightens bank stock return volatility in Japan and Germany, at least through two channels. First, as indicated by the private information hypothesis, economic agents in Japan and Germany try to extract information from increased interest rate volatility in the United States and carry out trades on that basis. This additional trading activity produces larger volatilities in the former markets. In particular, a shock in the United States may drive the agents operating in the three markets to alter their positions (for hedging or speculative purposes) in all of these markets, creating a geographic spillover of volatility. Naturally, factors such as transaction costs, position limits set by stock
exchanges, and capital constraints will curtail the extent of the spillover (Fleming et al. [1998]). Second, as indicated by the "public information" hypothesis, macro announcements in the United States simultaneously influence markets in the three countries, creating a co-movement in levels, as well as volatilities, between the United States and Japan/Germany. This co-movement may last more than one period and was particularly strengthened by the prevailing monetary policy coordination among the three countries during part of the sample period.

Increased interest rate volatility in Japan is found to be beneficial to U.S. banks as it moderates their stock return volatility. An explanation may be that increased interest rate volatility in Japan prompts the borrowers and depositors of Japanese banks to switch to the U.S. banking market. This redistribution enlarges the pool of U.S. bank customers, allowing a lower credit risk, a lower cost of funds, and a higher level of profit.\textsuperscript{13} In addition, increased volatility in Japan may also result in a higher demand for derivative products from U.S. banks for hedging purposes, consequently enhancing their profitability; U.S. banks can then trade off some of the higher profitability for a more moderate risk level.

A second scenario may be that increased volatility in Japan prompts bank managers in the United States to take steps to reduce their exposure.\textsuperscript{14} Agency problem in the form of self-interest of bank managers plays a significant role in this process. With increased volatility in Japanese and German markets, bank managers in the United States may be alarmed that their jobs could be lost, and their wealth (their stock options, and stock holdings in their bank) is likely to lose value. These concerns can motivate the managers to restrain bank risk.

Under both of these scenarios, increased interest rate volatility in Japan moderates the stock return volatility of the rivaling U.S. banks. The fact that U.S. interest rate volatility shocks subject Japan and Germany to the same fate as the United States and, in particular, the fact that in the German case the spillover is unidirectional from the United States, indicate that the United States leads these foreign markets.

5.3.3 Spillover of Unsystematic Risk

The coefficient values for unsystematic risk, presented in Table 2, indicate that stock return volatility of the Japanese banking sector is significantly and negatively affected by unsystematic shocks in the U.S. banking sector ($\delta_{13} < 0$ and significant). While the U.S. bank stock return volatility is also negatively affected by shocks in Japan, the effect is not statistically significant at the traditional levels ($\delta_{23} < 0$ and insignificant). In the U.S.–German case (Table 3) the effects are negative and significant in both directions.

\textsuperscript{13} To verify this effect, data were acquired on U.S. bank claims on Japanese customers and regressed on the lagged interest rate volatility in Japan. The positive coefficient obtained on the interest rate volatility confirms that as volatility increases in Japan, Japanese bank customers switch to the competing U.S. banks. We would like to thank an anonymous referee for this suggestion.

\textsuperscript{14} Note that the effect of the volatilities occurs with a one-month lag.
At least four conclusions can be drawn here. First, unsystematic shocks are of a competitive nature; namely, that an adverse shock to the U.S. banking sector (loan losses, security breaches, technology shocks) redistributes market shares in favor of its Japanese/German counterparts, providing a better pool of customers and allowing a less dispersed return distribution there. In other words, Japanese/German and U.S. banks serve as competitors (rivals) for one another. Second, in the U.S.-Japan case, as with interest rate uncertainty, the unsystematic shock impact is sensitive to the country of origin, with the United States acting as a leader and Japan acting as a follower. Third, interest rate volatility and unsystematic shock effects are dissimilar in pattern. Interest rate volatility shocks in the United States pull the other two countries with them in the same direction, while unsystematic shocks display a competitive character, widening the gap in risk between the bank portfolios of the two countries. The former effect may be due to the leadership of the United States in world monetary policy; the latter reflects the substitutability of large banks in the global context. Fourth, the pattern of unsystematic shock dynamics makes the United States and Japanese/German bank stocks suitable for hedging against this category of risk.

Test results for the spillover effects at the volatility level ($H_{20}-H_{26}$) are reported in Tables 4 and 5. Contrary to the findings at the mean level, test results indicate the prevalence of spillover effects for all postulated hypotheses for both Japanese and German cases, except one in the German case ($H_{23}$). The significance of these tests provides strong evidence in favor of interdependence and spillover of interest rate volatility and unsystematic risk between the United States and Japan/Germany.

A good example for international transmission of shocks from Japan to the United States is the spillover effect of the sharp decline (more than 50%) in the Japanese stock market in the late 1980s to the U.S. banking sector. Peek and Rosengren (1997) provide a detailed account of the transmission of these shocks to the United States through the Japanese banking system. According to Peek and Rosengren's scenario, the passage of the Basle Accord in 1988 played an essential role in this process. The Accord on the one hand mandated risk-based capital requirement and, hence, increased capital obligations, and on the other hand allowed banks to count up to 45 percent of the unrealized gains in their equity holding as bank capital. The Accord did not adversely affect the Japanese banks initially, because they had accumulated a considerable amount of capital gain as a result of the spectacular increase in the Japanese stock prices in the 1980s. However, when the Japanese market declined precipitously in the late 1980s and early 1990s, capital gains evaporated and the banks' capital positions became inadequate, forcing the banks to sharply reduce loans. Given the reluctance of the Japanese banks to curtail loans to their long-term domestic borrowers, and given their large international

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15. For references concerning global versus competitive shocks, see footnote 6.
presence, the brunt of the loan curtailment was felt by borrowers in other countries, especially in the United States. Customers of Japanese banks in the United States were, hence, driven to U.S. banks, which were experiencing an inadequate loan demand due to the U.S. recession, and had also already recapitalized. As a result, U.S. banks were able to enhance their profitability and improve their risk diversification through this new and attractive lending opportunity. The severe real estate loan difficulties in Japan further intensified the problem for Japanese banks and benefited their American competitors. In brief, increased volatility in Japan helped calm the U.S. banking sector through this process.

5.3.4 Implications

Several implications can be drawn from these findings. First, inferences concerning the strength of the “heat wave” and the “meteor shower” forces are based, respectively, on the coefficient estimates for the domestic and foreign shocks. Lack of significance of domestic interest rate volatility and unsystematic shock denote rejection of the “heat wave” hypothesis, while non-significance of the corresponding foreign shocks reject the “meteor shower” hypothesis. The magnitudes of the coefficients for these variables determine the relative power of the two forces in determining the volatility patterns. Similarly, the reaction pattern of the bank stock return volatility to domestic shocks has implications on country-specific autocorrelation and shock persistence. The data reveal the prevalence of both “heat wave” and “meteor shower” effects but with varying relative strengths across countries. Specifically, Japan and Germany are both affected by the meteor shower forces coming from the United States in the form of unsystematic shocks and interest rate volatility, and neither is affected by the heat wave effects of lagged domestic unsystematic shocks. The United States is affected by meteor shower effects of interest rate volatility in Japan and unsystematic shocks in Germany, as well as heat wave effects from domestic unsystematic shocks. The United States and Japan seem to be more strongly driven by domestic forces than Germany is. One can conclude that the question is not which of the two forces determines the volatility patterns but rather how important the relative strength of each force is.

Second, monetary and fiscal policymakers in each country considered can ill-afford ignoring the effect of policy decisions and unsystematic shocks in the other. Each country must take steps to coordinate its policies with those of the others and to account for the effect of the latter’s policies and shocks on their economies in order to succeed.

Third, volatility interdependence across national borders is indicative of the global nature of the banking enterprise. Under this condition, financial crises in the banking system of one country have a tendency to be transmitted to others, increasing the probability of a systemic meltdown. This scenario is consistent with recent evidence concerning the Asian and Russian financial crises. The significance of cross-country effects between the United States and Germany/Japan also indicates that the German/Japanese banking markets are integrated with that of the
United States. As a result, the U.S. bank data do contain information about the German/Japanese bank stock return patterns and can help predict their performance. The reverse also holds true but to a lesser extent.

Finally, significance of interest rate volatility and unsystematic risk coefficients indicate that lagged values of the second moments of the interest rate and bank stock return distributions, in both domestic and foreign markets, play a role in describing the distribution of the bank stock returns. Hence, these moments have to be incorporated in model specification and policy formulation. This result confirms Koutmos and Booth’s (1995) finding that dependencies at the second moment level are far more extensive than those at the first moment level.16

5.4 Equality of Spillover Effects Across Countries

5.4.1 Symmetry of Cross-Country Interest Rate Effects

The coefficient estimates for interest rate volatility spillover effects between Japan and the United States, and the Likelihood Ratio test results, reported, respectively, in Tables 2 and 4, indicate an asymmetric cross-country interest rate volatility effect (φ₁₁4 ≠ φ₂₂₃). According to the coefficient estimates, the effect of interest rate volatility in the United States on the Japanese banking sector is larger in magnitude and much more stringently significant than that of the interest rate volatility in Japan on the United States. The test statistics for the null of symmetric inter-country transmission of shocks (H₂₇) shows that the difference in magnitude is statistically significant. This finding is indicative of a U.S. leadership position between the two countries and stands in contrast to the existing literature, which finds Japan to be mostly unaffected by U.S. shocks (Arshanapalli and Doukas [1993]).

The results for the U.S.–German model are reported in Tables 3 and 5. In this case, the coefficient estimates and the t-ratios show that interest rate volatility in

16. It is interesting to contrast the sensitivities of the bank stock return to shocks in the interest rate, exchange rate, and market volatility in the pre– and post–Basle Accord period. Prior to the Accord, bank capital requirement varied across countries. Hence, a given shock, for example, in interest rates, would alter the interest rate risk profile and capital needs of the banks in different countries in a dissimilar manner. This would in turn alter the relative attractiveness of the banking markets to investors and would engender a wave of substitution and spillover across these markets. However, under a uniform capital requirement regime, called for by the Basle Accord, banks in the participating countries are affected similarly by such shocks, producing little incentive for substitution and little spillover. Moreover, in this latter regime, changes in capital requirement will be parallel and equal in magnitude. Thus, such changes will not bring about a redistribution of banking activity or a spillover within the signatories of the Accord.

Along the same lines, when monetary policies of a block of countries are coordinated, interest rates will be raised (or curtailed) in the same direction and by the same amount in all of the countries. In this case, there will be no change in the interest rate of one country relative to another to evoke a substitution process across these counties. As a result, coordinated changes in interest rates will only impact the banks in countries outside the block. Additionally, the reduction in interest rate volatility and shock spillover may alter the bank sensitivities to interest rate changes. The findings on the direction and the extent of such effects will have implications on asset pricing, hedging strategies, and bank policy decisions. These issues are the subject of future research.
the United States does affect Germany, while interest rate volatility in Germany does not affect the United States. This pattern also denotes a lack of symmetry. The Likelihood Ratio test, however, lacks sufficient power to reject the null of symmetric spillover. The co-movement between the German and the U.S. banking markets, shown in Table 3, can still be taken to lend support to the leading role of the United States. Factors contributing to U.S. leadership include the role of the dollar as the major world currency (serving as a medium of exchange, unit of account, store of value, and standard of deferred payment), leadership in monetary policy coordination, international trade volume, and policy credibility in the eyes of the world.

5.4.2 Symmetry of Cross-Country Risk Spillover

The coefficient values for the unsystematic risk parameters ($\delta_{13}, \delta_{23}$) indicate that the United States is not significantly affected by the unsystematic shocks in Japan, while the Japanese banking sector is influenced by unsystematic shocks in the United States ($H_{24}-H_{26}$). This finding of asymmetric interdependence, based on t-tests, suggests a leadership role for the United States in the world of banking, in relation to its Japanese counterpart. In the German case, the cross-effects of unsystematic risks between the two countries are found to be both significant and negative. Namely, shocks emanating from the United States significantly affect the German banking sector, and shocks in Germany get transmitted to the United States, but the movements in the two markets are in opposite directions. However, the Likelihood Ratio test of equality of the effects again lacks significance ($H_{28}$). It is notable that the lack of Likelihood Ratio test power in this and the previous case may be due to the use of aggregate (monthly) data, which is likely to mask some short-term effects (Kearney and Patton [2000]).

6. Conclusions

The issue of contagion among financial markets of the world is of special interest because shocks and maladies in any one market may be exported to others, creating a domino effect. The purpose of this study was to examine and contrast the market, interest, and exchange rate sensitivities of the major banking institutions in the United States, Japan, and Germany, and to investigate the prevalence and

17. A question of interest is whether banks operating under the universal banking system, thin firewall, and thick firewall regulatory systems are equally risky, or whether risk changes as the degree of product diversification in banking varies. The Likelihood Ratio test statistics reject the equality of market risk between the United States and Japan banking systems but fail to do so between the United States and Germany ($H_{28}$). Based on the order of the magnitude of the beta coefficients, one can conclude that U.S. banks are the riskiest among the three, with Germany and Japan taking the second and third positions. One explanation of this pattern may be that risk does decline with product diversification up to a point, represented, for example, by the Japanese system, but it rises again as diversification extends beyond a core of products closely related to banking. These tests, however, may not be meaningful because betas are measured relative to different market indexes, the risk of which differs across markets. Hence, they cannot be compared reliably.
intensity of the international transmission of risk and return among the banking markets in these countries. A bivariate GARCH framework is adopted which permits the bank stock sensitivities to the macroeconomic variables to be assessed under general conditions, and allows tests of spillover of interest rate volatility and unsystematic risk to be carried out between each two countries in the sample, namely United States-Japan, and United States-Germany.

Empirical results indicate that market betas are strongly significant and lie within a plausible range for all three countries. Similarly, exchange rate sensitivities are found to be rather strong and reflect the exposure of the banks in the sample to foreign exchange risk. While the interest rate levels are found to have insignificant effects, interest rate volatility coefficients and unsystematic risk display statistically significant effects on domestic and foreign markets, in most cases. The significance of interest rate volatility and/or unsystematic risk in one country on the volatility of the other countries establishes the prevalence of contagion in banking markets. In addition, the significance of these variables—along with the ARCH and GARCH parameters—strongly suggest that the bank stock return distributions maintain a time-varying element, and that they should be modeled as such. The policy implication of this finding is that the policymakers should focus their attention on the second, more so than the first, moment of the interest rate distribution. The magnitude and the direction of the spillover effects vary across the countries under consideration. The spillover effects of interest rate uncertainty between the United States and Japan/Germany are found to be asymmetric, with the United States playing a leadership role in this regard. When interest rate volatility shocks originate in the United States, they subject both the Japanese and German banks to the same destiny. However, heightened interest rate volatility in Japan calms the U.S. banking markets, while those in Germany have an insignificant spillover effect. Unsystematic shocks, when significant, are of a local "competitive" nature, namely that adverse shocks to the banking sector of one country are beneficial to the other. This pattern may be due to the fact that U.S. banks are an alternative or a competing group to their Japanese/German counterparts. When Japanese/German banks are subject to shocks, their customers switch to the U.S. market, enhancing the risk and return profile of the U.S. banks.

REFERENCES


