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The sensitivity of bank stock returns to market, interest and exchange rate risks

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This paper presents and estimates a multifactor model of bank stock returns that incorporates market return, interest rate and exchange rate risk factors. A model of the optimizing behavior of an international banking firm is used to derive the sensitivity coefficients of the alternative factors. Regression equations are estimated that are based on either actual or unexpected values of the underlying factors with a post-October 1979 time dummy variable and with a money-center bank dummy variable. Standard results are obtained for the market and interest rate variables while new results are derived for the exchange rate variable. The specific effects of the latter variable are found to be dependent on the time period of observation and the money-center status of banks.

1. Introduction

The interest rate variable is important for the valuation of common stocks of financial institutions because the returns and costs of financial institutions are directly dependent on interest rates. Various authors have, therefore, examined the empirical sensitivity of stock returns of financial institutions to changes in market interest rates.[1] On the international side, the advent of the flexible exchange rate system in the 1970s and the growing internationalization of the economy, including the banking sector, has introduced another macro financial variable, the exchange rate, as a potential determinant of bank stock returns. However, no empirical study has yet been published that explicitly examines the joint interaction of exchange rates and interest rates on bank stock pricing.

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[1] See Booth and Officer (1985), Chance and Lane (1980), Chen and Chan (1989), Flannery and James (1984), Kane and Unal (1988), Lynge and Zumwalt (1980), Martin and Keown (1977), Stone (1974) and Sweeney and Warga (1986).

Table 1

Foreign currency positions of US banks.[a]

Year-end	Canadian dollars	German marks	Japanese yen	Swiss francs	British pounds
1975	130	714	30	−170	−42
1976	80	1,130	70	308	3
1977	−22	1,069	78	334	45
1978	141	1,261	70	316	−56
1979	−61	490	35	−75	−85
1980	−75	731	30	4	−80
1981	−319	617	56	−294	−69
1982	−430	2,168	10	494	−148
1983	50	1,399	−16	−934	−373
1984	−27	6	−94	−435	−303
1985	−172	1,499	76	−679	−434
1986	−486	−819	67	−826	−671
1987	−409	−4,971	267	−1,680	447

[a] In millions of foreign currency units, except yen, which is in billions.
Source: US *Treasury Bulletin.*

These financial variables influence bank stock returns through their effects at both the individual firm level and the market level. At the firm level, the sensitivity of a bank's discounted stream of profits to each variable depends on the characteristics of the bank's asset and liability position. At the market level, stock returns are related to financial variables via a market equilibrium pricing relationship. In this paper, we use a multifactor index model to examine empirically the joint sensitivity of the rates of return of common stocks of large US banking institutions to interest rate, exchange rate and market risk factors. Consideration of exchange rates as a factor affecting bank stock returns is new, as is the micro international banking model that provides empirically testable hypotheses about the sensitivity coefficients of bank stock returns to the underlying market, interest and exchange rate risk factors.

The empirical work covers the 48 largest US banking institutions for the period 1975–1987. To gain an understanding of the foreign exposure of the US banking system, table 1 presents data on the foreign currency positions of US banks *in foreign currency units.* As table 1 indicates, the net currency positions are mostly positive throughout the 1970s. From that period onwards, the net position in Canadian dollars, Swiss francs and British pounds declines. While the position in the German mark remains positive during the early 1980s, it too finally turns sharply negative in the mid 1980s. The amount by which banks have hedged their reported net foreign positions is not known. To the extent that unhedged positions do exist, banks would necessarily be exposed to foreign exchange rate risk.[2] Our results indicate that in fact exchange rates exert an important influence on bank stock returns independent of the other market and interest rate factors. The sign and significance of the estimated coefficient for the exchange rate, however, does differ depending on the time period covered, the nature of the banking business (money center or regional bank), and whether the risk factors are defined in actual or unexpected terms.

The outline of the paper is as follows: Section 2 presents the multifactor model and discusses several issues associated with its use. The micro international banking model is presented in section 3 and the empirical results on the sensitivity of bank stocks to risk factors are discussed in section 4. Section 5 examines the pricing of risk factors. Section 6 contains a brief conclusion.

2. The multifactor index model

2.1. The bank stock return equation

Following the existing literature, we use a multifactor model to describe the returns on bank stocks. A micro banking model in section 3 provides a theoretical basis for constructing empirical hypotheses about the magnitude of the sensitivity coefficients for different classes of banks and alternative time periods. Assuming the US dollar is the numeraire currency, the following model can be used to describe the ex post nominal rate of return on stocks,

$$\boldsymbol{R}=\boldsymbol{E}+\boldsymbol{S}\boldsymbol{F}+z, \tag{1}$$

where $\boldsymbol{R}$ is a vector of the nominal rate of stock returns at time t, $\boldsymbol{E}$ is a vector of expected stock returns at time t, $\boldsymbol{F}$ is a vector of risk factors with mean zero and unitary variance, $\boldsymbol{S}$ is a matrix of the sensitivity coefficients to the risk factors, and z is a vector of idiosyncratic terms which are mean zero and serially uncorrelated. While a multi-index model of this type can be estimated directly, the model has convenient mathematical properties if the indices are orthogonal to each other [see, e.g., Elton and Gruber (1991, pp.

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[2] Year-end data on the US banking system's claims and liabilities payable in foreign currencies are available. These data are not broken down into individual countries and thus cannot be aggregated on the same trade-weighted basis as is the exchange rate used in this study. Nonetheless, these data show that the net position payable in foreign currencies is positive in the 1970s, declines sharply in 1983, and turns negative in 1986 and 1987.

133–136)]. These mathematical properties enable us to isolate the sensitivity of each factor after the exclusion of the correlated components. As will be discussed later, a variant of this equation, supported further by the banking model in the next section, will be estimated for individual banks and a portfolio of banks with and without the imposition of factor orthogonality.

Specification of the risk factors is needed for a meaningful interpretation of the coefficients. Most of the empirical studies on interest rate sensitivity use a variant of the two-index model suggested by Stone (1974), where the interest rate change factor augments the usual market return factor. Inclusion of the interest rate change factor is also consistent with Merton's (1973) intertemporal asset pricing model. Among more recent empirical studies, Sweeney and Warga (1986) have examined the impact of expected and unexpected interest rate changes on stock returns of different industries, while Flannery and James (1984) have related the interest rate sensitivity of common stocks of financial institutions to the maturity composition of the firm's assets and liabilities.

Solnik (1974) raised the issue of exchange rate risk in an equilibrium asset pricing context, although, as he pointed out, a short position in foreign bonds or the use of a hedging instrument can reduce foreign exposure. In his model, exchange rate risk arises because of divergent consumption patterns of investors. At the micro level, Flood and Lessard (1986) and Choi (1986) relate the firm's foreign exchange exposure to underlying market conditions for its outputs and inputs. Adler and Dumas (1983) suggest that the firm's exchange rate risk exposure can be measured by a coefficient in a regression of the firm's stock returns on exchange rate changes, while Eun and Resnick (1988) show the empirical significance of systematic exchange rate risk. Regarding the international activities of banks, Aharony et al. (1985) use the market model to show that the International Banking Act of 1978 had a significantly positive impact on money-center banks that were competing directly with foreign banks. Grammatikos et al. (1986) investigate the portfolio returns and risk associated with the aggregate foreign currency position of US banks. They find that banks have imperfectly hedged their overall assert position in individual foreign currencies and exposed themselves to exchange rate risk. This finding suggests that exchange rate risk may importantly influence bank stock returns.

2.2. *Assumed properties of the macro financial variables*

Expressed in ex post terms, the following identities describe the macro financial variables,

$$R_{\mathrm{m}} = E(R_{\mathrm{m}}) + u_{\mathrm{m}}, \tag{2}$$

$$e = E(e) + u_e, \tag{3}$$

$$r = E(r) + u_r, \tag{4}$$

where R_m is the actual rate of return on the market portfolio, e is the actual rate of appreciation in the foreign-currency value of the domestic currency, and r is the actual percentage rate of change in the domestic nominal default-free interest rate. Variables with $E(\cdot)$ denote expected values, while u_i defines the innovation or unexpected component of a specific variable. The innovations may be correlated depending on the specific macroeconomic model and exogenous variables that are used to describe the observed data. For example, if R_m, e and r are assumed to be functions of, say, the money stock growth rate (as well as other exogenous variables), the expectations $E(R_m)$, $E(e)$ and $E(r)$ would also be functions of the expected money stock growth rate. The resulting expectational errors would then be necessarily correlated because they would contain at least one similar term, the forecast error of the money stock growth rate. This correlation depends, however, on the assumed form of a specific macroeconomic model. In this paper we do not attempt to construct a macroeconomic model that could explain the time series properties of the macro financial variables. Instead, we assume that a data-based method, such as an autoregressive moving average function, generates expectations. With this approach, the question of correlation among the innovations is strictly an empirical and not a theoretical issue.[3]

In our empirical investigation, we identify the risk factors in eq. (1) with the three financial expectational errors,

$$F = [u_m, u_r, u_e]. \tag{5}$$

This identification assumes that, as the period unfolds, information about a financial variable becomes available marketwide that indicates, relative to its expectation, new information. Because the degree of correlation among the innovations is an empirical issue, an innovation in one variable can reveal

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[3] It is possible that the imposition of international parity conditions may establish a connection among the expectational variables in (2)–(4) that may either invalidate the data-based procedure or lead to correlation among the expectational errors. For example, the expected appreciation of the exchange rate and the interest rate may be related through an international interest rate parity (IRP) condition. However, because our data-based expectational procedure does not specify a separate equation for $E(r_f)$, the expected nominal interest rate in the foreign country, it cannot lead to a set of expectations that is inconsistent with interest rate parity. That is, if interest rate parity is assumed to be valid, the data-based values for $E(e)$ and $E(r)$ automatically generate an implied value for $E(r_f)$. This degree of freedom built into the assumed procedure implies that the estimated expectational errors are not necessarily correlated because of an IRP condition.

information that is not necessarily correlated with the information contained in the innovations of the other variables.

2.3. Data

The multifactor model is estimated using monthly data over the period January 1975 to December 1987. The data on individual bank stock returns are generated from the COMPUSTAT PDE tape as the sum of the holding-period capital gain and dividend yield. The bank stock data cover the 48 largest US commercial banking institutions (those with assets in excess of 10 billion dollars at the end of 1987 as reported in *Fortune*, June 6, 1988). The market return is similarly calculated as the rate of price change and the dividend yield for Standard and Poor's 500 stocks obtained from the Wharton Econometric Forecasting Associates, Inc. The interest rate variable is the monthly average of daily rates of return on three-month US Treasury bills as published in the *Federal Reserve Bulletin*. The exchange rate is the trade-weighted multilateral foreign exchange value of the dollar against a basket of currencies of the other Group of Ten countries plus Switzerland which is also published in the *Federal Reserve Bulletin*. The weights used in the calculation of the multilateral exchange rate by the Federal Reserve are the 1972–76 average total trade shares of each of the ten countries.

2.4. Estimation procedure for the financial innovations

If financial markets are efficient, the expected values of the relevant fundamental variables should have already been reflected in asset values and returns, and hence only the unexpected or innovated components should affect asset returns. Chen et al. (1986) use innovated variables (as well as changes in actual values) as factors in a multifactor asset pricing equation. We follow the same approach and use the unexpected variables as our factors, although we also experiment with the actual variables. The use of unexpected variables ensures the absence of a multicollinearity problem and is an alternative to standard orthogonalization methods.

One method of orthogonalization in a multi-index model uses the residual obtained from a regression of one factor on another. Gilberto (1985) indicates, however, that this method introduces a bias in the estimated coefficients. To avoid this bias, we construct estimates of the expected components of the alternative data series from a univariate autoregressive moving average ARIMA model of the general form,

$$\Omega(B)\,\Delta X_t = \mu + \Gamma(B) z_t, \tag{6}$$

where ΔX_t represents the differencing of the X_t data series, and z_t is a shock

Table 2

Correlation coefficients for innovation residuals.[a]

	u_r	u_m	u_e
u_r	1	−0.2	0.35
u_m	−0.2	1	−0.11
u_e	0.35	−0.11	1

[a] In this table, u_r = interest rate innovation, u_m = market rate innovation, and u_e = exchange rate innovation.

term. B is the back-shift operator and $\Omega(B)$ and $\Gamma(B)$ represent the autoregressive and moving average components, respectively. The following ARIMA equations were estimated to determine the expected values of the three independent variables:

$$(1+\underset{(0.089)^*}{0.181}B^{12})(1+\underset{(0.151)^*}{0.544}B^2)\Delta R_{mt}=\underset{(3.58)^*}{14.939}+(1+\underset{(0.077)^*}{0.367}B+\underset{(0.133)}{0.568}B^2)z_{mt}, \tag{7}$$

$$(1-\underset{(0.09)^*}{0.200}B)(1-B)\Delta e_t=-\underset{(0.218)}{0.152}+(1-\underset{(0.038)^*}{0.918}B)z_{et}, \tag{8}$$

$$\begin{aligned}&(1+\underset{(0.098)}{0.158}B^3)(1+\underset{(0.084)}{0.161}B^6)(1+\underset{(0.083)^*}{0.187}B^{12})(1+\underset{(0.156)}{0.124}B)\Delta r_t\\&\qquad=-\underset{(0.005)}{0.003}+(1+\underset{(0.123)}{0.675}B)z_{rt}.\end{aligned} \tag{9}$$

Standard errors are given in parentheses; an asterisk represents significance at the 0.05 level. The particular ARIMA equations were chosen after experimentation with different lags up to twelve periods. The above equations imply that changes in the long-run steady state values of these variables are determined by a moving average (MA) of random shocks, i.e., in the long run $X_t = X_{t-1} + \mathrm{MA}(z)$. The unexpected components of the alternative financial variables are determined by subtracting the predicted values in eqs. (7)–(9) from the actual values.[4]

The estimated correlation coefficients for the innovation residuals are presented in table 2. All of the estimated coefficients are significant at the 0.01 level. Inspection of table 2 suggests that the market and exchange rate innovations are the least correlated while the interest rate and exchange rate innovations exhibit the highest degree of correlation. In addition, diagnostic

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[4] We also tried the standard orthogonalization method. The results do not differ significantly and hence are not reported here.

tests, discussed in section 4, indicate that multicollinearity is not present when using the innovations as independent regression variables.

3. Determination of the sensitivity coefficients

3.1. The micro banking model

The model describes the behavior of an international bank that extends loans maturing in two periods to domestic and foreign borrowers financed with one-period deposit funds raised both domestically and internationally. Letting $\hat{e}$ represent the dollar value of foreign exchange $(=1/e)$, the US currency value at time period t of the various balance sheet items is denoted by L_t^{d} and $\hat{e}_t L_t^{\mathrm{f}}$ for domestic and foreign loans and D_t^{d} and $\hat{e}_t D_t^{\mathrm{f}}$ for domestic and foreign deposits. In addition, it is assumed that the bank engages in a domestic one-period risk-free lending/borrowing market such as the federal funds market. The quantity of fed funds is denoted by X_t^{d} and is positive for a net funds lender. Letting R_t^{d} represent the bank's reserves, the balance sheet in US currency is given by the following equation,

$$X_t^{\mathrm{d}} = D_t^{\mathrm{d}} + \hat{e}_t D_t^{\mathrm{f}} - R_t^{\mathrm{d}} - L_t^{\mathrm{d}} - L_{t-1}^{\mathrm{d}} - \hat{e}_t L_t^{\mathrm{f}} - \hat{e}_t L_{t-1}^{\mathrm{f}} + NW_t, \tag{10}$$

where NW_t represents the bank's net worth. As (10) shows, the balance sheet contains both old and new loans but only new deposits.

The bank's profit depends on the difference between its interest income and the sum of its interest and transaction costs. Regarding interest income and cost, the bank is assumed to charge r_t^{dl} on domestic loans and r_t^{fl} on foreign loans while it pays r_t^{fd} on foreign deposits and r_t^{dd} on domestic deposits. The default-free interest rate is denoted by r_t^{dx}. The bank is a price-taker with differential access to price information. At the beginning of the period the bank possesses perfect information about the two deposit rates and the two loan rates that will prevail during the period but imperfect information about the exchange rate and default-free rate that will prevail over the same period. This assumption about the accuracy of pricing information reflects the belief that *local* prices such as a bank's loan and deposit rates are deterministic as compared to *market* prices such as the exchange rate and nominal interest rate, which are stochastic. This classification of deterministic and stochastic variables is consistent with competitive markets and is only necessitated by our need to define the macro market variables as the systematic risk factors.

Regarding other costs affecting the bank's profit, we assume that the bank is subject to default risk on the domestic and foreign loans extended in the previous period. Letting μ_t^{d} and μ_t^{f} represent random variables denoting the fraction of loans defaulted at home and abroad, the US currency value of defaulted loans is given by $\mu_t^{\mathrm{d}} L_{t-1}^{\mathrm{d}}$ and $\mu_t^{\mathrm{f}} \hat{e}_t L_{t-1}^{\mathrm{f}}$ for domestic and foreign loans. Thus, the model assumes that there are three different shocks that affect the bank's profit during a given time period–interest rate, foreign exchange rate, and default shocks. The bank is also assumed to experience t-period quadratic transaction costs arising from the extension and maintenance of both foreign and domestic loans and the acquisition of foreign and domestic deposits. In US currency terms, transaction costs for domestic and foreign loans are represented by $(c^{\mathrm{dl}}/2)(L_t^{\mathrm{d}})^2$ and $\hat{e}_t(c^{\mathrm{fl}}/2)(L_t^{\mathrm{f}})^2$, and by $(c_t^{\mathrm{dd}}/2)(D_t^{\mathrm{d}})^2$ and $\hat{e}_t(c^{\mathrm{fd}}/2)(D_t^{\mathrm{f}})^2$ for domestic and foreign deposits.

At the beginning of a period the bank is assumed to maximize the discounted present value of expected profit, $E(\pi)$, by choosing optimal quantities of foreign and domestic loans, foreign and domestic deposits, and net federal funds sold. Letting β represent the discount factor, the bank's profit for periods t and $t+1$ in US currency units is given by

$$\begin{aligned}
\pi_t + \beta\pi_{t+1} = {} & r_t^{\mathrm{dl}} L_t^{\mathrm{d}} - (c^{\mathrm{dl}}/2)(L_t^{\mathrm{d}})^2 + r_{t-1}^{\mathrm{dl}}(1-\mu_t^{\mathrm{d}})L_{t-1}^{\mathrm{d}} \\
& + \hat{e}_t r_t^{\mathrm{fl}} L_t^{\mathrm{f}} - \hat{e}_t(c^{\mathrm{fl}}/2)(L_t^{\mathrm{f}})^2 + \hat{e}_t r_{t-1}^{\mathrm{fl}}(1-\mu_t^{\mathrm{f}})L_{t-1}^{\mathrm{f}} \\
& + r_t^{\mathrm{dx}} X_t^{\mathrm{d}} - (1-\alpha_{\mathrm{d}}) r_t^{\mathrm{dd}} D_t^{\mathrm{d}} - (c^{\mathrm{dd}}/2)(D_t^{\mathrm{d}})^2 \\
& - (1-\alpha_{\mathrm{f}})\hat{e}_t r_t^{\mathrm{fd}} D_t^{\mathrm{f}} - \hat{e}_t(c^{\mathrm{fd}}/2)(D_t^{\mathrm{f}})^2 \\
& + \beta\{r_{t+1}^{\mathrm{dl}} L_{t+1}^{\mathrm{d}} - (c^{\mathrm{dl}}/2)(L_{t+1}^{\mathrm{d}})^2 + r_t^{\mathrm{dl}}(1-\mu_{t+1}^{\mathrm{d}})L_t^{\mathrm{d}} \\
& + \hat{e}_{t+1} r_{t+1}^{\mathrm{fl}} L_{t+1}^{\mathrm{f}} - \hat{e}_{t+1}(c^{\mathrm{fl}}/2)(L_{t+1}^{\mathrm{f}})^2 \\
& + \hat{e}_{t+1} r_t^{\mathrm{fl}}(1-\mu_{t+1}^{\mathrm{f}})L_t^{\mathrm{f}} + r_{t+1}^{\mathrm{dx}} X_{t+1}^{\mathrm{d}} - (1-\alpha_{\mathrm{d}}) r_{t+1}^{\mathrm{dd}} D_{t+1}^{\mathrm{d}} \\
& - (c^{\mathrm{dd}}/2)(D_{t+1}^{\mathrm{d}})^2 - (1-\alpha_{\mathrm{f}})\hat{e}_{t+1} r_{t+1}^{\mathrm{fd}} D_{t+1}^{\mathrm{f}} \\
& - \hat{e}_{t+1}(c^{\mathrm{fd}}/2)(D_{t+1}^{\mathrm{f}})^2\},
\end{aligned} \tag{11}$$

where α_{d} and α_{f} are the required reserve ratios against domestic and foreign deposits, respectively. Substituting the balance sheet constraints for X_t^{d} and X_{t+1}^{d} into (11), forming the expectation of the discounted profit stream, $E(\pi_t) + \beta E(\pi_{t+1})$, and differentiating with respect to L_t^{d}, L_t^{f}, D_t^{d}, and D_t^{f} gives the optimal values of foreign and domestic loans and foreign and domestic deposits.

3.2. Unexpected bank profit

A macro financial risk factor affects bank stock rates of return to the extent that an unanticipated change in the factor is associated with an unexpected change in the discounted stream of bank profits. If such an influence were absent, new information about the financial risk factor would not lead to a reevaluation of a bank's discounted profits and thus of the rate of return on its equity. Using a tilde over a variable to indicate an optimal value, unexpected profit is given by

$$\begin{aligned}\pi_t - E(\pi_t) = {} & [\hat{e}_t - E(\hat{e}_t)]\,\{r_t^{\mathrm{fl}}\tilde{L}_t^{\mathrm{f}} - (c^{\mathrm{fl}}/2)(\tilde{L}_t^{\mathrm{f}})^2 - (1-\alpha_f)r_t^{\mathrm{fd}}\tilde{D}_t^{\mathrm{f}} \\ & - (c^{\mathrm{fd}}/2)(\tilde{D}_t^{\mathrm{f}})^2\} + [r_t^{\mathrm{dx}} - E(r_t^{\mathrm{dx}})]\tilde{X}_t^{\mathrm{d}} \\ & - [\mu_t^{\mathrm{d}} - E(\mu_t^{\mathrm{d}})]\,r_{t-1}^{\mathrm{dl}}L_{t-1}^{\mathrm{d}} \\ & - [\hat{e}_t(1-\mu_t^{\mathrm{f}}) - E\{\hat{e}_t(1-\mu_t^{\mathrm{f}})\}]\,r_{t-1}^{\mathrm{fl}}L_{t-1}^{\mathrm{f}}. \end{aligned} \qquad (12)$$

As eq. (12) indicates, the innovation to profits is based on innovations to the exchange rate, nominal interest rate, and the foreign and domestic loan default rates. Both the sign and magnitude of the coefficients in (12) depend on the optimal choices of the bank. The first term in (12) shows that a bank, which optimally chooses to take a zero net foreign lending/borrowing position in the current period, would not expose its profit to unexpected movements in the exchange rate. This term represents a translation risk and thus, depending on whether the bank is optimally a net lender or borrower in foreign currency, the coefficient of the exchange rate term would be positive or negative. The last term in (12) describes a second channel through which the exchange rate may affect a bank's profit. This channel could be viewed as a combination of translation and economic risks associated with foreign exposure because it depends on μ_t^{f}, the foreign default rate which represents foreign country risk. The second term in (12) shows that the relationship between the innovation in profit and the unexpected change in the short-term risk-free domestic interest rate depends on the bank's optimal decision regarding its net short-term lending or borrowing position.[5] Because this paper focuses on large banking institutions, which are net borrowers of funds, the sign of this coefficient should be negative empirically. Finally, in the third term in (12), the sign of the coefficient on the unexpected change in the domestic loan default rate is negative. It is likely that $[\mu_t^{\mathrm{d}} - E(\mu_t^{\mathrm{d}})]$ is negatively related to a positive innovation in the domestic market rate of return (arising, for example, because an unexpected increase in aggregate output simultaneously leads to an increase in the market rate and a reduction in the domestic loan default rate). Thus, unexpected bank profit

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[5] Flannery (1983) examines the effect of interest rates on bank profitability in a similar framework.

and hence the return on bank stock would be positively related to a market rate innovation.

4. Estimation results

4.1. Estimates of the international banking model

The empirical bank stock equation is based on eqs. (1)–(5) with the addition of a dummy variable, D, which indicates either the status of a bank or a specific time period:

$$R_i = b_0 + b_1 u_m + b_2 u_r + b_3 u_e + b_4 D + b_5 u_m D + b_6 u_r D + b_7 u_e D. \tag{13}$$

The banking model in section 3 predicts the signs of b_1, b_2, and b_3. In addition, the model underscores the importance of the net foreign exchange exposure position, which is measured by the dummy variable in two dimensions: (a) whether the bank is a money-center bank, and (b) whether the time period in which the bank is operating is the post-October 1979 period. Since it is possible that structural change and the bank status factors operate both linearly through the intercept term and in a nonlinear fashion through the coefficients of the three risk factors, we include intercept as well as slope dummies in (13).

Given the differences in the net foreign exchange exposure positions of US banks (table 1), the response of bank stock prices to exchange rate surprises should differ between the 1970s and 1980s. In addition, the change in operating procedures instituted by the Federal Reserve in October 1979 led to a marked increase in interest volatility [Johnson (1981)], which is a matter of major concern to large banks with negative interest-rate-gap exposures.

To investigate these potential inter-decade structural changes, the time dummy was set equal to zero for observations prior to October 1979. Because this choice of a particular data is arbitrary, we also report results for two other dummy variable dates – January 1979 when the International Banking Act became operative and January 1981 when the Depository Institutions Deregulation and Monetary Control Act became effective. This procedure differs in principle from the method used by Kane and Unal (1990) in which a different sample of banks and a data-based methodology are used to confirm the existence of switch dates during the 1970s and 1980s. In fact, for large banks they report the estimated switch date as March 1977, which is significantly different from our choice of October 1979. Essentially, Kane and Unal describe the Federal Reserve Board's switch in operating procedures as an endogenous response to unspecified developments in the banking system and the economy as a whole, commencing in March 1977. In other words, the banks' actions preceded in time and significantly influenced the Federal Reserve Board's change in operating procedures. In our opinion, this attributes a foresight to banks that does not appear to be reflected in the market for debt instruments as a whole. That is, as reported by Johnson (1981), pre- and post-October 1979 interest rate volatility differ sharply but there is no evidence indicating that the level of interest rates increased during the pre-October 1979 period as compensation for the imminent increase in interest rate volatility. Rather, the evidence on interest rates suggests that the switch in operating procedures was in the nature of a shock to the entire financial system. This interpretation of the evidence provides the rationale for our choice of an October 1979 dummy.

As discussed above, we also use intercept and slope dummies for the money-center status of a bank. The model presented in section 3 predicts that the stock prices of banks with zero net foreign positions (which we assume are predominantly non-money-center banks) should be unaffected by unexpected exchange rate movements. On the other hand, banks engaged in international lending and borrowing (assumed to be predominantly money-center banks) are more likely to have unhedged foreign positions and thus their stock prices should be responsive to unexpected exchange rate movements.

Before examining the regression results in table 3, an important question is where multicollinearity is introduced into the regression equations through the ARIMA estimation procedure used to model the innovations. To detect the pattern and extent of multicollinearity, Belsley et al. (1980) suggest the use of condition numbers (CN) derived from the decomposition of the $X'X$ matrix, where X is the matrix of regressor variables. The CN for a matrix is defined as the square root of the ratio of the largest to the smallest characteristic root. When the regressors are orthogonal, CN equals unity. The larger is CN, the higher is the degree of correlation among the regressor variables. The rule of thumb is that $CN > 30$ indicates the presence of serious multicollinearity. According to this rule, the values of CN derived for the regressors in the empirical work reported in this paper are consistent with the absence of any serious multicollinearity problem.

Table 3 reports the result of a cross-section time-series estimation of a portfolio of 48 largest commercial banking institutions in the US. A striking result is that only the October 1979 time dummy regression contains significant coefficients for all the intercept and slope dummies. In the January 1979 regression the only significant coefficient is the slope dummy for the market rate, while in the January 1981 regression the slope dummies for both the market and exchange rates are significant. Thus, the January 1979 regression provides very weak evidence for a behavioral shift over time whereas the evidence is slightly stronger in the January 1981 regression. This finding in favor of the October 1979 regression, however, should be expected

Table 3

Estimation results using innovation values: Cross-section and time-series estimations for a portfolio of banks.[a]

	Money-center dummy	October 1979 dummy	January 1979 dummy	January 1981 dummy
Constant	18.366	19.16	18.32	19.383
	(15.10)	(11.09)	(9.75)	(12.82)
u_m	1.015	0.858	0.813	0.723
	(33.04)	(19.95)	(14.25)	(16.90)
u_r	−145.12	−44.65	−127.66	−185.88
	(−7.50)	(−1.28)	(−3.08)	(−8.25)
u_e	0.026	−0.242	0.270	−0.067
	(0.50)	(−3.27)	(2.47)	(−0.78)
D	−3.497	−7.634	−2.022	−3.331
	(−1.61)	(−3.40)	(−0.91)	(−1.63)
u_mD	−0.018	0.231	0.270	0.441
	(−0.33)	(5.27)	(4.21)	(8.26)
u_rD	1.132	−144.32	−34.90	40.864
	(0.03)	(−3.75)	(−0.78)	(1.22)
u_eD	0.229	0.447	−0.191	0.208
	(2.42)	(6.01)	(−1.60)	(2.10)
R^2	0.2	0.21	0.2	0.21
F	266.2	280.5	270.5	277.4

[a] Numbers in parentheses are t-values. In this table, u_r = interest rate innovation, u_m = market rate innovation, and u_e = exchange rate innovation. D is either a dummy variable for 15 money-center banks or a time dummy variable for the period noted in the column.

because, as discussed above, the switch in operating procedures appears to have been completely unanticipated by debt instrument markets. Thus, if bank behavior is responsive to unexpected changes in monetary regimes, it should become evident at the time when the regime shift occurs.

The results on the estimated sensitivity coefficients for the October 1979 regression in table 3 provide broad support for the international banking model. The model predicts that the sign of the interest rate term depends on a bank's net short-term domestic lending position, which tends to be negative for large banks. In table 3, the pre-October 1979 interest rate coefficient has the correct sign but is not significant. The post-October 1979 coefficient is determined by adding the coefficient values for the u_r and u_rD terms. This sum is negative and equals −188.97. The significance of this coefficient is determined from table 4, which reports hypothesis tests on various combinations of coefficients. In the case of the post-October 1979 interest rate coefficient, the test for a zero effect (test 5b in table 4) can be rejected at the 0.01 level. Thus, unexpected movements in interest rates have a significant negative effect during the post-October 1979 period. For the entire sample period, the test that there was no interest rate effect on bank stocks (that is, $u_r=0$ and $u_r+u_rD=0$ or $u_r=u_rD=0$) can also be rejected at the 0.01 level.

Table 4

Tests of hypotheses.[a]

Hypotheses	Money-center dummy	October 1979 dummy
1. No overall dummy effect ($D=u_mD=u_rD=u_eD=0$)	2.37 (0.0501)	22.40 (0.0001)
2. No slope dummy ($u_mD=u_rD=u_eD=0$)	2.35 (0.0501)	27.67 (0.0001)
3. No intercept dummy ($D=0$)	2.58 (0.1080)	11.58 (0.0007)
4. No market effect		
a. $u_m=u_mD=0$	784.8 (0.0001)	824.5 (0.0001)
b. $u_m+u_mD=0$	478.4 (0.0001)	1,568.3 (0.0001)
5. No interest rate effect		
a. $u_r=u_rD=0$	40.66 (0.0001)	55.41 (0.0001)
b. $u_r+u_rD=0$	25.14 (0.0001)	110.2 (0.0001)
6. No exchange rate effect		
a. $u_e=u_eD=0$	5.41 (0.0045)	21.49 (0.0001)
b. $u_e+u_eD=0$	10.58 (0.0011)	19.49 (0.0001)

[a] Numbers in parentheses are the probability that the actual value exceeds the F-value. In this table, u_r = interest rate innovation, u_m = market rate innovation, and u_e = exchange rate innovation. D is either a dummy variable for 15 money-center banks or a time dummy variable for October 1979. Tests 1, 2, and 3 report F-values for various hypotheses about the intercept and slope dummy variables. Tests 4, 5 and 6 examine hypotheses about individual coefficients. For these three tests, the b-test reports the significance of either the money-center variable or the post-October 1979 variable. The a-test reports the F-value for the joint test that the coefficients of *both* the money-center and non-money-center variables are zero or that the coefficients of *both* the pre-October 1979 and post-October 1979 variables are zero.

These results tend to confirm previous findings that the interest rate effect only becomes strongly positive after 1979.

A similar confirmation of the micro banking model is provided by the coefficient on the market rate. For the pre-October 1979 period, table 3 indicates that the u_m coefficient is significantly positive and that the coefficient has significantly increased in magnitude during the post-October

1979 period. For this latter period, the estimated value of the u_m coefficient is 1.089, which, according to the hypothesis test $u_m + u_m D$ in table 4, is significantly positive at the 0.01 level. The increase in the u_m coefficient in the post-October 1979 period may reflect the increased credit risk of the banking system that occurred as banks acquired riskier assets in response to the interest rate deregulation commencing in 1981.

Regarding the exchange rate, the banking model predicts that the sign of the sensitivity coefficient should be related to the unhedged net foreign claims position of US banks payable in foreign currency. While the magnitude of the unhedged position is unobservable, table 1 suggests that it is likely to have declined after 1979, probably turning negative in the mid 1980s. Grammatikos et al. (1986) also provide indirect evidence suggesting that hedging activity over this period has been imperfect. Thus, the model predicts a negative coefficient for unexpected movements in the foreign exchange value of the dollar in the mid-1970s and a possible sign reversal in the 1980s. The results in table 3 confirm the model's prediction. The exchange rate coefficient is significantly negative in the pre-October 1979 period. After October 1979, the point estimate of the coefficient is 0.205, which, as the coefficient test $u_e + u_e D = 0$ in table 4 indicates, is significant at the 0.01 level. These results provide strong confirmation of the predicted role of foreign exchange rates in the stock pricing of large banks.

In an attempt to pin down more precisely the class of bank whose stock price depends on foreign exchange movements, table 3 reports regression estimates using money-center dummy variables for both the intercept and slope terms. Inspection of table 3 indicates that the coefficients on the unexpected market and interest rate variables, which refer to the pricing of non-money center bank stock, have the predicted signs, both of which are significant. On the other hand, the slope dummies for the two variables are insignificant, indicating that money-center status per se does not lead to any differential effect in response to unexpected market and interest rate movements.

The results are different, however, for the unexpected exchange rate variable. The insignificance of the u_e coefficient in table 3 indicates that the stock prices of non-money-center banks are independent of unexpected exchange rate movements. However, these exchange rate movements play an important role in the stock pricing of money-center banks because the coefficient of $u_e D$ is significantly positive. The point estimate of this coefficient for the money-center banks is 0.256, which is significant at the 0.01 level as test 6b in table 4 indicates. This significantly positive coefficient for money-center banks is consistent with the existence of an unhedged net foreign borrowing position in foreign currency. Data are not available, however, to determine whether this is in fact the position of these banks. Nonetheless, the overall results are in agreement with observations indicating that money-center banks are more heavily involved in international lending and borrowing than non-money-center banks and thus, if an exchange rate effect exists, this effect is more likely to be found in the stock prices of money-center banks.

Table 4 presents several additional hypothesis tests concerning the role of the dummy variables in the determination of bank stock returns. Test 1 examines the overall influence of the dummy variables in the money-center equation and the October 1979 time dummy equation by testing the null hypothesis that the coefficients of all the dummies are zero. This hypothesis is rejected at 0.01 level in the time dummy equation and at the 0.05 level in the money-center equation. Tests 2 and 3 address the question of whether the intercept or slope dummies play a significant role in explaining bank stock returns. A comparison of the two tests indicates that the slope dummies have a higher level of significance than the intercept term in both equations. Thus, these tests confirm that there are different responses to the unexpected movements of the financial variables not only through time but across different types of banks as well.[6]

4.2. Estimates with actual data as regressors

Although the risk factors in the multifactor model are identified with the innovations in the financial variables, we also provide estimates of the model using *actual* values of the financial variables as regressors. The use of actual values has been a common practice in previous empirical investigations. Moreover, it allows us to highlight the relative contribution of our model that defines innovations in financial variables as the principal determinant of bank stock prices. The results for a portfolio of banks are presented in table 5 with the money-center and October 1979 time dummies and in table 6 for fifteen individual money-center banks as well as the average money-center banking institution. Note that the regression for the average bank is reported in the last row of table 6.

Inspection of table 5 shows that the results for the market and interest rate variables are similar to those in table 3. On the other hand, table 5 presents a much different and more puzzling picture of the effect of exchange rates on bank stock returns. In the money-center equation the coefficient of the exchange rate variable is significant at the 0.01 level whereas the coefficient of the exchange rate dummy variable is not. With actual data, one would be forced to conclude that the international positions of the money-center banks play no role in determining their stock prices. Similarly, in the time dummy

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[6] The money-center and time dummy variables were also entered simultaneously in the same regression equation. The results, which are available from the authors, show that the estimated coefficients of all the dummies are virtually identical to those reported in table 3.

Table 5

Model estimates using actual values: Cross-section and time-series estimations for a portfolio of banks.[a]

	Money-center dummy	October 1979 dummy
Constant	4.552	7.542
	(3.53)	(3.93)
R_m	0.840	0.647
	(30.07)	(12.60)
r	−155.44	−145.93
	(−9.60)	(−3.72)
e	0.144	0.074
	(2.88)	(0.73)
D	−3.665	−6.227
	(−1.59)	(−2.66)
R_mD	0.023	0.271
	(0.46)	(4.68)
rD	42.547	−8.585
	(1.47)	(−0.21)
eD	0.152	0.145
	(1.70)	(1.30)
R^2	0.18	0.18
F	235.8	239.2

[a] Numbers in parentheses are t-values. In this table, the variables R_m, r, and e represent the market rate, the percentage change in the three-month Treasury bill rate and the percentage change in the trade-weighted foreign currency value of the dollar, respectively. D is either a dummy variable for 15 money-center banks or a time dummy variable for the period commencing October 1979.

equation there is no evidence of any exchange rate effect even though Grammatikos et al. (1986) indicate that unhedged positions have existed throughout the period. Overall, therefore, these results question the reliability of using actual values for the exchange rate.

Compared to unexpected data, the use of actual data leads to a much different implication for the role of the exchange rate on bank stock prices. This difference arises because actual data incorporate movements in both the expected and unexpected components of the exchange rate. To the extent that an observed change in the exchange rate reflects an anticipated change, bank stock prices would have already responded to the anticipated change at some point in the past. A regression of actual changes in bank stock prices on actual changes in the exchange rate would yield, therefore, an estimated coefficient value of zero.

Turning to the individual bank equations in table 6, the market return is uniformly significant while the effects of the other factors are quite varied.

Table 6

Estimation results for money-center banks.[a]

Bank	Constant	R_m	r	e	R^2	F
Bank of New York	1.375	1.013	−180.52	0.358	0.36	28.5
	(0.24)	(8.31)	(−2.56)	(1.65)		
BankAmerica	−8.862	0.705	−61.302	0.652	0.1	5.4
	(−0.98)	(3.58)	(−0.54)	(1.86)		
Bankers Trust	6.688	0.823	−182.75	0.324	0.19	11.6
	(0.91)	(5.14)	(−1.97)	(1.13)		
Chase Manhattan	−2.009	0.988	−24.766	0.246	0.2	12.9
	(−0.27)	(6.06)	(−0.26)	(0.85)		
Chemical	−0.459	0.884	−147.81	0.269	0.21	13.5
	(−0.07)	(5.77)	(−1.67)	(0.98)		
Citicorp	−5.474	0.989	−131.37	0.461	0.25	17
	(−0.79)	(6.59)	(−1.51)	(1.72)		
Continental Illinois	−12.664	0.869	−17.685	0.421	0.08	4.2
	(−1.08)	(3.41)	(−0.12)	(0.93)		
First Chicago	−5.557	1.012	−82.753	0.326	0.19	11.7
	(−0.67)	(5.64)	(−0.80)	(1.02)		
First Interstate	4.397	0.812	−192.46	0.177	0.2	12.2
	(0.61)	(5.18)	(−2.12)	(0.63)		
Irving	11.334	0.608	−34.762	−0.454	0.11	6.2
	(1.46)	(3.61)	(−0.36)	(−1.51)		
Manufacturers Hanover	−5.1	0.872	−192.24	0.58	0.2	12.9
	(−0.68)	(5.36)	(−2.04)	(2.00)		
Marine Midland	10.112	0.871	−80.708	0.104	0.13	7.4
	(1.12)	(4.45)	(−0.71)	(0.30)		
Morgan	4.256	0.666	−61.307	0.231	0.13	7.5
	(0.62)	(4.48)	(−0.71)	(0.87)		
Security Pacific	5.917	1.011	−143.2	0.339	0.24	15.8
	(0.80)	(6.33)	(−1.55)	(1.19)		
Wells Fargo	9.345	0.827	−159.76	0.328	0.18	11.2
	(1.26)	(5.15)	(−1.72)	(1.39)		
Money-center average	2.73	0.852	−134.1	0.219	0.34	51.5
	(0.79)	(11.3)	(−3.08)	(1.63)		

[a] Numbers in parentheses are t-values. In this table, the variables R_m, r, and e represent the market rate, the percentage change in the three-month Treasury bill rate, and the percentage change in the trade-weighted foreign currency value of the dollar, respectively. The time period of estimation is January 1975 to December 1987.

The rate of change in short-term interest rates is significant at the 0.01 level for the average bank and at better than the 0.10 level for Bank of New York, Bankers Trust, Chemical, First Interstate, Manufacturers Hanover, and Wells Fargo. The exchange rate variable, however, is not significant at the 0.10 level for the average bank. In fact, the only money-center banks for which the exchange rate is significant at better than the 0.10 level are Bank America, Citicorp, and Manufacturers Hanover.[7]

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[7] Individual bank regressions were also run using innovations as independent variables. The results are qualitatively similar to those in table 6 and are available from the authors.

5. Estimation of factor risk premia

For the sample of banks used in this study the above analysis establishes the significance of the sensitivity of bank stock returns to the assumed risk factors within the context of a multifactor index model. In this section, we examine the pricing of these factors in the framework of Ross' (1976) arbitrage pricing theory (APT).

APT postulates the return-generating function specified in (1). In the absence of arbitrage profits, the expected return can be written as $\boldsymbol{E}=\lambda_0\boldsymbol{I}+\boldsymbol{S\lambda}$ where $\boldsymbol{\lambda}$ is the vector of risk premia, $\boldsymbol{S}$ are the sensitivity coefficients of the risk factors, λ_0 is the expected rate of return on a zero-beta portfolio and $\boldsymbol{I}$ is a vector of unity. Substituting this equation into (1) yields the equilibrium pricing equation at a point in time:

$$\boldsymbol{R}=\lambda_0\boldsymbol{I}+\boldsymbol{S\lambda}+\boldsymbol{\nu} \tag{14}$$

where $\boldsymbol{\nu}=\boldsymbol{SF}+\boldsymbol{z}$ is a vector of error terms.

Eq. (14) was estimated using a standard two-step procedure. In the first step, the factor sensitivities were estimated by an ordinary least squares regression of (1) on the time-series data for each of the 48 banking firms. These estimates of individual bank sensitivities were then used in the second stage to estimate the factor risk premia for the entire sample period as well as two subperiods (pre- and post-October 1979). The second-stage estimation was carried out on the pooled time-series cross-section data using the Parks generalized least squares algorithm available in SAS. The Parks method (1976) takes a pool of time-series and cross-section data and produces period-average estimates of the risk premia after correcting for both serial correlation in the time series and heteroskedasticity and contemporaneous correlation among the cross sections. As such, this error structure is more general than alternative structures such as that used by Fama and MacBeth (1974), which do not incorporate serial correlation in the individual disturbance terms nor account for interdependence in the behavior of the banks at a point in time.[8]

Following Chen et al. (1986), we use unexpected as well as actual values for the risk factors. The results in table 7 indicate that the interest rate risk premium is significantly negative in both the unexpected and actual value estimations for the post-October 1979 period. This negative interest rate risk premium is consistent with previous work [e.g., Sweeney and Warga (1986)]. The estimate of the exchange risk premium is also significantly negative for the entire period as well as the post-October 1979 period. This finding arises

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[8] An alternative procedure to the two-step method is the simultaneous estimation of factor sensitivities and premia using full-information maximum likelihood as employed by Gibbons (1982) and Sweeney and Warga (1986).

Table 7

Estimation of factor risk premia.[a]

	Intercept	Market	Interest rate	Exchange rate
A. Using unexpected values				
Entire period	10.054	6.270	−0.015	−8.715
	(1.66)	(0.95)	(−1.64)	(−2.49)
Pre-October 1979	12.548	−2.244	−0.006	−4.066
	(3.53)	(−0.58)	(−0.87)	(−1.81)
Post-October 1979	13.306	2.653	−0.021	−13.282
	(1.89)	(0.40)	(−1.96)	(−2.97)
B. Using actual values				
Entire period	13.768	2.106	−0.023	−12.542
	(2.44)	(0.31)	(−2.06)	(−3.20)
Pre-October 1979	10.883	−0.275	−0.016	−2.917
	(3.13)	(−0.06)	(−2.12)	(−1.35)
Post-October 1979	18.846	−2.336	−0.028	−19.708
	(2.73)	(−0.30)	(−2.07)	(−3.92)

[a] Numbers in parentheses are *t*-values.

whether the estimate is derived from unexpected or actual value estimations. The negative coefficient of the exchange risk premium indicates that the market attaches a negative value to an expected increase in the foreign exchange value of the US dollar when pricing the stocks of large US banks. Overall, this result is consistent with the currency translation impact of a net negative unhedged foreign asset position for these banks, which is suggested by the data in table 1, especially for the post-October 1979 period. As table 7 also shows, the magnitude of the interest and exchange rate risk premia on bank stock prices appears to be larger in the post-October 1979 period relative to the pre-October 1979 period,[9] which is consistent with the results in section 4.

Finally, it is noteworthy that the market risk premium is insignificant in both the unexpected and actual value estimations. This is due to the diffusion of the market factor by the interest and exchange rate risk factors within the context of a multifactor model. As Chen et al. (1986) have shown, the market may be simply proxying for more fundamental economic variables.

6. Conclusion

This paper has presented a multi-factor model of bank stock rates of return. The assumed factors included the market rate of return, the percentage change in the short-term domestic interest rate, and the percentage

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[9] We also used January 1981 as an alternative cutoff point. The results are slightly inferior to those obtained using the October 1979 dummy.

change in the exchange rate. A micro model of an international banking firm has also been presented to provide predictions of the signs of the coefficients of the unexpected components of the market, interest, and exchange rate variables. Regression equations have been estimated that are based on these unexpected values of the underlying factors. For completeness, we have also estimated regressions based on actual values. The regressions have been estimated with a post-October 1979 time dummy variable and with a money-center bank dummy variable. Standard results have been obtained for the market and interest rate variables while new results have been derived for the exchange rate variable. We find that exchange rate innovations were significantly negatively related to bank stock returns prior to October 1979. After that date, the relationship became significantly positive. As a partial explanation for this finding, we noted that at approximately the same time the balance sheet of the banking system showed a decline from a positive net position in several major foreign currencies to a negative position that became especially large in the mid 1980s. There is, however, no firm evidence on the extent to which banks hedged their foreign currency positions. In addition, we find that the returns of money-center banks as a group are also significantly related to the exchange rate. Thus, within the context of our joint modeling of bank stock returns and exchange rate innovations, these findings for both the time and money-center dummy equations indicate that exchange rate innovations cannot be omitted in investigations of the stock returns of large banks.

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