

Economic Review

**Federal Reserve Bank
of San Francisco**

1994 Number 1

Mark E. Levonian

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and Other Market Risks**

Andrew K. Rose

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Phenomena?**

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The Federal Reserve Bank of San Francisco's Economic Review is published three times a year by the Bank's Research Department under the supervision of Jack H. Beebe, Senior Vice President and Director of Research. The publication is edited by Judith Goff. Design, production, and distribution are handled by the Public Information Department, with the assistance of Karen Flamme and William Rosenthal.

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Bank Capital Standards for Foreign Exchange and Other Market Risks

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Research Officer, Federal Reserve Bank of San Francisco. I am grateful to Jennifer Soller for research assistance and to Gary Johnsen for data. Conversations with Beverly Hirtle and Elizabeth Laderman helped clarify the paper.

The Basle Committee on Banking Supervision has proposed methods for incorporating consideration of market risks—exchange rate, interest rate, and equity price risks—into risk-based capital standards for banks. This paper shows that the separate and seemingly different proposed approaches to the three sources of risk are consistent with one another, reflecting a single unifying theme. That theme is the measurement of risk through a weighting of two different measures of portfolio size, the gross position and the net position. A simple theoretical model demonstrates that such an approach can be viewed as a simple (specifically, an affine) approximation to a portfolio variance calculation based on the full variance-covariance matrix of market returns, and thus provides a reasonable basis for a practical approach to capital standards. An empirical test of one part of the framework, the proposal for exchange rate risk, shows that the approximation may be very accurate: the proposed Basle approach captures over 95 percent of the variation in foreign exchange risk across a sample of banks from the Twelfth Federal Reserve District.

I. INTRODUCTION

This paper investigates the extension of risk-based capital standards to cover market-related risks. In 1988, the Basle Committee on Banking Supervision (the Basle Committee) published standards for capital adequacy, establishing a system in which minimum capital requirements for banking firms are sensitive to differences in risk.¹ The risk-based capital standards specified in the Basle Accord came into full force at the end of 1992, and have been adopted by many countries. When the standards were issued, the Basle Committee acknowledged that the resulting assignments of minimum capital primarily reflected an assessment of credit risk, or the risk of losses due to counterparty default. Consideration of other types of risk was left to national regulatory authorities or to future deliberations of the Basle Committee and its subgroups.

In April 1993, the Basle Committee sought comments on a consultative paper describing proposals for incorporating additional types of risk into the original framework (Basle Committee, 1993). “Market risks” are those due to unexpected changes in financial market prices that are unrelated to the creditworthiness of particular borrowers or counterparties; the Basle proposals cover stock prices, the prices of foreign currencies as reflected in exchange rates, and debt prices as reflected in interest rates. Since market risk is considered distinct from credit risk, the emphasis is on price fluctuations that reflect general market movements, rather than those related to changes in the condition of specific issuers.

This paper develops a conceptual model in which the new market risk proposals can be understood and analyzed. The underlying, unifying theme of the standards is emphasized. Building on the conceptual model, the suitability of the proposals is evaluated. For purposes of illustration, much of the analysis is based on consideration of foreign exchange rate risk, which in some ways is the simplest of the three; the paper discusses the parallel implications for other types of market risk in less detail.

1. The Basle Committee consists of representatives from Belgium, Canada, France, Germany, Italy, Japan, Luxembourg, the Netherlands, Sweden, Switzerland, the United Kingdom, and the United States. It usually meets at the Bank for International Settlements in Basle, Switzerland.

II. CONVENTIONAL AND RISK-BASED CAPITAL STANDARDS

Before turning to market risk, it is helpful to review the general role of capital standards in bank supervision. Risk is an unavoidable element of the business of banking, and banks must take risks to be economically useful in the financial system. Managers of well-run banks are aware of the risks they face, and take steps to manage those risks to maximize the net value of their banks. However, certain features of the banking system—most notably the imperfectly priced government support of banks through deposit insurance and other elements of the federal “safety net,” and the externalities associated with bank failures—lead to a tendency toward excessive risk. Levels of risk are “excessive” to the extent that the probability of bank failure resulting from the private, unregulated decisions of bank managers exceeds the level of failure that maximizes social welfare. To deal with this tendency toward excessive risk, central authorities in most countries impose some type of oversight on the banking system in special licensing, regulation, and ongoing supervision.

Standards for capital adequacy are an aspect of bank regulation common to most countries. These capital standards establish minimums for bank capital. The term “capital” is used in many ways in economics and finance, but in the context of bank capital adequacy it is the portion of a bank’s financing that can absorb losses that would otherwise cause the bank to fail and impose an external cost on the economy. Generally this means equity, although regulators consider certain types of debt to be capital in some circumstances.

Minimum capital requirements help ensure the solvency of regulated institutions, but the only capital standard that can *guarantee* solvency is a requirement of complete equity financing. Such a standard is impossible with depository institutions by definition, so regulators instead set capital standards to reduce the probability of insolvency to some acceptable level. The acceptable level depends on regulators’ tolerance for risk, which in turn may reflect judgments regarding the potential welfare costs of insolvency balanced against the costs imposed by the regulations.

The probability that a bank will become insolvent depends on the level of its capital and the variance or standard deviation of changes in that capital. The conventional approach to capital adequacy sets minimum capital relative to the assets of the bank, with a floor placed under allowable capital-asset ratios. Under certain assumptions, such an asset-based standard is equivalent to requiring capital to exceed a multiple of the standard deviation of changes in capital. Specifically, if all bank assets have the

same variance, and provided liabilities contribute trivially if at all to total risk, then the standard deviation of changes in capital can be expressed as $\sigma_A A$, where σ_A is the standard deviation of a bank’s return on assets. In that case, a minimum capital ratio of $\gamma\sigma_A$ can set the probability of insolvency at the acceptable level, with the coverage ratio γ determined by regulators. If σ_A is about 2 percent (a typical empirical finding) and regulators aim to cover two standard deviations (that is, $\gamma=2$), then the minimum capital ratio should be 4 percent.²

In contrast to conventional asset-based leverage constraints, the risk-based capital standards established under the 1988 Basle Accord set minimum capital relative to a weighted sum of the bank’s assets.³ Levonian and Kendall (1993) show within a simplified model of the Basle Accord that the credit risk standards can be viewed as an extension of simple leverage standards; the Accord relaxes the assumption that all asset types have a common variance, making σ_A a weighted average of the volatilities of the different asset types. However, the Basle Accord retains the assumption that liabilities are irrelevant, and the risk weights largely reflect only credit risk.

III. MARKET RISKS IN THEORY

Neither the conventional nor the credit-risk-based approaches to capital standards can be stretched to cover market risks. Credit risks generally run in one direction: The bank gains if the credit standing of a counterparty improves, and loses if credit quality deteriorates. On the

2. An asset-based standard ignores differences in bank profitability, implicitly assuming that the expected change in capital is zero. In practice, regulators aim to err on the side of conservatism, and are reluctant to presume that banks will achieve a positive rate of return. Bank supervision may incorporate profitability more subtly, perhaps in the enforcement of capital standards; for example, supervisors might exert less pressure on a profitable bank with low capital than on an unprofitable bank in the same position.

3. The Basle framework applies to assets and off-balance-sheet items. The notional value of a bank’s off-balance-sheet exposures are converted into “credit equivalent” amounts through a set of conversion factors intended to reflect the amounts actually at risk for the bank; on-balance-sheet assets are combined with the converted off-balance-sheet amounts and classified into one of several categories according to the credit risk associated with the underlying counterparties. Amounts in each risk category are then multiplied by a risk weighting factor (higher for riskier categories) and the weighted amounts are summed. The resulting total risk-weighted assets forms the basis for the capital adequacy calculation; minimum ratios of various types of capital to risk-weighted assets are established in the Basle Accord. For further description of the standards established under the Basle Accord, see Bhala (1989).

other hand, increases in market prices can cause either gains or losses for a bank, because exposure to these prices can be either long or short.⁴ Liabilities create short positions; for example, a deposit denominated in a foreign currency creates short foreign exchange exposure for the issuing bank. Since such positions may contribute substantially (either positively or negatively) to total portfolio risk, liabilities cannot be ignored, and a simple asset-based calculation cannot correctly capture the potential for losses due to market risk.

With risky positions both long and short, the variance of changes in capital requires a matrix presentation. Suppose there are N market variables—stock prices, interest rates, or exchange rates—that might affect the solvency of banks. Let Σ represent the variance-covariance matrix of percentage changes in the prices of these instruments; thus Σ is $N \times N$, with the variance of each instrument on the diagonal, and the covariance between each pair off the diagonal. Let D represent a vector of the bank's net dollar positions in the instruments, with N components. Then the bank's portfolio variance—that is, the variance of the change in total portfolio value—is given by $\sigma_p^2 = D' \Sigma D$.

It is tempting to regard this matrix-based portfolio calculation as the solution to the market risk problem. Regulators could set minimum capital at some multiple γ of the portfolio standard deviation σ_p , at a level deemed adequate for protection against bank failures. Such standards would accurately reflect differences in risk across banks and over time.

However, practical considerations may require standards for market risk to meet additional criteria. Foremost among these is simplicity; the more complicated the regulation, the greater the expense, for several reasons. Complex standards are more difficult to draft, and once written are more difficult to explain to regulated banks, to supervisory staff, and to others. Complicated standards often are information intensive, increasing the reporting burden imposed on banks and raising the costs of data collection and analysis for regulators. Banks and regulators also may find it more difficult to monitor compliance. Moreover, to the extent that more complicated methods rely on sophisticated computational techniques, or on unobservable values that must be estimated or subjectively determined, enforcement costs are likely to climb.

One aspect of simplicity is that elementary functional forms are desirable. Linear forms are among the simplest, and therefore are preferred. Regulators also may want any new capital standards to have the general form of the old standards, under which minimum capital is set as a ratio to some measure of value such as total assets or risk-weighted assets. Requiring that a market risk standard be expressed similarly places even greater constraints on the functional form than does the requirement that it be linear. The history of the Basle Committee's work suggests that these considerations were important. Of course, simplicity cannot be the only goal in establishing a capital standard; the standard also must be accurate, with risk measured fairly precisely. An optimal policy balances these concerns, trading off simplicity for precision. A degree of imprecision may be acceptable when the cost of implementing more precise but more complex regulatory regimes is considered.

Viewed within the context of this tradeoff, the matrix-based portfolio variance calculation is precise but is unlikely to be simple enough. The policy challenge is to develop a precise measure of market-related risks—with precision measured relative to portfolio variance—that is sufficiently simple, preferably one that results in a dollar figure against which a typical minimum capital ratio can be applied. To meet this challenge, the Basle Committee began by examining existing approaches in use by bank supervisors around the world. Of the various market risks, foreign exchange is the one for which regulators have developed the best quantitative measures of exposure. The next section discusses the range of existing practice examined by the Basle Committee.

IV. FOREIGN EXCHANGE MARKET RISK IN PRACTICE

In many countries, banks are required to calculate their overall currency positions at given points in time; regulators use the resulting "aggregate open position" for each bank as a measure of exchange rate risk. Implicitly, regulators assume that foreign exchange risk depends positively on the size of this open position, analogous to the assumption in conventional capital standards that portfolio risk is proportional to total assets. Such calculations are based on the vector of positions D , and do not explicitly use the matrix Σ . Since portfolio variance depends on both D and Σ , it is reasonable to think that these open position calculations might be related to risk, but with a loose and imperfect linkage.

Each of the various aggregation approaches in common use begins by constructing a hypothetical portfolio of

4. Positions are defined as "long" if a rise in price increases the value of the portfolio; this might occur if the bank actually holds the currency, bond, or stock, or has contracts to receive delivery of those items at some future date at a prespecified price. Conversely, "short" positions lose value when price rises; shorts generally result from commitments to make future delivery.

foreign currency positions for each bank, or a foreign exchange "book," with risk identical to the bank as a whole. For some banks this mirrors the way exposure actually is managed: Each business unit within the bank hedges away any currency risk it generates through internal transactions with the bank's foreign exchange trading desk. However, the same principle applies whether or not this is actually done. With all of the relevant risk collapsed into a single actual or hypothetical book, the problem becomes one of computing the total exposure arising from this foreign exchange portfolio. Long and short positions generally are netted within any single currency, but national practices differ in important ways with regard to the degree of netting of long and short positions *across* currencies. Three alternative approaches for netting across currencies to obtain a measure of aggregate open position are in common use by bank supervisors in major countries.

To illustrate the three alternatives, simple schematic diagrams of two foreign exchange books are presented in Figure 1. The relative dimensions of the rectangles reflect the relative values of the long (L) and short (S) positions, and the net portfolio position (T), all in terms of the domestic currency. In Portfolio I the aggregate value of long positions exceeds the aggregate value of short positions, and the foreign exchange book is a net asset for the bank; in Portfolio II the short positions are worth more than the longs, and the book is a net liability. What is a valid measure of exposure to exchange rate changes for these portfolios?

One intuitively appealing measure of potential loss is the net position, which is simply equal to T in Figure 1. This reflects the net investment of the bank in the foreign exchange book at a point in time, or the cost of acquiring or divesting the portfolio on the current market. The net position has been used by some regulators as the measure of foreign exchange exposure, most notably in Japan; it will be referred to here as Net Aggregate Position (NAP). NAP also can be computed as the absolute value of the sum of all foreign currency positions, counting shorts as negative values.

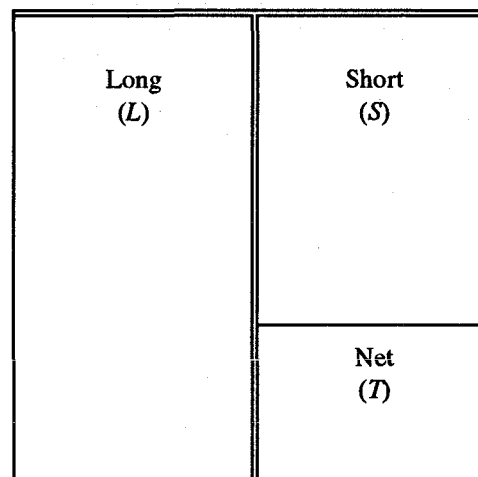
However, suppose the long exposure is in Canadian dollars and the short exposure is in German marks. If the dollar exchange rates for these two currencies move in opposite directions, the bank's total loss could far exceed T ; for example, the net position might change from positive to negative. Consequently, some regulators have chosen to assess exposure by taking the total of the two areas L and S ; this measure has been used in Germany and other countries. This will be referred to as Gross Aggregate Position (GAP). GAP is calculated as the sum of the values of all long positions, plus the absolute value of all short positions; that is, it is the sum of all foreign currencies counting

shorts as positive positions. Thus, the gross measure is $GAP = L + S$, whereas the net measure is $NAP = T = |L - S|$. From the definitions, it is evident that $GAP \geq NAP$, and $GAP = NAP$ only if $L = 0$ or $S = 0$.

FIGURE 1

TWO TYPICAL FOREIGN EXCHANGE BOOKS

PORTFOLIO I: NET LONG

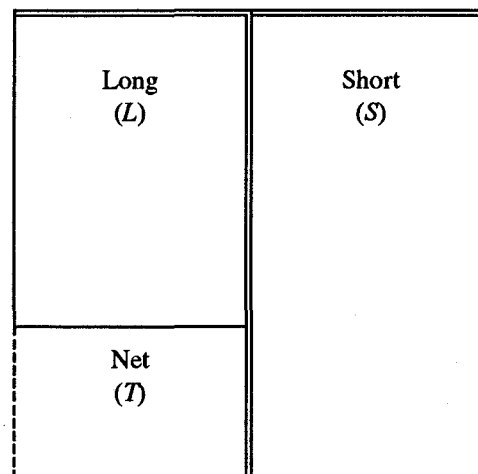


$$NAP = |L - S| = T$$

$$GAP = L + S$$

$$BAP = L$$

PORTFOLIO II: NET SHORT



$$NAP = |S - L| = T$$

$$GAP = S + L$$

$$BAP = S$$

A third practical gauge of foreign exchange exposure, generally attributed to bank regulators in the U.K. but adopted by other countries as well, is the larger of the absolute values of shorts and longs. This "Bank of England" Aggregate Position, or BAP, is therefore $\max[L, S]$. As the larger of L and S , BAP is always the "length" of the T -account balance sheet, the total value of one side; in Portfolio I, this would be L , whereas in Portfolio II it would be S . An alternative definition of BAP that is sometimes used is "the sum of short positions in all currencies, including the home currency." The equivalence of the two definitions is clear from Figure 1. The rectangular area T gives the net position in the domestic currency, which in Portfolio I can be viewed as additional short exposure: If the domestic currency rises in value against other currencies, the value of the book declines. Hence in Portfolio I the short position *including* the home currency is the total area of rectangles S and T together, which is of course equal to L , the larger of L and S . Similarly, in Portfolio II the domestic currency position effectively is a long position, so the aggregate short position is simply S ; this again is equivalent to taking the larger of L and S .

Each measure—NAP, GAP, and BAP—was considered and tested by the Basle Committee; in the end, the Committee favored BAP. The Basle Committee perceived BAP to be a compromise between the "conservative" GAP and the "liberal" NAP. In fact, it is a compromise in a very significant sense: BAP is the simple average of GAP and NAP. To see this, first note that:

$$(1) \quad \begin{aligned} \text{GAP} &= L + S = \max[L, S] + \min[L, S] \\ \text{NAP} &= |L - S| = \max[L, S] - \min[L, S] \end{aligned}$$

Then BAP can be written as:

$$(2) \quad \begin{aligned} \text{BAP} &= \max[L, S] \\ &= \frac{1}{2} (\max[L, S] + \max[L, S]) \\ &= \frac{1}{2} (\max[L, S] + \min[L, S] \\ &\quad + \max[L, S] - \min[L, S]) \\ &= \frac{1}{2} (\text{GAP} + \text{NAP}) \end{aligned}$$

An equivalent restatement is that BAP always yields a result halfway between the gross and net exposures. Thus BAP is indeed a "compromise" measure.⁵

NAP, GAP, and BAP can be viewed as variants of a more general measure of portfolio position. Define "weighted aggregate position" (WAP) as the weighted sum of gross and net aggregate positions:

$$(3) \quad \text{WAP} = w_g \text{GAP} + w_n \text{NAP}$$

The other measures are easily seen to be special cases:

$$\begin{aligned} &\text{GAP if } w_g = 1 \text{ and } w_n = 0 \\ (4) \quad &\text{WAP} = \text{NAP if } w_g = 0 \text{ and } w_n = 1 \\ &\text{BAP if } w_g = \frac{1}{2} \text{ and } w_n = \frac{1}{2} \end{aligned}$$

Turning from risk measurement to the construction of capital standards, a capital requirement for foreign exchange risk could be based on WAP. A minimum ratio c of capital to aggregate foreign exchange position could be established, with position measured by BAP or any other variant of WAP. This is precisely the Basle Committee's proposal: banks would be required to have enough capital (above that required to cover other types of risk) to cover 8 percent of BAP.⁶ As indicated in Section II, to be adequate this minimum capital should correspond to $\gamma \sigma_p$, where σ_p is the standard deviation of changes in capital (in this case flowing entirely from the foreign exchange portfolio) and γ is regulators' desired coverage ratio.

V. EQUITY AND INTEREST RATE RISK PROPOSALS

The recent Basle release also covers equity price risk and interest rate risk. The equity proposal applies to banks' holdings of common equity shares, as well as options, futures, warrants, and other instruments whose value depends on share prices or the level of stock market indexes. The interest rate proposal applies to traded debt securities and derivatives; as a result, it only incorporates a portion of total interest rate risk, ignoring major components such as loans and deposits.⁷ This section provides an overview of both proposals. As with foreign exchange, these two proposals turn out to be versions of WAP.

One notable difference between these two proposals and the foreign exchange proposal is that they substitute completely for the old treatment; that is, traded debt and equity instruments would no longer be covered by the original

of either side of the balance sheet separately; BAP is always equal to the total value of *one* side of the balance sheet, and hence is always exactly half of the sum of the other two measures.

6. The Basle Committee also has suggested a possible alternative, under which banks would simulate the response of their portfolios to typical exchange rate fluctuations.

7. A separate proposal from the Basle Committee describes a framework for collecting information on interest rate exposure for all of the assets and liabilities of the bank, both on- and off-balance-sheet. That framework is for information only; there is no explicit risk calculation or capital charge, although the Committee expects that the information may be used as the foundation for future capital standards covering the bank as a whole.

5. The relation $\text{BAP} = \frac{1}{2}(\text{GAP} + \text{NAP})$ is also evident from Figure 1. Since $\text{GAP} + \text{NAP}$ is equal to the sum of L , S , and T , it is twice the value

risk-based capital framework. Capital required under the foreign exchange market risk proposal would be in *addition* to any capital required to meet the existing credit risk standards.

Equity Price Risk

The equity proposal covers risk due to changes in stock prices. Some banks have direct holdings of equity shares or equity-linked instruments. In some countries this could be quite important, depending on the extent of bank powers. Also, the new standards apply on a consolidated basis; in countries (such as the United States) where banks are affiliated with brokerage or investment banking units, the equity risk standards may be important.

As in the foreign exchange proposal, banks convert options and futures into spot equivalents, and then consolidate all exposures into a single hypothetical portfolio. The result in the foreign exchange case was a set of long and short positions in individual currencies; for the equity case, the positions are in the shares of different issuers or in stock market indexes. Positions may be long or short in each equity, with short exposure arising from short sales or from short positions in derivative instruments.

The proposal uses the long and short positions to compute gross and net aggregate positions, GAP and NAP. Gross and net positions are then weighted and summed to set minimum capital. This obviously is a weighted aggregate position calculation of the form discussed above. The weights proposed by the Basle Committee are 1.0 and 1.0, unless the portfolio is well diversified, in which case the weights are 1.0 on NAP and 0.5 on GAP. The resulting aggregate position is multiplied by a minimum capital ratio of 8 percent. The Basle draft combines the capital ratio with the weights; for example, the weights for the diversified portfolio case are expressed as 8 percent of net and 4 percent of gross. The Basle document refers to the composite weight on GAP as "*x*" and the weight on NAP as "*y*," and calls this "the *x* plus *y* approach." It clearly is equivalent to WAP.

Interest Rate Risk

The traded debt securities proposal is much more complicated, and has some features that do not fit neatly within the WAP framework. As with the other market risks, a hypothetical portfolio is constructed: Whereas in the foreign exchange case the positions were in individual currencies, and in equities the positions corresponded to different issuers or indexes, in the debt proposal banks report net positions in different maturities or repricing periods. Derivative instruments are converted to spot equivalents, and

duration weights are used to convert each time band to a corresponding interest rate sensitivity. In addition, each position is multiplied by a risk weight that combines an interest rate volatility (standard deviation) and a factor for the number of standard deviations of capital coverage desired by regulators; in terms of the discussion in Section II above, the risk weights correspond to $\gamma\sigma$.

Banks report long or short positions in each of the 13 bands, which are grouped into three "zones" corresponding to short-term, medium-term, and long-term. Table 1 illustrates the structure of the basic maturity ladder. Exposures are netted in stages, first within maturity bands, then across bands within each of the three maturity zones, and then finally across the zones. At each stage, a certain amount of the netting is "disallowed," using various "disallowance factors." An aggregate position results. Since individual positions have been premultiplied by risk weights corresponding to $\gamma\sigma$, the result after the netting process is *not* multiplied by a capital ratio (such as 8 percent); it already corresponds to a dollar amount of capital.

The way the disallowances are computed turns the netting process into a WAP calculation. Consider one stage of the netting, say, between time bands within a single zone. In each band the bank may have either a long or a short position. (For example, there would be a maximum of

TABLE 1
MATURITY LADDER FOR INTEREST RATE RISK

TIME BAND	MATURITY RANGE	ZONE
1	0-1 month	Zone 1 (Short Term)
2	1-3 months	
3	3-6 months	
4	6-12 months	
5	1-2 years	Zone 2 (Medium Term)
6	2-3 years	
7	3-4 years	
8	4-5 years	Zone 3 (Long Term)
9	5-7 years	
10	7-10 years	
11	10-15 years	
12	15-20 years	
13	over 20 years	

six long or short positions in Zone 3.) These band exposures are netted, generating a NAP for that zone. The disallowance factor is a number δ (between 0.10 and 1.50, differing by zone and band) to be multiplied by the smaller of the total long and total short positions; the resulting dollar-value disallowance is added to NAP from the zone to compute a position for that zone. Formally, the calculation is $\text{NAP} + \delta \min[L, S]$.

It may not be obvious that this is a WAP calculation. Note from the pair of equations in (1) that $\text{GAP} - \text{NAP} = 2 \min[L, S]$. Then the computed position is:

$$\begin{aligned} (5) \quad \text{NAP} + \delta \min[L, S] &= \text{NAP} + \frac{\delta}{2} (\text{GAP} - \text{NAP}) \\ &= \frac{\delta}{2} \text{GAP} + \left(1 - \frac{\delta}{2}\right) \text{NAP} \end{aligned}$$

Equation (5) shows that the netting process with disallowances does yield WAP. The amount of the disallowance is related to the weighting: a larger disallowance factor gives relatively more weight to gross versus net. Note that $\delta=0$ corresponds to NAP, $\delta=1$ corresponds to BAP, and $\delta=2$ corresponds to GAP.

Thus, the equity and interest rate risk proposals reflect the same underlying theme as the foreign exchange proposal: The use of WAP to weight gross and net aggregate positions, yielding a dollar exposure against which a minimum capital ratio can be applied. Since all three use versions of WAP, WAP is the key to understanding and analyzing the market risk proposals. The next section returns to the example of exchange rate risk to examine whether WAP is likely to be a good measure of market risk.

VI. WAP IN A SIMPLIFIED PORTFOLIO

WAP is a simple, practical measure of portfolio position, linearly combining elements of the position vector D . WAP has the distinct advantages of readiness of comprehension and ease of application, as do its variants, such as the Basle Committee's foreign exchange selection BAP. Moreover, WAP could serve as the foundation for a proportional standard, with minimum capital set at some ratio c relative to WAP. But since WAP bears little obvious resemblance to the portfolio variance $\sigma_p^2 = D' \Sigma D$ discussed in Section III, its precision—that is, its ability to accurately reflect interbank differences in risk—may seem questionable. This section presents a simplified model of a portfolio showing that GAP and NAP, the components of WAP, are clearly related to the portfolio variance calculated from the variance-covariance matrix; this result has implications for the likely precision of WAP in general. Foreign exchange risk is again used as a convenient example, although the currency

positions could just as easily be interpreted as debt or equity positions.

Consider a U.S. bank managing a portfolio of N foreign currencies. Assume that the portfolio consists of n short currency positions, and therefore $N-n$ long currencies. The value of each currency is measured in units of the domestic currency (the U.S. dollar) as numeraire; thus, there are $N+1$ total currencies in the model. The dollar value of currency i in the portfolio is d_i .

Prices of the foreign currencies fluctuate randomly from period to period due to changes in supply and demand, perhaps with some anticipated trend. Assume that the unanticipated rate of change in each of the N exchange rates is distributed with variance σ^2 , and that all cross-currency correlations are equal to ρ . If D is the $N \times 1$ vector of positions and Σ is the $N \times N$ variance-covariance matrix of the rates of change in exchange rates—with diagonal elements equal to σ^2 and off-diagonal elements equal to $\rho\sigma^2$ —then the variance of changes in the value of the foreign exchange portfolio is given by:

$$(6) \quad \sigma_p^2 = D' \Sigma D = \sum_{i=1}^N \sigma^2 d_i^2 + 2 \sum_{i=1}^{N-1} \sum_{j=i+1}^N \sigma^2 \rho d_i d_j.$$

To simplify the problem further, assume that each position is of equal absolute dollar value.⁸ Long positions have positive value $d_i = d > 0$ and total dollar value $(N-n)d$, whereas short positions are effectively liabilities and hence have $d_i = -d < 0$ and negative total value $-nd$. Then the variance can be written:⁹

$$(7) \quad \sigma_p^2 = \sigma^2 d^2 N(1-\rho) + \sigma^2 d^2 (N-2n)^2 \rho.$$

Defining a "portfolio composition factor" P as:

$$(8) \quad P = \sqrt{d^2 N(1-\rho) + d^2 (N-2n)^2 \rho},$$

the portfolio variance can be written simply as:

$$(9) \quad \sigma_p^2 = \sigma^2 P^2.$$

An attractive interpretation of this expression for σ_p^2 is that foreign exchange risk in a bank's portfolio can be viewed as the product of two components. One component is exchange rate volatility arising from the external environment of the foreign exchange markets, in this model represented by σ^2 . This variance is multiplied by the second component, the square of the portfolio composition factor P , which reflects the size and composition of the individual bank's foreign exchange book. Since the exchange rate environment does not vary across banks within

8. Alternatively, σ_i could be permitted to vary across currencies and d_i assumed proportional to $1/\sigma_i$ (that is, smaller positions in more volatile currencies).

9. Details of this step are given in the Appendix.

a given financial system, the value of σ^2 affects the level of risk in the system but not how risk varies across banks; differences in risk across banks must stem from differences in portfolio composition.

P is related algebraically to the simpler aggregate position measures used by bank supervisors around the world. In the N foreign currency model, $GAP = Nd$. With n short positions and $N-n$ long, $NAP = |N-2n|d$. Substituting into equation (8) above yields:

$$(10) \quad P^2 = GAP^2 \frac{(1-\rho)}{N} + NAP^2 \rho.$$

Thus P^2 is a weighted sum of squares of GAP and NAP, with the weights depending on cross-currency correlations of exchange rates for any given number of currencies.

In view of this relationship, consider the WAP measures—GAP, NAP and BAP—that have been used in the past to measure risk. A precise standard would set minimum capital at $\gamma\sigma_P$, which is equal to $\gamma\sigma P$ from equation (9). If WAP happened to be proportional to P , then minimum capital could be set as a ratio to WAP, with γ and σ incorporated into the capital ratio. Such a standard would be precise, in the sense that it would measure risk correctly for any combination of NAP and GAP, and at the same time would be simple. Is any variant of WAP proportional to P ?

Several special cases are interesting. Equation (10) implies that $P = NAP$ if $\rho = 1$, an intuitive result: If changes in exchange rates are perfectly correlated, then the foreign currencies are effectively interchangeable, and can be treated as a single currency. Long and short positions within a single currency of course should be netted. As a result, NAP, which nets longs and shorts across the entire book, treats the exposures correctly. With $\rho = 1$, a minimum capital ratio $c = \gamma\sigma$ applied to NAP is simple, proportional, and precise. (This result is independent of the particular form of the model.)

If exchange rate changes are uncorrelated ($\rho = 0$), then equation (10) implies $P = GAP/\sqrt{N}$. In that case, a capital standard for foreign exchange risk could be based on GAP as the measure of exposure, with the minimum capital ratio $c = \gamma\sigma/\sqrt{N}$. The special case of $NAP = 0$ also is interesting; NAP is zero if a bank runs a “balanced book,” with no net position in the domestic currency. GAP again is precisely proportional to portfolio risk: equation (10) shows that $P = GAP\sqrt{(1-\rho)/N}$. The appropriate minimum capital ratio would be $c = \gamma\sigma\sqrt{(1-\rho)/N}$.

Nevertheless, it is clear from (10) that in general a WAP standard cannot be perfectly precise, because WAP depends linearly on GAP and NAP while P depends on the square root of their weighted sum of squares. If a standard based on a weighted root sum of squares of gross and net

exposure were regarded as sufficiently simple, P itself could yield a very precise capital standard. However, such a standard may be regarded as unacceptably complex. Given that the simpler WAP is imprecise, it still may be “close enough” to P to be acceptable.

Equation (10) describes P as a function of net and gross exposure; in three dimensions, P is a portion of an asymmetric cone. In contrast, WAP is affine;¹⁰ it is a plane in three dimensions. The task of devising a capital standard based on WAP can be viewed as one of choosing the weights to make the WAP plane approximate the P cone fairly closely for all n and d , given the number of currencies N and the correlation coefficient ρ . As discussed above, WAP can fit P perfectly only under polar conditions, with $\rho = 0$ or $\rho = 1$. In the general case, WAP can only be made “close” to P ; the fit of the capital standard is tailored by adjusting the relative weights on net and gross exposures, w_n and w_g . The best weighting will depend in part on N and ρ .

VII. OPTIMIZING THE WAP WEIGHTS

The preceding section suggested that WAP might be a good risk measure, balancing simplicity and precision: simple because it builds on current practice and is a linear combination of exposures, and precise because a correct choice of the relative weights on gross and net could make WAP approximate the theoretically correct portfolio composition factor. The Basle Committee’s foreign exchange proposal incorporates a specific weighting, BAP, in which the weights on NAP and GAP are both $1/2$. Are these the best choices? More generally, how should the weights be chosen?

Returning to the simple portfolio model with a fixed number N of foreign currencies and a variance-covariance matrix Σ , assume that bank portfolios differ only in scale. That is, assume that all banks have the same currency mix (reflected in uniform values of n , or equivalently in uniform ratios of NAP to GAP), but may have positions of different sizes (d differs). Let Δ be the common NAP/GAP ratio; Δ reflects the degree of portfolio imbalance, with $\Delta = 0$ for a balanced portfolio, and $\Delta = 1$ if exposure is all long or all short.¹¹ All bank currency portfolios thus lie along a single ray with slope Δ in the NAP-GAP plane,

10. An affine function is the multidimensional equivalent of a linear function; a function f is affine if $f(x) = Ax + b$, where x is a vector of variables, b is a vector of constants, and A is a fixed matrix of constants. In three dimensions, an affine function is a plane.

11. This assumption might not be too unrealistic; banks would have the same, or nearly the same, net currency positions if they all used similar portfolio optimization algorithms to manage exposure.

although as exchange rates change randomly over time Δ is likely to vary.

If w_n and w_g are chosen to make WAP tangent to P along the ray defined by $NAP/GAP = \Delta$, then WAP will be locally precise, in the sense that WAP will equal P for any portfolio scale d selected by individual banks. Moreover, WAP will track changes in risk precisely for local variation in Δ , since tangency equates the partial derivatives of WAP and P with respect to Δ ; first order changes in measured risk would be the same as first order changes in actual portfolio risk.

Formally, since $\Delta = |N - 2n|/N$ it is possible to rewrite WAP and P (from equations (3) and (8)) as functions of Δ and d , given N and ρ :

$$(11) \quad WAP = Nd(w_g + w_n\Delta)$$

and

$$(12) \quad P = Nd \left(\frac{(1-\rho)}{N} + \rho\Delta^2 \right)^{1/2}.$$

Since WAP and P both pass through the origin (that is, both are zero when d is zero), the weights that make WAP tangent to P at a given Δ can be derived by simultaneously equating the partial derivatives of WAP and P :

$$(13) \quad \frac{\partial P}{\partial d} = \frac{\partial WAP}{\partial d} \quad \text{and} \quad \frac{\partial P}{\partial \Delta} = \frac{\partial WAP}{\partial \Delta}.$$

The relevant partial derivatives are:

$$(14a) \quad \frac{\partial P}{\partial d} = N \left(\frac{(1-\rho)}{N} + \rho\Delta^2 \right)^{1/2},$$

$$(14b) \quad \frac{\partial P}{\partial \Delta} = Nd\rho\Delta \left(\frac{(1-\rho)}{N} + \rho\Delta^2 \right)^{-1/2},$$

$$(14c) \quad \frac{\partial WAP}{\partial d} = N(w_g + w_n\Delta),$$

$$(14d) \quad \frac{\partial WAP}{\partial \Delta} = Nd w_n$$

Equating (14a) to (14c) and (14b) to (14d) as in (13) allows solution for the optimal weights w_n^* and w_g^* :

$$(15) \quad w_n^* = \rho\Delta \left(\frac{(1-\rho)}{N} + \rho\Delta^2 \right)^{-1/2}$$

and

$$w_g^* = \frac{(1-\rho)}{N} \left(\frac{(1-\rho)}{N} + \rho\Delta^2 \right)^{-1/2}.$$

Values of the optimal weights can be computed from equations (15) for realistic values of N , ρ , and the ratio Δ . What are reasonable choices of parameters? If N is interpreted as the number of *major* currencies, then ρ might be interpreted as the average correlation coefficient. The vast bulk of currency exposure for U.S. banks is concentrated in six major foreign currencies—German mark, Japanese yen, British pound, Swiss franc, Canadian dollar, and Australian dollar—suggesting $N=6$. The average correlation between biweekly changes in dollar exchange rates of these six currencies (measured over non-overlapping two-year intervals from 1981 through 1992 as described in Section VIII below) ranges from .38 to .56, with a mean of .47. Table 2A presents illustrative calculations of w_n^* and w_g^* based on these parameter values. Besides the six major foreign currencies, U.S. banks tend to have moderate exposures in other currencies such as the Italian lira, French franc and Dutch guilder; to consider the implications of differences in the number of currency positions, Table 2B presents optimal weights for $N=9$.

Even for a given combination of the parameters N and ρ , the accuracy of the WAP approximation varies depending on the NAP/GAP ratio Δ . Thus, in practice the choice of weights for WAP should depend on the range of net and gross positions that regulators aim to fit most closely. For example, other elements of bank supervision may lead most banks to run foreign exchange books that are balanced or nearly balanced, so that the typical NAP (and Δ) is small. In that case, the choice of weights likely would be made from the left-most column of Table 2A or of Table 2B.

There are two ways these weights could be used for capital regulation. Consider the case of $N=6$, $\rho=.47$, and $NAP/GAP=.33$. Under one approach, banks would compute their open foreign exchange positions as 42 percent of their net exposure plus 24 percent of their gross exposure, and might be required to have capital equal to at least 4.4 percent of this sum.¹² This is how the Basle foreign exchange proposal uses WAP in its BAP incarnation. A second approach would combine the capital ratio with the weights w_n^* and w_g^* ; a composite capital charge would be made against the net position, and an additional charge would be made against the gross position. In this example, banks would be required to have at least enough capital to cover 1.8 percent of net exposure (4.4 percent of 0.42) and 1.0 percent of gross exposure. This composite approach

12. The standard deviation of two-week rates of change over the entire 1981-1992 period for the six major foreign currencies was 1.46 percent. Three standard deviations of coverage ($\gamma=3$) would imply a capital ratio of about 4.4 percent to be applied against the aggregate open position.

TABLE 2A

OPTIMAL WAP WEIGHTS WITH $N=6$

	NAP/GAP = 1		NAP/GAP = .67		NAP/GAP = .33		NAP/GAP = 0	
ρ	w_g	w_n	w_g	w_n	w_g	w_n	w_g	w_n
.38	.15	.55	.20	.49	.27	.33	.32	0
.47	.12	.63	.16	.57	.24	.42	.30	0
.56	.09	.70	.13	.66	.20	.51	.27	0

TABLE 2B

OPTIMAL WAP WEIGHTS WITH $N=9$

	NAP/GAP = .78		NAP/GAP = .56		NAP/GAP = .33		NAP/GAP = .11	
ρ	w_g	w_n	w_g	w_n	w_g	w_n	w_g	w_n
.38	.13	.54	.16	.49	.21	.38	.25	.16
.47	.10	.62	.13	.58	.18	.47	.23	.21
.56	.08	.70	.10	.66	.15	.56	.21	.26

would correspond to the treatment in the Basle Committee's equity price risk proposal, the "x plus y" approach.

From (15), the ratio of the WAP weights from the optimal approximation is:

$$(16) \quad \frac{w_n^*}{w_g^*} = \frac{\rho N \Delta}{1 - \rho}$$

This ratio depends positively on ρ , N , and Δ . If exchange rates are highly correlated, then changes in the value of long positions tend to be offset by changes in the value of short positions; net exposure becomes most relevant, and the optimal w_n^* is high relative to w_g^* . With a larger number of foreign currencies, N , diversification eliminates more portfolio risk for any given gross size of the portfolio, and w_g^* is reduced relative to w_n^* . Finally, as Δ goes to zero and portfolios become more balanced (NAP goes to zero), then risk comes to depend mainly on GAP, and the optimal w_g^* becomes large relative to w_n^* .

The Basle Committee's foreign exchange proposal places equal weights on gross and net.¹³ Figure 2 shows combina-

tions of Δ and ρ for which the ratio in equation (16) is equal to one (and the Basle weighting is optimal) for various N . The graph implies that with ρ in the range of .35 to .55, the Basle proposal may be optimal provided bank portfolios are reasonably balanced (with NAP no greater than about 30 percent of GAP). The Basle proposal would be optimal for lower values of ρ if long and short currency positions within portfolios tend to be unbalanced.¹⁴

Capital standards based on WAP are fairly clever. They appear to depend only on the dollar size of positions, and are simple in form; they also appear to ignore correlations between different exchange rates. However, information from the variance-covariance matrix is incorporated in the choice of weights for gross and net exposures: the covariance determines the relative weights, and the variance scales the weights proportionally.

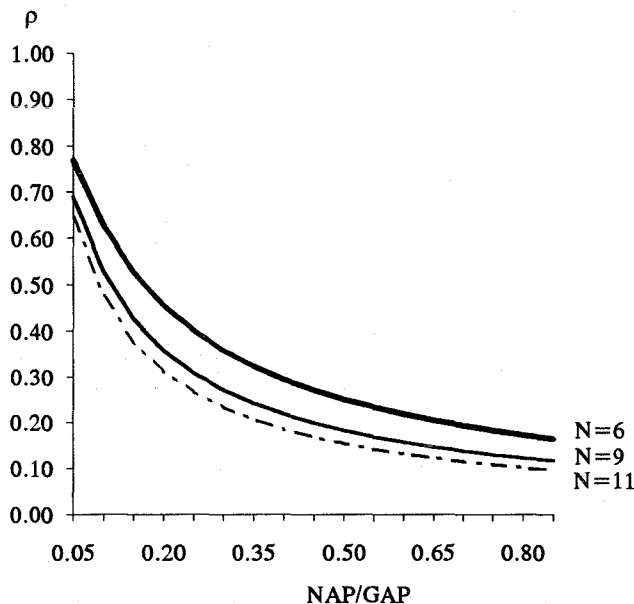
direction for the appropriate degree of coverage. For example, weights of $w_n = .8$ and $w_g = .4$ with a minimum capital ratio of 4 percent have exactly the precision and coverage of $w_n = .4$, $w_g = .2$, and an 8 percent standard.

14. These results suggest that the Basle proposal may weight gross exposure too heavily. However, other risks related to settlement and delivery may be relatively high in transactions involving currency exchange. Those risks plausibly depend on gross exposure; if so, additional capital related to GAP may be warranted.

13. The Basle weights are 0.5 and 0.5, but to evaluate WAP's ability to track risk across banks and over time only the relative weights matter, not their absolute levels. Since WAP is multiplied by a minimum capital ratio to set a standard for capital adequacy, the weights can be scaled up or down proportionally, with the capital ratio scaled in the opposite

FIGURE 2

PARAMETER COMBINATIONS THAT MAKE
EQUALLY WEIGHTED WAP OPTIMAL



VIII. A TEST OF THE BASLE FOREIGN EXCHANGE MEASURE

The analysis in the preceding section suggests that BAP might be expected to work reasonably well in some cases. However, the model used in that analysis makes highly stylized assumptions regarding exchange rate processes and foreign exchange portfolio structures. In practice, banks do not all have the same ratio of NAP to GAP, and may not even be tightly distributed around any particular ratio. Thus, rather than a WAP plane that is tangent along a single ray, the optimal policy might be a plane that leads to small differences between WAP and P for combinations of NAP and GAP over some *range* of Δ ratios, perhaps one minimizing the integral of the squared difference. In addition, relaxation of other simplifying assumptions (such as the special structure of the Σ matrix) may mean that in practice the surface mapping NAP-GAP combinations into σ_p is less regular in form than the P cone described above. Thus, actual bank portfolios probably are scattered around on an irregular surface above the NAP-GAP plane, and the practical question is whether a WAP approximation can be constructed to fit these points acceptably well. Requiring that the result be expressed as a conventional-looking capital ratio applied to WAP adds an additional constraint, that the plane should go through the origin, so that risk is

measured at zero (and no capital is required) if both NAP and GAP are zero.

Considering these real-world wrinkles, the relevant question is an empirical one: Can WAP be made approximately proportional to the actual σ_p ?¹⁵ More specifically, the Basle Committee has proposed BAP, the equally weighted variant of WAP, to gauge exchange rate risk. This section uses a regression approach to evaluate BAP empirically as an affine approximation (see footnote 10) to actual foreign exchange portfolio risk, using data on exchange rates and on banks' foreign exchange positions.

The data on banks' foreign currency positions come from the FFIEC 035 report, a confidential survey of currency exposure conducted by federal banking regulators. The format of the collected data corresponds closely to the theoretical specification of the position vector D above. For the FFIEC 035 report, all of a bank's exposures in any single currency—including those arising from loans, deposits, securities and other sources denominated in foreign currency, both spot and forward—are collapsed into a single hypothetical position, either long or short. The only divergence from the theoretical model is that the positions are denominated in units of foreign currency; for this analysis, they were converted to U.S. dollars using the exchange rate prevailing as of the reporting date.

Currency positions were taken from the December reports for 1990, 1991, and 1992, for all banks in the Twelfth Federal Reserve District. Virtually all of the exposure was in the six major foreign currencies, so only these are considered in the analysis. One notable feature of the FFIEC 035 data is that relatively few banks file the report, reflecting the fact that many banks have immaterial foreign exchange exposure; in the Twelfth District, only 15 banks reported foreign exchange exposures for 12/90, 9 banks for 12/91, and 8 banks for 12/92. Thus, foreign exchange risk may not be a widespread concern, although it may be large for some individual banks. The six individual major currency positions were calculated for each bank, and BAP was computed from these positions.

Portfolio variances for each bank also were calculated from the vector of positions, based on variance-covariance matrices of percentage changes in exchange rates. The FFIEC 035 positions were considered to be typical portfolios that banks could hold at any time, and applied to Σ matrices estimated for specific dates to compute the portfolio variances as they would have been if the portfolios had

15. The theoretical analysis in Section VI investigated the relationship between WAP and P . Under the assumptions of that model, $WAP = P$ implied $\sigma_{WAP} = \sigma_p$, so an analysis of the first condition encompassed the second as well.

been held at those dates.¹⁶ For the matrix estimations, the 1981–1992 period was divided into six two-year subperiods. Two-year subperiods were deemed to be a reasonable compromise: Σ is more likely to be stable over shorter periods, but an estimation period that is too short produces estimates with unacceptably wide confidence intervals. A series of non-overlapping two-week percentage changes in exchange rates was constructed from actual dollar exchange rates within each subperiod for each of the six major foreign currencies. (The two-week convention, initiated by the Basle Committee in testing the proposal, is based on considerations of how rapidly bank portfolio losses due to exchange rate changes can be recognized and acted upon by banks or regulators.) Six variance-covariance matrices (one for each subperiod) were estimated from the percentage changes in exchange rates. Portfolio standard deviations were estimated as $\sigma_p = [D'\Sigma D]^{1/2}$, where each of the observed currency portfolios is characterized by a dollar position vector D . Combining 32 bank portfolios with matrices from six subperiods yielded a data set with 192 observed pairs of $(\sigma_p)_{it}$ and BAP_{it} , one for each bank i in period t .

A rough nonparametric test of the strength of the relationship between BAP and σ_p can be constructed from the rank correlation of the two variables. At a minimum, BAP or any other proposed measure of portfolio risk should yield higher values for higher risk portfolios and lower values for lower risk portfolios. Calculation of the Spearman rank correlation coefficient indicates that BAP and σ_p are highly rank correlated: The coefficient for the entire sample is 0.991, significantly greater than zero at virtually any confidence level.

The high rank correlation is encouraging, but BAP should pass more rigorous tests if it is to be the foundation for a simple yet precise capital standard. In particular, BAP should be roughly proportional to the theoretical portfolio composition factor P , that is $P \approx \beta BAP$. The portfolio standard deviation σ_p then would be approximately equal to $\sigma\beta BAP$, from equation (9). Thus, in a regression of the form:

$$(17) \quad (\sigma_p)_{it} = \alpha + \sigma\beta BAP_{it} + \varepsilon_{it},$$

goodness-of-fit should be high and the coefficient β should be measured with little error; for BAP to be proportional to σ_p , the coefficient α should equal zero. In addition, it may be desirable for β to be stable across subperiods. If those

conditions are satisfied, then BAP is a simple, proportional, and relatively precise measure of foreign exchange portfolio risk. For estimation, the exchange rate standard deviation σ is replaced with the average standard deviation, averaged across the major foreign currencies for each subperiod. Denoting the variance-covariance matrix for subperiod t as Σ_t , the average volatility is computed as the square root of the average variance for each subperiod, or $\bar{\sigma}_t = \sqrt{\text{trace}(\Sigma_t)/6}$. Setting a capital standard then requires an estimate of $\bar{\sigma}$, but this average volatility is constant across banks, and in practice developing a representative estimate should not be hard. A coverage ratio of γ would be achieved by setting a minimum capital ratio of $c = \gamma\bar{\sigma}\beta$.

Two types of heteroskedasticity are likely in estimating (17). One is related to the scale of bank portfolios: the error variance is likely to be higher for larger portfolios. A simple correction for scale-related heteroskedasticity is to divide through by BAP before estimating, creating a transformed equation with errors that are no longer proportional to BAP . The second type relates to the subperiods used to estimate the matrices of exchange rate variances and covariances: In theory, the ability of BAP to match P depends on p for a given number of currencies, and exchange rate correlation coefficients vary across the two-year subperiods. This second source of heteroskedasticity is handled through weighted least squares estimation, allowing the variance of the regression residuals to vary across subperiods.

With the correction for scale-related heteroskedasticity, the equation to be estimated is:

$$(18) \quad \frac{(\sigma_p)_{it}}{BAP_{it}} = \alpha \frac{1}{BAP_{it}} + \bar{\sigma}_t \beta + u_{it},$$

where i is an index for the portfolio, t indexes the sample subperiod, and $u_{it} = \varepsilon_{it}/BAP_{it}$. Estimation results are shown in the first column of Table 3, with standard errors reported in parentheses below each coefficient. \bar{R}^2 is the usual goodness-of-fit statistic corrected for degrees of freedom, and the sum of squared residuals is reported as SSR.¹⁷

The results show that most of the conditions for use of BAP as the basis for a capital standard are satisfied (intertemporal stability is addressed separately below). The estimate of α is insignificantly different from zero and

16. The obvious drawback to this approach is that banks' decisions regarding foreign exchange exposures may depend in part on the variance-covariance matrix of exchange rates. The empirical importance of this problem is left as an issue for future testing.

17. The same regression was run without division by BAP , yielding coefficient estimates that were qualitatively similar to those reported in the table. Inspection of the residuals from both regressions indicated that scale-related heteroskedasticity was in fact an issue in the untransformed regression, and that dividing each observation by BAP largely eliminated the problem.

TABLE 3

ESTIMATION OF EQUATION (18)

	(1)	(2)
α	0.01 (0.01)	— —
β	0.88 (0.01)	0.89 (0.01)
\bar{R}^2	0.970	0.971
SSR	14.70	14.94

the standard error of β is relatively small, so σ_p can be assumed proportional to BAP with relative impunity (given $\bar{\sigma}$). The fit of the regression as measured by the adjusted R^2 is high, perhaps remarkably so considering the simplicity of the BAP approach for measuring market risk. The second column presents the results with the intercept restricted to zero to illustrate the relatively minor effect on β of forcing σ_p to be proportional to BAP.

In equation (18) and Table 3, the slope and the intercept of the relationship between BAP and the portfolio variance are restricted to be the same in each of the sample subperiods. These restrictions on the coefficients must be relaxed if the stability of β is to be evaluated. An alternative regression is:

$$(19) \quad \frac{(\sigma_p)_{it}}{\text{BAP}_{it}} = \sum_{t=1}^6 \alpha_t \frac{1}{\text{BAP}_{it}} + \sum_{t=1}^6 \bar{\sigma}_t \beta_t + u_{it}$$

In this form, restrictions on the coefficients α_t and β_t can be tested with standard F tests.

Table 4 shows the estimation results for equation (19). In the first column, both intercept and slope are allowed to differ for each subperiod. (In effect these are six separate regressions, one for each period, since the error variances also differ across subperiods.) None of the intercepts is significantly different from zero at the 5 percent level. The slope coefficients range from 0.82 for the 1985–1986 period to 0.94 for the 1981–1982 period. In the second column of the table, β is restricted to be the same for all subperiods. The restricted coefficient estimate is 0.88; in this form, α is significantly different from zero for the 1981–1982 and 1989–1990 subperiods. An F test of the β restrictions yields a test statistic of 2.91, with 5 and 180 degrees of freedom; this value lies between the 95th percentile of the F distribution (2.26) and the 99th percentile (3.12). Thus, although β is not truly stable, it is not terribly unstable. Additional testing reveals that the 1983–

TABLE 4

ESTIMATION OF EQUATION (19)

	NO RESTRICTIONS	β RESTRICTED	α RESTRICTED
α_{81-82}	0.03 (0.02)	0.04 (0.02)	0.01 (0.01)
α_{83-84}	0.00 (0.01)	-0.01 (0.01)	0.01 (0.01)
α_{85-86}	0.00 (0.02)	-0.01 (0.02)	0.01 (0.01)
α_{87-88}	0.02 (0.01)	0.03 (0.01)	0.01 (0.01)
α_{89-90}	0.03 (0.02)	0.04 (0.01)	0.01 (0.01)
α_{91-92}	-0.02 (0.02)	-0.01 (0.02)	0.01 (0.01)
β_{81-82}	0.94 (0.04)	0.88 (0.01)	0.96 (0.04)
β_{83-84}	0.83 (0.03)	0.88 (0.01)	0.82 (0.03)
β_{85-86}	0.82 (0.03)	0.88 (0.01)	0.81 (0.02)
β_{87-88}	0.92 (0.03)	0.88 (0.01)	0.93 (0.03)
β_{89-90}	0.94 (0.04)	0.88 (0.01)	0.95 (0.03)
β_{91-92}	0.91 (0.04)	0.88 (0.01)	0.89 (0.04)
\bar{R}^2	0.961	0.970	0.959
SSR	12.66	13.69	13.22

1984 and 1985–1986 periods are statistically different from the other subperiods; an F test fails to reject the hypothesis that β takes one value (0.82) for 1983–1986, and a second value (0.93) for the remainder of the sample. The fact that even the statistically different coefficients for the 1983–1986 period are in the rough vicinity of the other estimates suggests that the Basle approach may be workable.

The third column of Table 4 shows the effects of restricting the intercept across subperiods. As would be expected from the first column of the table, an F test does

not reject this restriction. The restricted intercept is not significantly different from zero, making a BAP-based proportional capital standard feasible. The primary conclusion from the regressions is that BAP is approximately proportional to P . The F tests imply that the factor of proportionality β is fairly stable over time, and that the value of P is typically about 80 to 95 percent of BAP.

One concern in moving from equation (19) to the construction of practical capital standards is that β is the factor of proportionality between P and BAP, whereas the ratio of σ_p to BAP at time t is actually $\bar{\sigma}_t\beta_t$. Thus, evidence that β_t is fairly stable might be of limited relevance, since the combination $\bar{\sigma}_t\beta_t$ may not be. Additional regressions were run with $\bar{\sigma}_t$ set equal to 1.0 in both (18) and (19), a restriction which effectively forces the coefficient β to incorporate the effects of exchange rate volatility σ , and therefore permits direct tests of the stability of $\bar{\sigma}_t\beta_t$. The results were not materially different from Tables 3 and 4, and so are not reported; goodness-of-fit was comparable, the intercepts were still insignificant, and the stability results for the slope coefficient were the same. As would be expected, the values of the β coefficients were higher, reflecting the fact that they include a $\bar{\sigma}$ factor that averages 1.46 over the entire sample period.

Using the restricted estimate of $\beta = 0.88$, the portfolio standard deviation is $\sigma_p \approx 0.88\bar{\sigma}\text{BAP}$. Based on the average $\bar{\sigma}$, capital equal to 1.28 percent (88 percent of 1.46) of the typical bank's BAP is sufficient to cover one standard deviation of changes in the value of the bank's aggregate foreign currency portfolio. If three standard deviations of coverage is considered desirable (a level which would cover all but 0.13 percent of the probable losses under a normal distribution), then the minimum capital ratio should be 3.85 percent of BAP. The Basle Committee has proposed applying an 8 percent ratio to BAP. Even taking the highest estimate of β from Table 4 (0.96 from the 1981–1982 subperiod with α restricted) and the highest $\bar{\sigma}_t$ (1.86 percent for 1985–1986), three standard deviations of coverage would correspond to a 5.36 percent capital ratio. Under these extreme assumptions, 8 percent capital provides about 4.5 standard deviations of coverage. Thus, while BAP appears to be a reasonably precise measure of risk, the proposed level of capital coverage appears to be very conservative. Such an apparently excessive degree of coverage might be justified as compensating for errors in the BAP approximation. Alternatively, regulators may want to allow for non-normality in the statistical distribution of exchange rate changes; stochastic processes may incorporate discrete random jumps, or distributions may be leptokurtic (fat-tailed).

IX. SOME COMMENTS ON THE OTHER MARKET RISKS

A similarly detailed analysis of the equity and traded debt (or interest rate) components of the Basle Committee's market risk proposals is beyond the scope of this paper, and is deferred for future research. However, a few observations can be made about particular aspects of these other drafts.

As noted in Section V, the Basle proposal for equity price risk gives gross exposure less weight in diversified portfolios than in undiversified portfolios. The analysis in Section VII indicates that this difference in weighting may be appropriate: For WAP to approximate P , NAP should get more weight relative to GAP when the number of positions is large. (Recall from (16) that w_n^*/w_g^* increases with N .) The equity proposal also gives GAP less relative weight than it is given in the foreign exchange proposal. Such a difference in weights is appropriate if the number of different issues in a diversified portfolio of equities is larger than the number of currencies in a typical bank currency portfolio, a reasonable assumption. Finally, calculations of return variances for the 30 stocks in the Dow Jones Industrial Average indicate that stock returns tend to be more volatile than exchange rate changes. Thus the higher coverage levels implicit in the equity proposal may be desirable (the composite capital weights on GAP and NAP are 4 percent and 8 percent respectively for diversified portfolios, and 8 and 8 for undiversified portfolios, compared to 4 percent and 4 percent for foreign exchange).

The traded-debt-instruments proposal also seems at least superficially in accord with the conceptual model. As discussed in Section V, the netting/disallowance process in the proposal effectively applies WAP in stages. WAP is a simple measure of portfolio risk for any portfolio, including sub-portfolios of, for example, Zone 2 (medium-term) securities. Thus, this proposal can be construed as an attempt to compute simple but accurate measures of position for various sub-portfolios, then combine these in a building-block approach to obtain a measure of total interest rate risk for the debt portfolio. In practice, the traded-debt framework may provide a better measure of risk than either the foreign exchange or the equity market risk components; both of those proposals use a single pair of weights on gross and net exposures for all portfolios, whereas the debt proposal in effect permits some flexibility in the NAP/GAP weighting. Allowing the weights to vary somewhat according to the composition of a bank's debt portfolio could provide superior results. Another desirable feature of the proposal is that differing volatilities of maturity bands are recognized directly, through the pre-multiplication by risk weights; in contrast, the foreign ex-

change proposal does not account for the fact that some exchange rates tend to vary more than others.

As equation (5) shows, the weights on gross and net in the interest rate risk proposal are determined by the disallowance factors; higher disallowance factors give relatively more weight to GAP versus NAP. Section VII indicates that an emphasis on GAP is desirable if the correlations between instruments in a portfolio (or subportfolio) are low. The Basle Committee's proposed disallowance factors are lowest within maturity bands, somewhat higher across bands within a single zone, and higher still across zones, with the highest disallowance factor (1.5) applying to netting between the short-term and long-term zones. These differences appear to correspond to the empirically observed pattern of correlations between interest rate changes across the term structure. Thus, the general pattern of disallowances seems roughly appropriate, although a more confident conclusion would require careful analysis of the entire proposal.¹⁸

Future research should consider applying regression analysis to both the equity and interest rate proposals, as was done in this paper for empirical analysis of the foreign exchange proposal. One difficulty is that data on bank positions with respect to these other market risks are inferior to the FFIEC 035 currency data. Central banks in various countries have done some confidential analyses of this type.

X. CONCLUSION

The recent proposals from the Basle Committee for incorporating market risks into risk-based capital standards are coherent and sensible, embodying a unified underlying theme: The minimum adequate level of bank capital is computed as a ratio of capital to risk exposure, with exposure measured as a weighted sum of gross and net positions from a hypothetical composite portfolio for each

bank. The conceptual model developed in this paper suggests that this approach can produce capital standards that are reasonably accurate, and at the same time are simple enough to be practical. A weighting of gross and net exposures (the WAP approach) can be viewed as an affine approximation (the equivalent of linear in several dimensions) to the true portfolio variance, and hence can link capital standards fairly tightly to portfolio risk in order to prevent failure probabilities from reaching excessive levels. A system based on a weighted root sum of squares of gross and net would be more precise, but also more complex.

Empirical testing of the foreign exchange proposal was based on exchange rate data for the six major non-U.S. currencies from 1981–1992 and a recent sampling of actual U.S. bank currency positions. The results indicate that the measurement framework proposed by the Basle Committee tracks foreign exchange rate risk remarkably well, capturing over 95 percent of the total variation in foreign exchange risk across the sample of banks. However, the level of coverage implicit in the 8 percent capital ratio may be somewhat high.

Conclusions regarding the equity price risk and interest rate risk proposals are tentative, since a detailed empirical analysis was not conducted in this paper. However, an initial reading of the other two market risk proposals against the background of the conceptual model suggests that they incorporate a number of appealing features.

Unfortunately, neither the common thread running through the market risk proposals nor the desirable properties of the WAP approach have been articulated clearly in the consultative documents released for public comment. The equity risk proposal is the only one of the three that explicitly describes the capital charge as a weighting of gross and net exposures, and that presentation is muddled by a discussion of "general risk" and "specific risk" that has little to do with the analytical merits of WAP. The interest rate risk proposal, as described above, uses a system of netting with "disallowances" to accomplish the weighting, which obscures the fact that the proposal is fundamentally a WAP calculation. The foreign exchange draft does point out that the proposal reflects the assumption of "some, but not perfect, correlation between the movements of different exchange rates" (Basle Committee, 1993, p.39). However, the aggregate foreign exchange position calculation is described as "the sum of the short positions or the sum of the long positions, whichever is the greater" (*ibid.*, p.38); as shown in Section IV, this is equivalent to equally weighted WAP, but the equivalence may not be obvious.

The Basle Committee is international, and the proposed standards are to apply internationally. This paper evaluates

18. Federal banking regulators in the United States have proposed a somewhat different approach to measuring interest rate risk for capital adequacy. The U.S. proposal is similar to the Basle proposal in the construction of a hypothetical portfolio broken into time bands, and the use of risk weights based on potential changes in the value of debt instruments when rates change. However, the U.S. proposal makes no use of "disallowance factors," implicitly setting δ to zero. As demonstrated above, $\delta = 0$ makes WAP equivalent to NAP, with no weight on gross exposure; this is in effect the approach taken by U.S. regulators, with long exposures in any time band netted against short exposures in any other band. As also shown above, NAP is the correct measure if $\rho = 1$, that is, if rates in all time bands are perfectly correlated. The Basle approach using disallowances can be viewed as a simple way to incorporate the fact that correlations across the yield curve are not perfect.

the proposals solely from a U.S. perspective; results for other countries might differ. Parallel analyses have been, and continue to be, pursued at other central banks around the world. Obviously, the final form of the market risk standards will be the result of international negotiation and agreement, and agreement will depend on how well the proposals meet the needs of the many countries involved. The Basle Committee also has suggested that the standards could be applied to other types of financial firms, such as securities houses and insurance companies, if regulators in those industries agree. Introducing an interindustry dimension adds to the challenge of reaching a consensus, and complicates any complete analysis of the market risk proposals.

As a final note, throughout the Basle documents (and this paper) each of the many types of risk—including credit risk, exchange rate risk, equity price risk, and interest rate risk—is considered and treated separately from the others. Such a presumption of separability may not be realistic in view of the likely interactions among these various sources of risk. Ideally, capital regulations should consider all types of risk simultaneously in a unified framework. However, breaking the capital adequacy problem into more manageable pieces may be the only practical approach, and separability may be a workable approximation. The possible damage done by this assumption should be the subject of future research.

APPENDIX

This appendix describes one of a number of ways to demonstrate the transition from equation (6) to equation (7) in the text. The variance of a portfolio of N currencies with equal variance and correlation, slightly modified from (6), is:

$$(A1) \quad \sigma_p^2 = \sigma^2 \sum_{i=1}^N d_i^2 + 2\sigma^2\rho \sum_{i=1}^{N-1} \sum_{j=i+1}^N d_i d_j.$$

The crux is evaluation of the summation terms. Note that by assumption each of the d_i is either d (for long positions) or $-d$ (for shorts). Clearly $d_i^2 = d^2$ for either type of position, so the first summation is simply d^2N .

The second term involves the double summation of products of positions in all pairs of foreign currencies. The total number of pairings in a set of N objects is $N(N-1)/2$, so this is the total number of $d_i d_j$ terms. These terms fall into three groups:

$$\begin{aligned} \text{Both currencies long: } d_i d_j &= d^2 \\ \text{Both currencies short: } d_i d_j &= d^2 \\ \text{One long, one short: } d_i d_j &= -d^2 \end{aligned}$$

If the positions were either all long or all short, then the terms in the double summation would sum to $d^2N(N-1)/2$. However, by assumption there are n short positions and $N-n$ long positions. The number of pairings of x objects with y objects is xy ; hence the number of short-long pairs is $n(N-n)$. It follows that the number of $d_i d_j = d^2$ pairs is not the maximum number $N(N-1)/2$, but rather $N(N-1)/2 - n(N-n)$. In addition, of course, each of the $n(N-n)$ positions with opposing signs contributes $d_i d_j = -d^2$ to the sum. Hence:

$$(A2) \quad \sum_{i=1}^{N-1} \sum_{j=i+1}^N d_i d_j = d^2 \left(\frac{N(N-1)}{2} - n(N-n) \right) - d^2 n(N-n).$$

Substituting this into the expression for the portfolio variance in (A1) gives:

$$\begin{aligned} (A3) \quad \sigma_p^2 &= \sigma^2 d^2 N + \sigma^2 d^2 (N(N-1) - 4n(N-n))\rho \\ &= \sigma^2 d^2 N + \sigma^2 d^2 ((N-2n)^2 - N)\rho \\ &= \sigma^2 d^2 N (1-\rho) + \sigma^2 d^2 (N-2n)^2 \rho \end{aligned}$$

as asserted in the text.

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Are Exchange Rates Macroeconomic Phenomena?

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This paper argues that macroeconomic variables are relatively unimportant determinants of exchange rates. The argument hinges on the fact that bilateral exchange rate volatility differs widely across pairs of countries, but macroeconomic volatility is much more similar across countries, at least at short- and medium-term frequencies. For instance, the French Franc/German Deutschmark exchange rate has dramatically lower volatility than the Canadian dollar/German Deutschmark rate, although France and Canada have approximately equal macroeconomic volatility vis-à-vis Germany.

I. INTRODUCTION

Most economists think that macroeconomic phenomena drive exchange rates. For instance, many economists believe that the 1992–1993 European Currency Crisis was the result (at least in part) of the Bundesbank's tight monetary policy, itself a response to the inflationary pressures generated by German unification. For another instance, the appreciation of the U.S. dollar in the early 1980s is frequently attributed to either Reagan's loose fiscal policy or Volcker's tight monetary policy, or both. Finally, most economists who model the exchange rate either theoretically or empirically, use macroeconomic models.

In this paper, I argue that macroeconomic phenomena are not especially important forces in driving exchange rates; there must be other things which are at least as important which also determine exchange rates, at least at short- and medium-term frequencies. While it is undeniable that macroeconomic forces are sometimes important, in this paper I seek to show that many shocks that drive exchange rates are not macroeconomic in nature.¹

My argument is quite simple. Suppose that we treat Germany as the domestic country. Exchange rates of various OECD countries have significantly different exchange rate regimes vis-à-vis Germany. In particular, the countries that participate in the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS), like Belgium, France, and the Netherlands, have relatively fixed exchange rates with Germany. On the other hand, a number of other countries, like Canada, Japan, and the United States have exchange rates which float relatively freely vis-à-vis Germany. Thus exchange rate volatility differs significantly by partner country. However, this is not true of macroeconomic variables. Most OECD countries have quite similar macroeconomic volatility: Germany's macroeconomic volatility vis-à-vis the ERM countries is not significantly different from Germany's macroeconomic volatility vis-à-vis the floating-rate countries. This fact has implicitly been noticed before in, e.g., Baxter and Stockman (1989). Flood and Rose (1993) use a similar logic, but compare individual countries over time rather than different countries across the same interval of time.

1. Sometimes of overwhelming importance, for instance, during hyperinflation.

Most countries manage their exchange rates in some way. But if macroeconomic variables do not account for much exchange rate volatility, then adjusting macroeconomic policies probably will not change the stability of exchange rates much. Thus the purpose of this paper is to understand the determinants of exchange rates better, and thereby allow policymakers to devise more effective tools to manage exchange rates. I am also interested in whether there appears to be an identifiable tradeoff between macroeconomic stability and exchange rate volatility.

The next section lays out the theoretical analysis; the data are then presented in Section III. The actual empirical results are presented in Section IV, which is followed by a brief conclusion.

II. THEORY

The theoretical model I use is the simplest possible macroeconomic model of the exchange rate; it is a monetary model with flexible prices. I choose this model for two reasons. First, it is frequently used by economists. Second, it is also extremely simple to manipulate and understand. However, I will show explicitly that the lessons one can learn from the simple monetary model generalize in a very natural way to a much broader class of macroeconomic models of the exchange rate. Thus one should think of the monetary model as a paradigm rather than as a literal description of reality.

I assume that domestic residents are allowed to hold three assets: domestic money, domestic bonds, and foreign bonds. Money is held to finance domestic (consumption) transactions; money demand depends negatively on the domestic interest rate, and positively on output. I assume for simplicity that the money demand function is linear in natural logarithms (except for the interest rate). The equation that describes equilibrium in the domestic money market is thus:

$$(1) \quad m_t - p_t = \beta y_t - \alpha i_t + \epsilon_t,$$

where m_t denotes the (natural logarithm of the) stock of money at time t , p denotes the price level, y denotes real income, i denotes the (level of the) nominal interest rate, and ϵ denotes a shock to money demand. It is important to note that the equation is explicitly stochastic. Indeed, I need not assume that ϵ is observable or particularly "well-behaved"; it need not have a mean of zero, nor be either independent or identically distributed over time, so long as it is stationary. It is worth noting explicitly that α is modeled as a structural parameter (as is β).

For simplicity, I assume that there is a comparable equation for the foreign country, and that domestic and foreign elasticities are equal:

$$(1') \quad m_t^* - p_t^* = \beta y_t^* - \alpha i_t^* + \epsilon_t^*,$$

where an asterisk denotes a foreign variable. Subtracting (1') from (1) and rearranging yields:

$$(2) \quad (p - p^*)_t = \alpha(i - i^*)_t + (m - m^*)_t - \beta(y - y^*)_t - (\epsilon - \epsilon^*)_t.$$

I next assume that goods prices are perfectly flexible in both countries. While admittedly unrealistic, this turns out to be a useful simplifying assumption; nothing of substance hinges on this postulate in the argument that follows. I will discuss informally the impact of loosening this assumption later on; Flood and Rose (1993) deal with this matter more rigorously.

I also assume that there are no large barriers to international trade, either natural (e.g., transportation costs or differences in natural preferences) or artificial (e.g., tariffs or other barriers to trade). That is, I assume that purchasing power parity holds, at least up to a disturbance term:

$$(3) \quad (p - p^*)_t = e_t + v_t,$$

where e denotes the domestic price of a unit of foreign exchange, and v is a stationary disturbance from purchasing power parity, assumed to be "small" in a sense that will be defined more precisely below.

Substituting this equation into (2), it is trivial to solve for the exchange rate:

$$e_t = \alpha(i - i^*)_t + (m - m^*)_t - \beta(y - y^*)_t - (\epsilon - \epsilon^*)_t - v_t$$

or

$$(4) \quad e_t - \alpha(i - i^*)_t = (m - m^*)_t - \beta(y - y^*)_t - (\epsilon - \epsilon^*)_t - v_t.$$

It is important to note that this equation is structural, and does not rely on important exogeneity assumptions (e.g., about the nature of the output, the exchange rate regime, or the sources of ϵ shocks). (The reason for combining exchange and interest rates on the left-hand side of (4) will be rationalized explicitly below.)

Domestic and foreign bonds are assumed to be perfect substitutes vis-à-vis risk, liquidity, tax treatment, and so forth. It will sometimes be convenient to assume that agents are risk-neutral and have rational expectations so that uncovered interest parity (UIP) holds:

$$(5) \quad (i - i^*)_t = E_t(de_t)/dt,$$

where $E_t(de_t)/dt$ is the expected rate of change of the exchange rate. However, none of the analysis I present relies on UIP. Below, I discuss the impact of allowing for deviations from UIP, which are well-known to be important empirically.

By substituting (5) into (4), the "flexible-price monetary model" can be written:

$$(6) \quad e_t - \alpha E_t(de_t)/dt = f_t \equiv (m - m^*)_t - \beta(y - y^*)_t - (\epsilon - \epsilon^*)_t - \nu_t,$$

where f_t denotes the "fundamental determinant" of the exchange rate.²

The objective of this paper is to investigate the fundamental determinants of exchange rates. I consider two different approaches to measuring fundamentals empirically.

In the flexible-price model, fundamentals are traditionally defined as:

$$(7) \quad TF_t \equiv (m - m^*)_t - \beta(y - y^*)_t - (\epsilon - \epsilon^*)_t.$$

Fundamentals in the monetary model of exchange rates with flexible prices are typically defined as TF (although sometimes the ϵ terms are set to zero); hence I call this measure "traditional fundamentals," denoted TF . This variable can be measured with data on money, income, shocks to monetary equilibrium, and the parameter β .

TF differs from the right-hand side of (6) by ν . Thus traditional fundamentals are equal to the right-hand side of (6) under the assumption that deviations to purchasing power parity are identically zero. Under the more realistic assumption that such shocks are negligible in the sense that their conditional volatility is low compared to the conditional volatility of TF , the latter differs from the right-hand side by the measurement error ν .

Traditional fundamentals represent the right-hand side of equation (4). However, the left-hand side can also be measured directly. Thus, a different measure of fundamentals is:

$$(8) \quad VF_t \equiv e_t - \alpha(i - i^*)_t.$$

VF denotes "virtual fundamentals."

It was not necessary to make the assumption of uncovered interest parity in deriving (8). However, if UIP holds, then virtual fundamentals can be used as an empirical measure of "fundamentals" f in the context of any single-factor exchange rate model, as is apparent in (6). Thus the hypothesis of UIP explains the functional form of virtual (and traditional) fundamentals, but is not a requisite component of the analysis.

Virtual fundamentals and the exchange rate will be highly correlated if either α is small or the volatility of the interest differential is low (or both). Virtual (like traditional) fundamentals are observable; one only needs data on exchange rates, interest rates, and a choice of the α parameter. Virtual fundamentals, in contrast to traditional fundamentals, use high-frequency asset-market data

(rather than coarser-frequency macroeconomic data). However, the two sets of fundamentals should behave similarly if the model describes reality "well."

If equation (4) holds exactly, then (7) and (8) are two different ways of measuring the same latent variable, namely, exchange rate fundamentals f . More generally, if the monetary model with flexible prices describes the actual data well, virtual and traditional fundamentals should have similar characteristics. Conversely, if virtual and traditional fundamentals are strikingly different, then this fact is strong evidence against the underlying model. Both virtual and traditional fundamentals are model-based, use raw economic data, and rely solely on the structural equation (4).

Much of the analysis that follows hinges on comparing characteristics of VF and TF . A particularly interesting characteristic to compare is conditional volatility; I use the standard deviation of the first difference of TF and VF . This statistic is a good choice for a few reasons. First, it is intrinsically interesting to policymakers concerned with exchange rate volatility. Second, as Meese (1990) shows, conditional volatility has proven to be difficult to explain with current exchange rate models. Third, it allows me to avoid various statistical issues associated with the potential nonstationarity of fundamentals. Finally, conditional volatility varies in an interesting and systematic way across countries with different exchange rate regimes and different measures of fundamentals. In particular, the volatility of virtual fundamentals differs systematically across currencies; unsurprisingly, fixed exchange rates have systematically lower conditional exchange rate volatility than more flexible rates. However, the conditional volatility of traditional fundamentals is, broadly speaking, similar across countries.

It is important to note in passing that my use of the term "fundamental" should not be taken to mean "exogenous," and I will certainly not assume that fundamentals are exogenous in the empirical work which follows. (This should be clear, since the empirical results of the paper stem from comparing measurements of both sides of equation (4), a structural equation.) The logic of the monetary model indicates that if the exchange rate is fixed perfectly, the money supply is endogenous; traditional fundamentals could only conceivably be exogenous for a country with perfectly freely floating exchange rates. Since most exchange rates are managed in some way, it would be wholly unreasonable (in the context of this theoretical model) to claim that fundamentals are exogenous. It is also unnecessary for me to assume that the exchange rate regime itself is exogenous.

2. In many empirical exercises, the ϵ shocks are assumed to be zero, $E_t(de_t)/dt$ is measured, and then various moments of the exchange rate are compared with those of fundamentals and $E_t(de_t)/dt$; Meese (1990) provides references. Here, I eschew explicit measurement of $E_t(de_t)/dt$.

III. THE DATA SET

My empirical work focuses on bilateral German Deutsche-mark exchange rates from 1960 through 1992 inclusive. I choose this sample because I am interested in comparing exchange rates and their fundamental determinants during a recent and interesting period; this period also happens to be one with a relatively high level of capital mobility. The fact that the sample includes regimes of both fixed and floating rates will also turn to be advantageous. Germany is chosen to be the home country since the Deutsche-mark is an important currency which has been the core of the fixed-rate ERM (and earlier of the "Snake"), while simultaneously floating against currencies like the yen and the U.S. dollar.

The data set is quarterly, and was extracted from the IMF's *International Financial Statistics* CD-ROM; it has been checked and corrected for transcription and rebasing errors. Since Germany is considered to be the domestic country, exchange rates are measured as the Deutsche-mark (DM) price of one unit of foreign exchange. The consumer price index is used to measure prices; short-term money market rates are used for interest rates (except in the cases of Canada, Sweden, and the U.K., where Treasury bill interest rates are used so as to maximize sample availability). All the series are transformed by natural logarithms, except for interest rates; the latter are annualized and measured as nominal rates divided by 100 so that e.g., an interest rate of 8 percent is used as .08. I consider eight industrial countries (above and beyond Germany): Belgium (which maintains a currency union with Luxembourg), Canada, France, Japan, the Netherlands, Sweden, the United Kingdom, and the United States.³

Time series graphs of the raw exchange rate data (not transformed by logarithms) are presented in Figure 1. I note that the nominal exchange rates are obviously quite stable during the Bretton Woods era. However, volatility during the period after the collapse of Bretton Woods in 1973 is currency-specific; ERM currencies are observably less turbulent than more freely floating currencies such as the dollar and the yen, at least vis-à-vis the DM.

IV. EMPIRICAL RESULTS

In this part of the paper, I construct both virtual and traditional fundamentals for eight different countries, throughout using Germany as the base country. I then compare

the different proxies for fundamentals. One key conclusion emerges; *the volatility of virtual fundamentals differs widely across countries, but the volatility of traditional fundamentals does not*. Throughout, I attempt to show that this key result is relatively insensitive, for instance, with respect to reasonable perturbations in the parameters, or to the exact form of the structural equations such as the asset market equilibrium condition.

I begin by considering virtual fundamentals.

Virtual Fundamentals

Virtual fundamentals are the left-hand side of equation (4), and are defined as $VF_t \equiv [e_t - \alpha(i - i^*)_t]$. Given that exchange rates and interest rates are observable, the construction of virtual fundamentals requires only one piece of nonobservable information, namely, α .

The literature indicates that α , the interest semi-elasticity of money demand, is likely to be a small number (see, e.g., the discussion in Flood et al. (1991)). I believe that a value of $\alpha = 0.1$ is reasonable, and that $\alpha = 1$ is excessively high. While I believe that $\alpha = 0.5$ is implausibly high, I pick it as the default value so as to make the case under adverse conditions (lower, more realistic, values of α will typically strengthen the argument of the paper, since VF trivially converges to e as α shrinks). However, it turns out that the main results do not really depend on α that much; even α values of substantially greater than unity deliver the main point. This robustness will be demonstrated directly with sensitivity analysis.⁴

Figure 2 is a series of time series plots of the levels of virtual fundamentals for all eight countries, using the default value of $\alpha = .5$ and the entire sample period. (Analogues for my preferred value $\alpha = 0.1$ lead to similar conclusions.) As in Figure 1, the scales of Figure 2 vary by country. Clearly, the plots are related and similar to those of the level of the exchange rate presented in Figure 1. Thus, the series are all relatively stable during the Bretton Woods era of fixed exchange rates and more volatile after 1973 for countries that float freely against the DM. However, ERM

4. I have attempted to estimate α directly. I derive the estimating equation by using UIP and taking first-differences: $\Delta e_t = \alpha \Delta(i - i^*)_t + \eta_t$, where the fundamental process is given by $f_t = f_{t-1} + \eta_t$ and η is a well-behaved disturbance term (white noise if f_t is a random walk).

To estimate this equation, I use IV, using three lags of both Δe and $\Delta(i - i^*)$ as instrumental variables. The results are poor in the sense that $\hat{\alpha}$ is usually imprecisely estimated, usually with a *negative* point estimate. (While I doubt that the instrumental variables are highly correlated with the regressor, OLS delivers similar results.) I have also tried to estimate α directly through various money demand equations with similarly poor results; α typically turns out to be small and insignificant, often negative.

3. My STATA 3.0 programs and data set are available upon receipt of one formatted high-density 3.5" diskette along with a self-addressed stamped envelope.

FIGURE 1

DM PRICE OF FOREIGN EXCHANGE

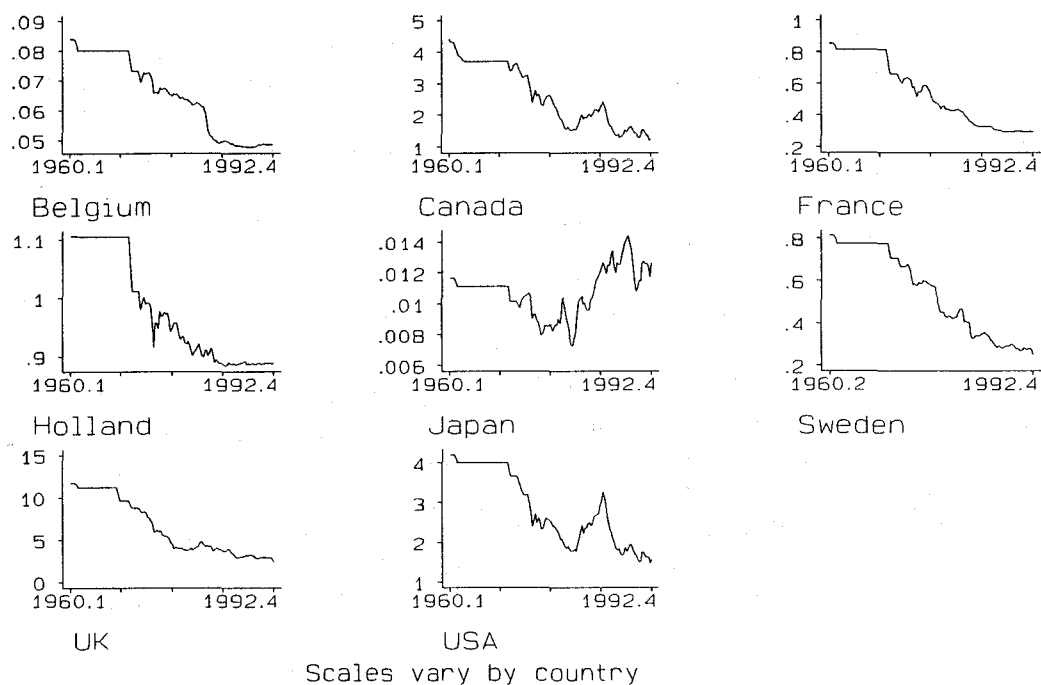
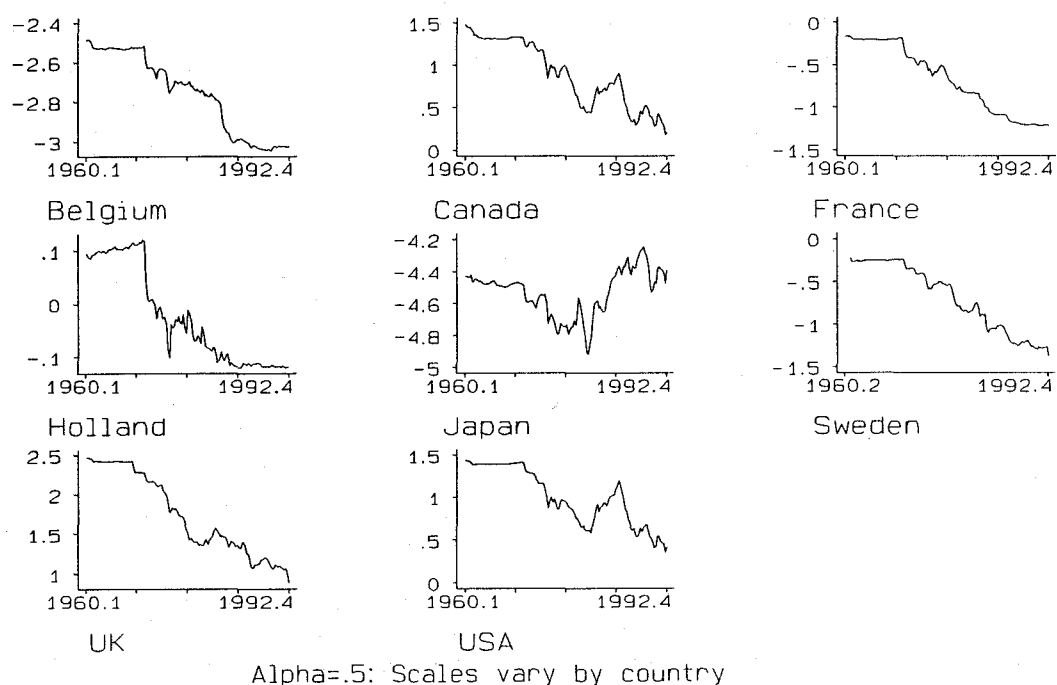


FIGURE 2

VIRTUAL DM FUNDAMENTALS



participants have more stable virtual fundamentals; for instance, Holland, which has pursued a policy of pegging rigorously to the DM, has a very stable virtual fundamental. That is, the graphs show a striking phenomenon which is central to this paper, namely that *the volatility of virtual fundamentals is much higher for floating currencies than for currencies that are fixed*. This result does not depend on the exact choice of α .

Traditional Fundamentals

I now consider the right-hand side of equation (4), i.e., traditional fundamentals, defined to be: $TF_t \equiv [(m - m^*)_t - \beta(y - y^*)_t - (\epsilon - \epsilon^*)_t]$.

At first glance, it appears to be difficult to produce empirical measures of traditional fundamentals. While money and income are readily observable, one needs an estimate of β , the income elasticity of money demand. Money demand functions are notoriously unstable and unreliable, making β a difficult parameter to estimate with any sense of reliability. For the same reason, the ϵ terms, which represent shocks to money demand, are an additional source of difficulty in measuring traditional fundamentals precisely.

Nevertheless, it turns out that for simple money demand functions, the only additional information that is actually required to build traditional fundamentals is a measure of prices. This can be seen by considering a linear regression of the differential form of the money demand function (i.e., the difference between domestic and foreign money demand functions, $(1) - (1')$):

$$(9) \quad (m - m^*)_t - (p - p^*)_t = \beta(y - y^*)_t - \alpha(i - i^*)_t + (\epsilon - \epsilon^*)_t$$

$$\Rightarrow (\hat{\epsilon} - \epsilon^*)_t \equiv [(m - m^*)_t - (p - p^*)_t] - [\hat{\beta}(y - y^*)_t - \hat{\alpha}(i - i^*)_t]$$

Recall

$$(7) \quad TF_t \equiv (m - m^*)_t - \beta(y - y^*)_t - (\epsilon - \epsilon^*)_t$$

$$\Rightarrow T\hat{F}_t = (m - m^*)_t - \hat{\beta}(y - y^*)_t - \{[(m - m^*)_t - (p - p^*)_t] - [\hat{\beta}(y - y^*)_t - \hat{\alpha}(i - i^*)_t]\}$$

$$(10) \quad \Rightarrow T\hat{F}_t = (p - p^*)_t - \hat{\alpha}(i - i^*)_t$$

It might be objected that a simple static (differential) money demand function such as (9) is likely to fit the data extremely poorly. While this point is surely true, my interest in (9) is peripheral, since I am most interested in

the *conditional innovations* of the traditional fundamentals. Including extra lagged terms in (9), which would improve the fit of the money demand model, will not change the conditional volatility of traditional fundamentals. Thus the levels of TF are less interesting to me than its first difference.

Time series plots of the levels of TF are presented in Figure 3; again the scales are country-specific. There are some differences across countries in TF volatility, and also differences for a given country between periods of fixed and floating rates. However, these differences tend to be relatively small and subtle. Thus, *in contrast with virtual fundamentals, the volatility of traditional fundamentals does not vary dramatically across countries*. This conclusion also does not depend on the exact value of α chosen.

Comparing Alternative Measures of Fundamentals

I now compare virtual and traditional fundamentals for the flexible-price monetary model.

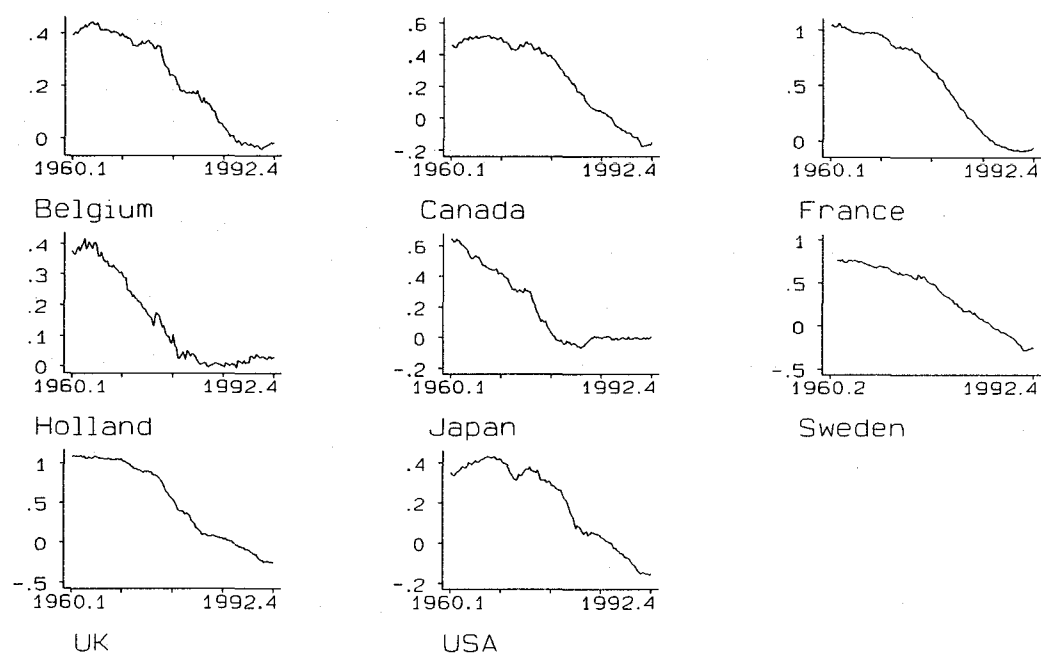
While Figures 2 and 3 can be used to compare virtual and traditional fundamentals informally, they are somewhat unhelpful in a number of respects. First, the scales on the "small multiple" graphics vary by country. Second, they do not emphasize the object of greatest interest, namely, the conditional innovations in fundamentals. This is especially important, given the issue of dynamic specification of the money-demand function which was discussed in the previous subsection. Finally, the distinctive properties of VF and TF can be easily emphasized by a close examination of an interesting subsample, namely, the period since the first quarter of 1979. This sample corresponds to the effective lifetime of the European Monetary System (EMS).

Figures 4 and 5 are analogues to Figures 2 and 3 in that they are respectively time series plots of virtual and traditional fundamentals for the eight countries. However, Figures 4 and 5 have three different features from Figures 2 and 3: (1) scales are comparable across countries within a figure (though still not across figures); (2) the sample is restricted to the period since the beginning of the EMS; and (3) the first differences (rather than the levels) are plotted. If fundamentals follow a random walk, then the first-difference is also the innovation.⁵ Incorporating these features makes it much easier to compare traditional and virtual fundamentals.

5. The hypothesis that both virtual fundamentals and traditional fundamentals contain a unit root cannot typically be rejected at conventional significance levels. However, some mean reversion undoubtedly exists, especially at lower frequencies. This issue is addressed more closely by Mark (1992) and Chinn and Meese (1993).

FIGURE 3

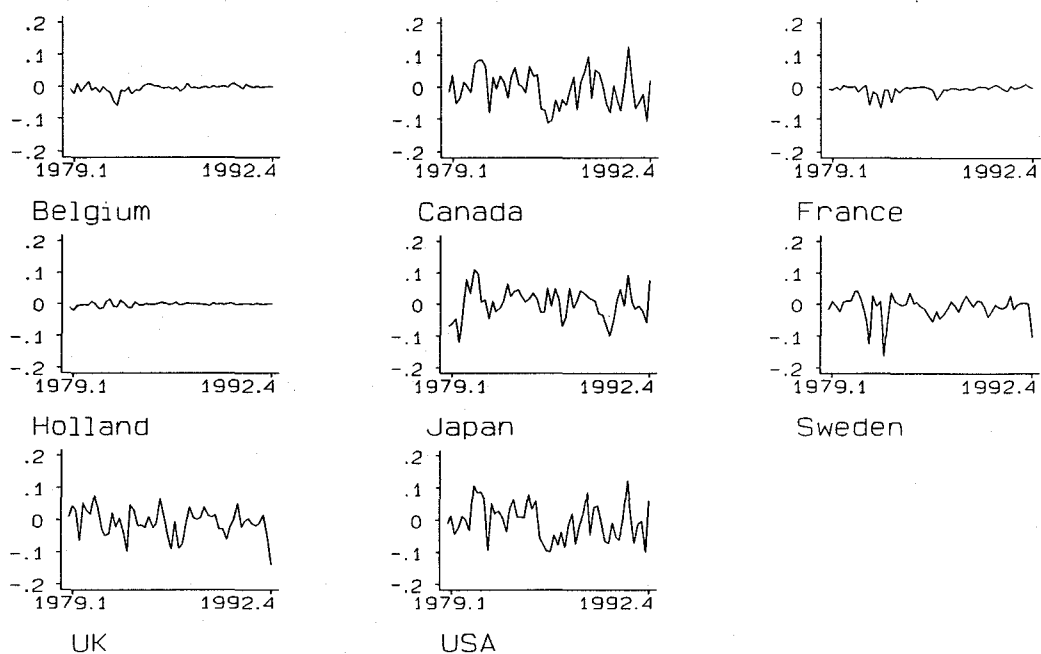
TRADITIONAL DM FUNDAMENTALS



Alpha=.5: Scales vary by country

FIGURE 4

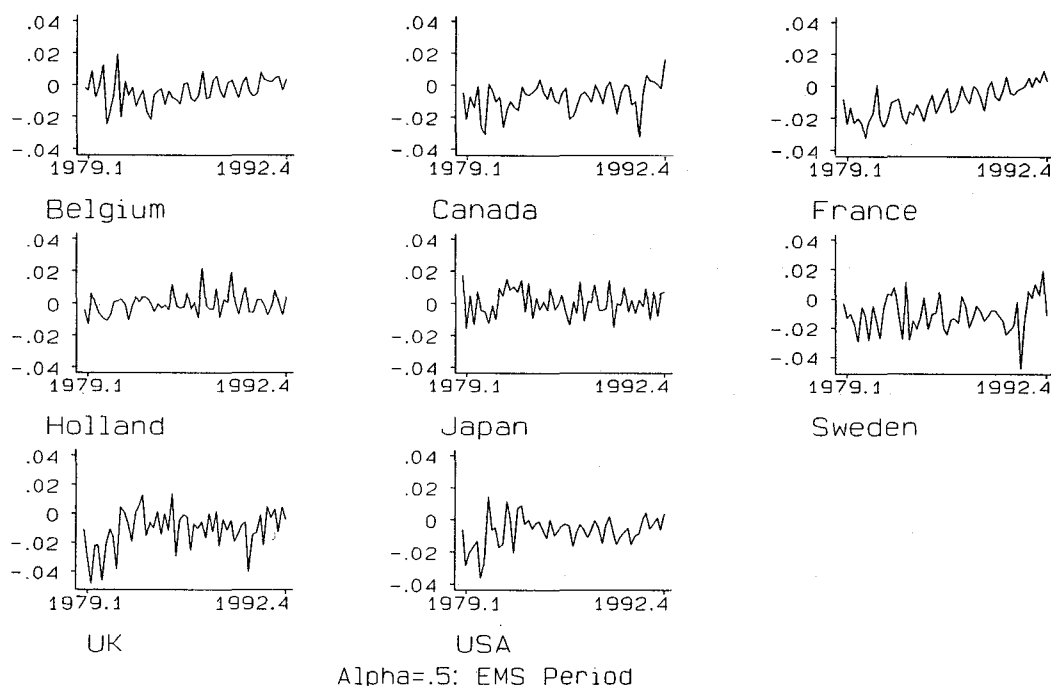
CHANGE IN VIRTUAL DM FUNDAMENTALS



Alpha=.5: EMS Period

FIGURE 5

CHANGE IN TRADITIONAL DM FUNDAMENTALS



A number of points emerge from Figures 4 and 5. First, Figure 4 clearly shows that the volatility of *virtual* fundamentals differs systematically and strongly by country. The three ERM members (Belgium, France, and especially Holland) have very stable virtual fundamentals. They stand in sharp contrast to countries with floating exchange rates like Japan and the United States. The differences in conditional volatility are statistically as well as economically significant. The actual sample standard deviation estimates of the first differences of virtual (and traditional) fundamentals are tabulated for three different values of α in Table 1. The statistics verify that the hypothesis of different levels of volatility can be confirmed at any reasonable level of statistical confidence.

Second, by way of contrast with Figure 4, the time series evidence in Figure 5, which portrays the first differences in *traditional* fundamentals, is not radically different across country. The actual sample statistics (again tabulated in Table 1 for three different values of α) confirm the presence of nontrivial differences in conditional volatility. However, the *TF* standard deviations are of the same order of magnitude for all eight countries considered, in contrast with the wild differences in *VF* volatility.

This point is perhaps easier to see in Figure 6, which is a graphical representation of some of the information pre-

sented in Table 1. The height of the bars measures the sample standard deviation of the first difference of fundamentals; two different values of α (.1 and 1.) are used for both traditional and virtual fundamentals. Figure 6 also emphasizes another interesting point; the typical measure of *TF* volatility is much lower than most comparable measures of *VF* volatility, (though there are obviously important differences across countries).

Perhaps the most striking presentation of the evidence is Figure 7, a simple scatterplot of *TF* volatility (on the ordinate) against *VF* volatility. The benchmark value of $\alpha = 0.5$ is used; the sample standard deviations for the EMS period are marked by the country name (the Canadian and U.S. observations overlap at the extreme right-hand side of the graph).

To summarize, there is overwhelming evidence that the volatility of virtual fundamentals for floating currencies is significantly higher than that for fixed currencies. However, this is by no means clear for traditional macroeconomic fundamentals; for reasonable parameter values, there is no substantial difference in volatility across countries with different exchange rate regimes.

TABLE 1

FUNDAMENTAL VOLATILITY DURING EMS

(SAMPLE STANDARD DEVIATIONS OF FIRST-DIFFERENCE)

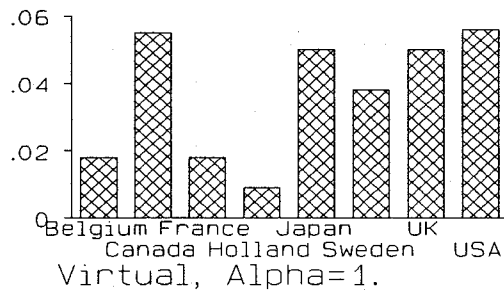
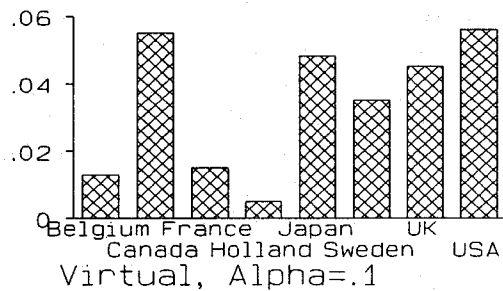
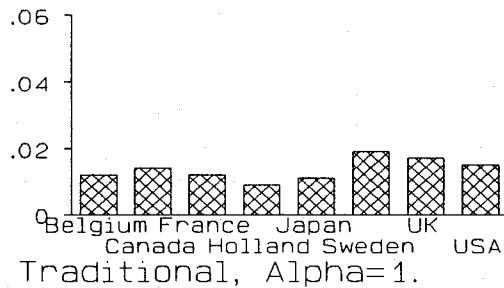
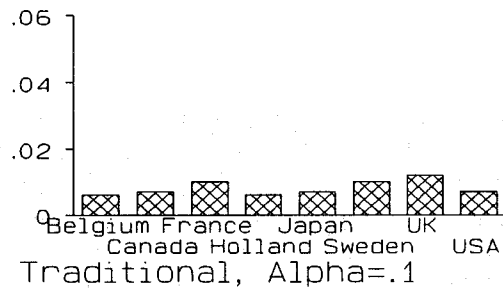
	e	TF			VF		
		.1	.5	1	.1	.5	1
Alpha							
Belgium	.013	.006	.008	.012	.013	.013	.014
Canada	.055	.007	.009	.014	.055	.056	.057
France	.014	.010	.010	.012	.014	.014	.016
Holland	.005	.006	.007	.009	.005	.006	.008
Japan	.048	.007	.008	.011	.048	.048	.047
Sweden	.035	.010	.012	.019	.036	.037	.040
UK	.045	.012	.014	.017	.044	.043	.042
US	.056	.007	.009	.015	.056	.058	.060

 $TF_t = [(m - m^*)_t - \beta(y - y^*)_t - (\epsilon - \epsilon^*)_t] = [(p - p^*)_t - \alpha(i - i^*)_t]$; $VF_t = [e_t - \alpha(i - i^*)_t]$; Germany is the home country.

FIGURE 6

VOLATILITY OF FUNDAMENTALS

Standard Deviation of First-Difference of Fundamentals
EMS Period: 1979:2-1992:4



Sensitivity Analysis

In this subsection, I show that the most important results of the empirical analysis are robust in the sense that a variety of perturbations in my basic methodology lead to the same conclusions.

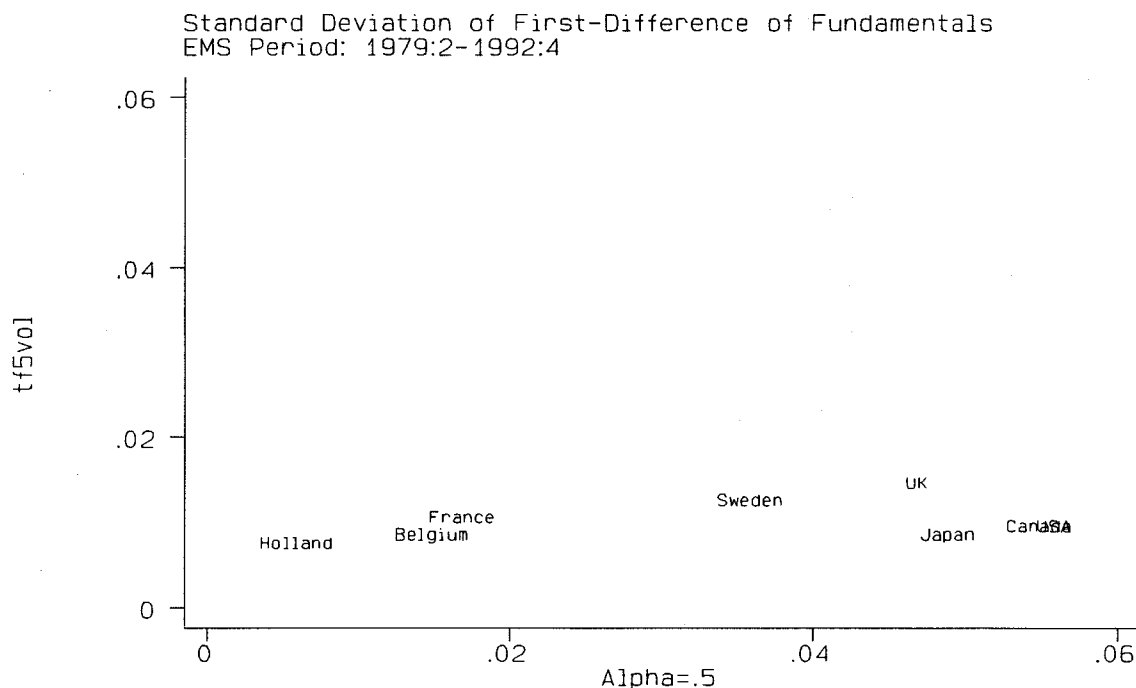
Clearly α , the interest semi-elasticity of money demand, plays a critical role in the paper. The conclusion that VF

volatility varies significantly more than TF volatility is consistent with a wide range of values for α .

Dealing with deviations from uncovered interest parity is only slightly more difficult. Under a strict interpretation of the monetary model, interest rates enter equation (4) because they affect money demand. Since the empirical work presented above merely compares measures of both sides of equation (4), UIP need not be assumed; hence

FIGURE 7

TRADITIONAL AGAINST VIRTUAL VOLATILITY



deviations from UIP have no impact on the analysis.⁶ This seems especially reasonable since interest differentials enter the empirical measures of VF and TF symmetrically.

I have already discussed the impact of lagged terms in the money demand function; since the analysis relies on the conditional volatility of fundamentals, the impact of such dynamics is negligible. Still, this is part of a more general issue, namely misspecification of the asset market equilibrium condition, i.e., equation (4). The form of misspecification of greatest concern is omitted variable bias; that is, the fact that important variables that affect monetary equilibrium have potentially been omitted from the right-hand side of (4), causing the latter term to have insufficiently different conditional volatility across countries.

There are two important points of relevance. First, it was not assumed that the money demand function worked perfectly in equation (1); indeed, the equation need not

even hold particularly well. Nontrivial deviations from money market equilibrium were incorporated into the ϵ terms; it may be recalled that there was no need to assume that these were particularly well-behaved. Specification errors in the money demand function can be dealt with in exactly the same fashion.

However, it turns out that there is no need to bury the issue by an appeal to the very general nature of the ϵ terms. Perhaps of greater importance is the fact that explicit inclusion of extra terms on the right-hand side of equation (4) will fundamentally change results only if the conditional volatility of these variables varies significantly across countries.⁷ However, it is exceedingly difficult to find macroeconomic variables with conditional volatility that vary across countries as much as that of virtual fundamentals, let alone in the same way. Expressed differently, almost no macroeconomic variables have conditional volatility that varies by exchange rate regime. For instance, Figure 8 is an analogue to Figure 6, but instead portrays country-specific standard deviations of the first difference of three different macroeconomic variables: the ratio of

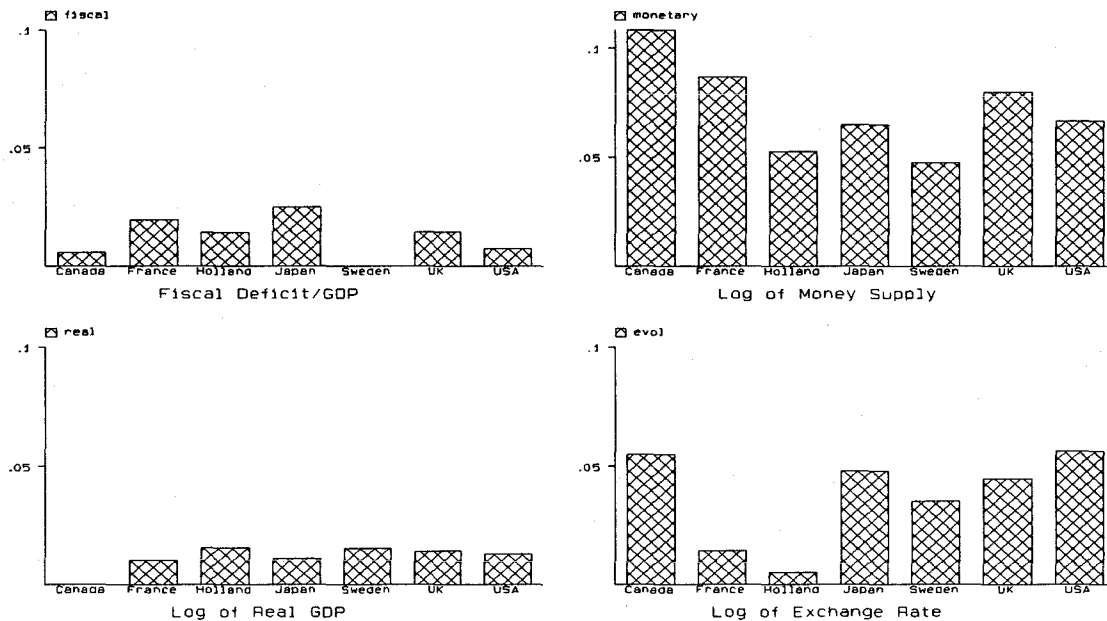
6. It is possible to interpret the left-hand side of equation (4) more generally. If one assumes UIP, then virtual fundamentals measure any single-factor model of the exchange rate. Correspondingly, if UIP holds up to a (possibly time-varying) risk premium, then virtual fundamentals measure this factor, plus the risk premium. So long as risk premia do not vary dramatically by country, such UIP deviations cannot account for the dramatic variation of VF volatility.

7. Implicitly, in a way that is correlated with the country-specific differences in conditional VF volatility.

FIGURE 8

VOLATILITY COMPARISONS: DIFFERENTIALS VIS-À-VIS GERMANY

Standard Deviation of First-Difference of Fundamentals
EMS Period: 1979:2-1992:4



the fiscal deficit to nominal GDP; the log of real GDP; and the log of narrow money (M1). (All three variables are displayed in differential form, so that the statistics are actually the sample standard deviation of, e.g., the first difference of the difference between the logs of German and domestic money. Also, the Swedish fiscal and Canadian real output data are missing.) Compared with the log of the exchange rate (which is also presented in Figure 8 and has dramatically different volatility by country), macroeconomic variables are just too similar to explain country-specific *VF* volatility. For this reason, it is not necessary to interpret the empirical work strictly within the confines of the monetary model with flexible prices, since plausible extensions that incorporate extra macroeconomic variables are unlikely to change the key conclusion of the paper. For instance, Flood and Rose (1993) replace the assumption of purchasing power parity with a sticky-price analogue (consisting of aggregate demand and Phillips-curves relationships) and show that extra terms must then be included in traditional fundamentals. However, inclusion of such terms leads to identical conclusions.

Succinctly, exchange rate volatility varies dramatically by country; macroeconomic volatility does not. For this reason it is hard to imagine that macroeconomic factors are very important determinants of exchange rates.

V. CONCLUSION

Expensive institutions such as the International Monetary Fund and the European Monetary System have been developed to combat exchange rate volatility; the latter is manifestly perceived by governments as being costly. Most developing and many developed countries in the world manage their exchange rates in some way, at least in part to reduce exchange rate volatility. These policy actions appear to have been at least partially successful; conditional exchange rate volatility varies strongly and systematically across countries. However, macroeconomic volatility does not vary nearly as dramatically. This brute stylized fact leads me to two policy conclusions and one puzzle.

First, countries concerned with "excessively high" exchange rate volatility should not look to macroeconomic conditions, at least not exclusively. This follows from the core conjecture of the paper, namely, that macroeconomic factors are not very important determinants of exchange rates. Empirically, this hypothesis finds a great deal of support in the data.

The second conclusion is that exchange rate stability need not come at the cost of macroeconomic instability.

This should be obvious simply from Figure 8; countries (like France and the U.K.) that are apparently quite similar in terms of macroeconomic volatility vis-à-vis Germany have dramatically different levels of exchange rate instability. Expressed alternatively, countries that have reduced their level of exchange rate volatility (such as Holland) do not appear to have paid a price in terms of macroeconomic volatility. If there are costs to reduced exchange rate volatility, they do not appear to be macroeconomic. This line of reasoning strengthens the case for fixed exchange rates, since low exchange rate volatility is manifestly a policy objective for many countries.

The remaining puzzle is, of course, "what can explain exchange rate volatility?" Unfortunately, there does not currently appear to be a good answer to this question. The empirical analysis has been shown to be relatively insensitive to a number of perturbations; it is hard to imagine that any set of macroeconomic variables has the characteristics necessary to explain exchange rate volatility. I am driven to the conclusion that much exchange rate volatility may be caused by microeconomic phenomena, such as noise traders and excessive speculation. However, this is just an unsubstantiated conjecture, which must be pursued further in future research. In the meanwhile, the determinants of exchange rate volatility remain an enigma.

For at least a decade it has been known that models of exchange rates work poorly in floating exchange rate regimes. This has led most economists to conclude that there may be an important variable (or set of variables) omitted from standard models. For instance, Meese (1990, p. 132) states: "It remains an enigma why the current exchange rate regime has engendered a time-series data base where macroeconomic variables and exchange rates appear to be independent of one another. One possible explanation is that economists have not yet discovered the appropriate set of fundamentals . . ." To date, relatively little progress has been made in identifying such variables. This paper has argued that the omitted (set of) variable(s) have an important identifiable characteristic, namely conditional volatility which is specific to the exchange rate regime. I am unaware of macroeconomic variables which have these characteristics.

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Stock Prices and Bank Lending Behavior in Japan

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This study attempts to shed light on whether stock price movements have contributed to recent fluctuations in bank lending in Japan by examining the historical relationship between stock prices and bank lending in that country. It is found that prior to the mid-1980s the relationship between stock prices and bank lending was weak, but subsequently strengthened considerably. This coincided with a change in the regulatory environment that encouraged banking institutions to pay more attention to their capital positions. Since the late 1980s, fluctuations in stock prices appear to have made important contributions to fluctuations in bank lending in Japan.

I. INTRODUCTION

Japan has experienced unusually sluggish growth in bank lending in recent years. Following double-digit growth in the second half of the 1980s, bank lending slackened markedly as the Japanese economy entered the current economic downswing. Nominal loan growth averaged 3.6 percent annually between February 1991 (when the Economic Planning Agency's coincident index of business conditions peaked) and May 1993. In contrast, in the three previous recessions Japan experienced since 1977, loan growth averaged nearly 11 percent.¹

While the reasons for sluggish credit and money growth are not yet fully understood, the timing is suggestive: the credit slowdown followed a steep decline in the Nikkei stock price index, which more than halved in value since reaching its peak at the end of 1989.² Indeed, the impact of such a steep asset price deflation on the Japanese financial system and on the real economy recently has been the subject of serious debate. To shed some light on this question, this article examines the historical relationship between movements in the stock price and bank lending in Japan, and explores whether stock price fluctuations appear to have contributed to explaining recent sluggish loan growth.

Changes in stock prices may influence bank lending through two channels. First, stock price fluctuations may affect loan demand by signaling changes in future economic activity. For example, the decline in the stock price after 1989 may reflect contractionary influences that lower loan demand, such as the decline in corporate capital spending triggered by the slump in final demand, poor

1. In real terms, loan growth fell to 1.2 percent over the same period, compared to 7.2 percent in the preceding 3 recessions. Note that loan growth was sluggish even though economic activity picked up for a time in the first half of 1993. The growth in broad monetary aggregate has also been sluggish. After expanding at an average annual rate of 11 percent in the late 1980s, nominal M2 + CDs growth slowed to 3.7 percent in 1991 and to 0.6 percent in 1992. Money growth actually turned negative during the second half of 1992.

2. After closing at ¥38,915 on the last trading day of 1989, the Nikkei 225 Stock Average bottomed out at ¥14,309 in August 1992. The index subsequently traded in the ¥18,000–¥20,000 range up to the time this paper was being completed (November 1993).

corporate earnings, and excess capacity.³ Loan demand in the recent downturn may have been weakened further by the need to roll over large amounts of equity-linked bonds that Japanese firms issued in the late 1980s and by sharp declines in land prices.

Second, stock price fluctuations may affect loan supply by affecting the capital position of banks. This second channel is potentially of greater importance in Japan than, say, in the U.S., because Japanese banks traditionally have taken significant positions in the equity as well as debt of the same firm.⁴ Under these conditions, a Japanese bank may be willing to lend more when Japanese stock prices are high or rising, and conversely, to lend less when stock prices are falling, since the bank can use capital gains on stocks to cushion itself from adverse shocks to assets.

Analysis of these demand and supply factors is complicated in part because it is likely that up to the early to mid-1980s, Japan's regulatory regime tended to dampen the relationship between stock prices and lending. Up to that time bank credit was heavily influenced by Bank of Japan (BOJ) credit guidelines (or "window guidance"), which limited the ability of banks to adjust lending in response to market conditions or their capital positions. Banks in any case had little incentive to pay attention to their capital positions. One reason is that the government is likely to have cushioned banks from adverse shocks that might be related to government-sanctioned credit. Another reason is that Japanese banks were not subject to explicit capital adequacy requirements until the 1980s. Under these conditions, stock prices would be expected to have little influence on bank lending.

Two developments in the 1980s are likely to have strengthened the link between stock prices and lending in Japan. First, the Bank of Japan deemphasized credit guidelines and gave Japanese banks more leeway in making loan decisions. The primary role of BOJ lending has been increasingly geared to very short-term adjustments in the financial market rather than to serve as a means to (implicitly) guarantee liquidity in the banking system (Suzuki 1987).

Second, there was growing international concern in the early 1980s about weak capital positions of banking institutions (Cooke 1984). In particular, partly as a result of the adoption of more stringent capital guidelines in the U.S. in 1981 and 1983, Japanese banks that were expanding their international operations in the 1980s faced pressure to strengthen their capital positions, so as to ensure that the Japanese banks faced foreign banks on an even competitive footing.⁵ The concern with harmonizing capital adequacy requirements eventually resulted in the drafting of risk-adjusted capital standards in Basle in December 1987. These were formally adopted by Japan and other industrial countries in July 1988.

Under the Basle Accord, by 1993 Japanese banks were to achieve risk-adjusted capital-to-asset ratios of 8 percent, in two tiers. Banks are allowed to count up to 45 percent of unrealized gains on equity holdings as Tier II capital. Under these rules, it is possible that during the stock market boom of the second half of the 1980s, rising stock prices fueled lending to a greater extent than if banks could not hold corporate shares. The subsequent decline in stock prices may have put the capital of some Japanese banks near the regulatory floor, thus constraining their loan supply. One indicator that this effect may have been important is the strong contraction in hidden reserves (reflecting unrealized capital gains) of city, long-term credit, and trust banks, from a combined total of ¥55.4 trillion in March 1989 to ¥14.6 trillion in September 1992 (Japanese Ministry of Finance 1993).

The possibility appears to be widely recognized that the Basle capital standards may have strengthened the link between fluctuations in Japanese stock prices and the supply of Japanese bank lending in the 1980s. For example, the Japanese Ministry of Finance (1993) points out that as a result of the Basle standard, broad fluctuations in asset prices "could have a destabilizing influence on the balance between fund supply and demand," and that (in the wake of asset price declines) the Basle standard "could be making it difficult to expand quantitative lending levels. . . ." Similarly, the Bank of Japan (1992), cites "the possible negative influence of BIS capital requirements in the event of any further slide in stock prices" on bank loan decisions. Since Japanese stock prices began declining, the financial press has also focused a great deal of attention on how such declines would affect the ability of banks to meet their capital requirements under the Basle Accord and the implications for bank lending behavior.⁶

3. See for example the report by the Institute of Fiscal and Monetary Policy, Japanese Ministry of Finance (1993) and the Bank of Japan (1992).

4. Until 1987 the legal limit on corporate equity holding by financial institutions was set at 10 percent of outstanding shares of any single firm. Since then, the limit was lowered to 5 percent. In 1991, close to 45 percent of the total number of corporate shares outstanding was held by financial institutions; about half of this share is estimated to be held by banks. In the U.S., where the Glass-Steagall Act strictly separates commercial and investment banking, corporate shareholding by banks is virtually nil.

5. See Kareken (1984).

6. From time to time the financial press offers estimates of the approximate level of the Nikkei stock price at which the Basle constraints

To examine the relationship between the stock price and bank lending in Japan, we estimate a small vector autoregression model of the Japanese economy using monthly data covering two samples: 1970.1–1983.12 and 1984.1–1992.12. To anticipate the main findings of this paper, we find that in the first period innovations in stock prices are followed by positive, but very small increases in bank lending. In contrast, innovations in the stock price are followed by relatively large increases in bank lending in the second period. In line with this, stock price changes play a negligible role in explaining fluctuations in bank lending in the first period, and a much more important role in the second period. In particular, stock price increases appear to have contributed to unexpectedly rapid increases in lending in the late 1980s and to unexpectedly slow growth in lending in the early 1990s.

These findings are consistent with the shift in the regulatory environment in the 1980s. Prior to the 1980s, banks attached relatively little importance to the amount of capital held and government credit guidelines may have limited their ability to adjust lending fully in response to shocks to their capital position. Other things equal, this would have loosened the linkage between stock price and lending. Growing concern about capital adequacy, eventually formalized in the Basle Accord, changed the rules of the game, inducing Japanese banks to pay more attention to their capital position. The unexpectedly steep decline in stock prices appears to have made this new regulatory constraint binding, or at least of concern, for the Japanese banks during the current economic downturn. However, because of the wide variety of contractionary influences affecting the Japanese economy, we cannot rule out sluggish demand as a contributor to the marked decline in loan growth.

This paper is organized as follows. In Section II, we briefly discuss the possible link between stock price movements and bank lending. We then examine regulatory and institutional factors in Japan that have affected this linkage and propose some hypotheses. Section III implements the empirical analysis, followed by concluding remarks in Section IV.

become binding. These estimates were particularly prevalent in 1992, when the Nikkei hit a trough. More recently, an article expresses concern about recent stock price declines in Japan, which are seen as "... beginning to crimp Japanese banks' ability to lend to business." (Wall Street Journal, November 16, 1993, p. 1). Nikkei stock price fluctuations are also believed to have affected the international operations of Japanese banks. See Terrell (1993).

II. THE LINK BETWEEN STOCK PRICE FLUCTUATIONS AND BANK LENDING

As the mechanism by which fluctuations in stock prices may affect loan demand is relatively straightforward, we will focus here on clarifying the possible link between stock price fluctuations and bank loan supply. To discuss such a link, it is necessary first to examine the relationship between bank capital and the supply of bank loans.⁷

To serve as a benchmark, the discussion initially abstracts from the role of regulation. We later relax this assumption and examine how the regulatory and other institutional environments in Japanese banking may have strengthened or weakened this capital to loan relationship.

Bank Capital and Lending

The bulk of assets that intermediaries hold consists of loans, each of which pays off only if the borrower's investment project succeeds. The deposits that banks collect, by contrast, are noncontingent liabilities with a fixed amount of promised payment, regardless of the outcome of the projects that the bank finances. An unexpected drop in the value of its assets, due to, say, borrowers' investment projects going awry, may thus force the bank into insolvency.

Banks can cushion themselves against such an adverse shock by maintaining equity capital. Bernanke and Gertler (1987) present a model where banks "voluntarily" adjust their capital-to-asset ratios to control default risk. Their model assumes that depositors have imperfect information on the quality of a bank's assets, which precludes the possibility of a payoff to depositors contingent on the return to the bank's investments. In such a setting, an incentive-compatible contract is for the bank to issue a noncontingent liability and collateralize it with bank equity capital. *Ceteris paribus*, a greater amount of capital allows banks to issue more deposits and to finance riskier investment projects. A similar equilibrium can arise if financial distress or insolvency is costly to the bank. For example, banks may hold capital because managers value their reputations, which would be lost in the event of bank default.

The supply of capital facing banks is not likely to be perfectly elastic, however. There is a limit, at least in the short run, to the extent to which capital can be accumulated through retained earnings. Capital market imperfections such as "lemons" or agency problems will also constrain banks' ability to raise capital through new equity

7. Our discussion abstracts from the demand side of the loan market. For example, to the extent stock prices reflect expectations on future corporate performance or economic conditions in general, a decline in stock price will be associated with a decline in loan demand.

issues.⁸ Given the imperfectly elastic equity capital then, a bank's loan supply can be constrained by its capital position. For example, a bank with a low capital-to-assets ratio—due either to large loan losses or rapid growth in deposits and loans in the past—may be forced to improve its capital position by reducing the growth in assets, and one way to achieve this is to decrease loan growth.

Stock Price Movements and the Supply of Bank Loans

Up to this point, we have focused on the ratio of book value capital to assets as an indicator of bank default risk. However, the capacity of a bank to absorb adverse shocks may vary significantly according to its off-balance sheet characteristics; that is, the market value of the bank's capital should also be a relevant factor determining bank risk and hence its loan supply behavior.

To see why, suppose that in addition to risky loans, the asset side of the bank's balance sheet also includes corporate shares, as is the case in Japan. Changes in the market value of the bank's shareholding clearly will have a bearing on its default risk. For example, a bank with substantial unrealized capital gains on its stockholdings will be able to write off larger amounts of loan losses by selling the securities and realizing the gains. By implication, loan supply will be relatively less constrained by book capital position for banks with sufficiently large "hidden reserves."

Conversely, a significant decline in stock prices will expose the bank to a greater amount of default risk than would be suggested by book capital position alone. Other things equal, therefore, we would expect a positive relationship between stock prices and bank lending.⁹

Regulatory and Institutional Factors

While theory suggests that capital position should affect bank loan behavior, the relationship also may be affected by regulation. A generally accepted view in the U.S. is that regulation tightens the linkage between bank capital position and lending (Keeley 1988, Bernanke and Lown 1991, Furlong 1992, Peek and Rosengren 1993). Some view the tightening of linkage through regulation as necessary because banks, as leveraged enterprises, have an incentive to

undertake more risk at the expense of depositors. The incentive problem is exacerbated if banks have access to an underpriced deposit insurance.¹⁰

Until the second half of the 1980s, Japanese banks were not subject to explicit capital-asset ratio requirements. Article 5 of the Banking Law (1981) stipulates a minimum bank capitalization of ¥1 billion for banks.¹¹ Although no liquid asset-to-deposit ratio is imposed by law, the Ministry of Finance provided administrative guidance that in the first half of the 1980s limited the average ratio of lending to deposit to below 80 percent, and maintained bank liquidity ratios above 30 percent. Banks also faced a maximum lending limit to one borrower: 20 percent of capital and reserves for city banks and 30 percent for long-term credit and trust banks. However, none of these provisions, legal or informal, directed Japanese banks to maintain some minimum ratio of capital to assets (Hendrie 1986).

In fact, throughout most of the postwar period, the regulatory and institutional environment in Japan appears to have worked to loosen rather than tighten the linkage between banks' capital position and lending. First, the Japanese financial system sought to minimize default risks of financial institutions by limiting competition. Under the so-called "convoy system" governing banking regulation, the authorities sought to reduce "destructive competition" and create a stable business environment for banks. To this end, the domestic financial market was isolated from foreign competition, and strict controls were applied to deposit rates, new entry into banking, and separation of long-term versus short-term finance.¹² Under the convoy system, all incumbent city banks grew at about the same pace, earning substantial rents from interest rate spreads and, tellingly, no financial institution was allowed to fail throughout the entire postwar period. The implicit socialization of risk is likely to have diluted individual banks' incentive to control risk and contributed to the low capital-to-asset ratios observed throughout most of the postwar period.

Second, lending by the BOJ provided a substitute to bank equity capital as a cushion against shocks to asset value. In fact, one defining characteristic of the postwar Japanese financial system is "overloan," which denotes a chronic tendency of commercial banks to extend more credit, either by lending or by purchase of securities, than they acquired from deposits or own capital, with the gap

8. Asquith and Mullins (1986) show, for example, that a firm's stock price decreases upon announcement of new equity issue, suggesting that the market discounts a lemons premium.

9. For purposes of this discussion, it is assumed that stock price changes are sufficiently persistent that they may be treated as permanent.

10. See Furlong, (1992) for further discussion.

11. Federation of Bankers Associations of Japan (1989).

12. See for example Suzuki (1987) and Aoki, Patrick, and Sheard (1993).

filled primarily by relying on borrowing from the BOJ. As noted by Suzuki (1987, p. 24) "the policies of allowing over-loan . . . reduced the banks' consciousness of their own funding position; that is, there was a diminution of self-reliance by banks because they were not forced to adjust total credit granted so long as reserves were available from the Bank of Japan. . . ." Third, the dependence of commercial banks on BOJ credit provided leverage for the monetary authority to influence the quantity and allocation of loans by banks under the system of window guidance. By constraining banks' lending decisions, window guidance would have further weakened the link between bank capital and lending.

Finally, close supervision and prudential control by the regulatory authorities provided an effective substitute for bank capital regulation as a means to control the moral hazard problem in banking discussed earlier. For example, in the course of conducting window guidance, the BOJ closely monitored on a daily basis individual banks' operations and fund positions.¹³ The Ministry of Finance (MOF) also played an instrumental role as monitor, especially in situations when a bank was judged to be mismanaged and needed drastic organization and asset restructuring. Typically, banks undergoing restructuring would be forced to accept a retired high-ranking MOF bureaucrat as an executive or even as president. Close monitoring of individual banks was possible to a greater extent in Japan than would have been possible in the U.S. because of the relatively smaller number of financial institutions.¹⁴

Under the convoy system, Japanese banks pursued a strategy of aggressively expanding deposits and lending, paying little heed to capital position (Goldsmith 1983, Suzuki 1987). For example, throughout most of the rapid growth period (roughly from the early 1950s to the early 1970s), the own capital-to-asset ratio averaged a little over 5 percent.¹⁵ Excluding various reserves, bank capital has averaged well under 1 percent of total assets since the early 1970s. These ratios are low by international standards. For example, the average ratio of primary book capital to asset in the U.S. was a little under 6.7 percent in the first half of the 1980s (Keeley 1988). They are also low by Japan's own historical standard: In the prewar period, bank own capital

was about 20 percent of total liabilities and total capital was 15 percent of liabilities¹⁶ (Suzuki 1987, p. 193).

The regulatory environment affecting bank capital and lending changed in the early 1980s in light of international concern about the weaker capital positions of banking institutions (Cooke, 1984). A particularly significant development was the concern expressed by U.S. regulators about the low capital ratios of Japanese banks expanding in the U.S. market. For example, in December 1983, the Federal Reserve Board approved Fuji Bank's application to acquire a nonbank subsidiary of a bank holding corporation (Walter E. Heller International Corporation) in the U.S. However, in its order, the Board observed that Fuji's reported capital ratio was much less than the 5 percent ratio that applied to U.S. banks. The Board also raised "the general question of whether the capital standards applicable to domestic bank holding companies should also be applied to foreign banking organizations making acquisitions in the United States . . ." (see Kareken 1984, p. 43-46).

The concern with harmonizing capital adequacy requirements eventually resulted in the drafting of risk-adjusted capital standards in Basle in December 1987. These standards were formally adopted in July 1988. The Basle capital adequacy standard requires that international banks achieve an overall risk-adjusted capital-asset ratio equal to at least 8 percent.¹⁷ The Accord provides a role for both book as well as market value capital. Specifically, at least half of the overall 8 percent ratio must consist of Tier I capital, which includes shareholders' equity and retained earnings. The balance can be met by Tier II capital, which can include subordinated debt, preferred shares, and hidden reserves, that is, unrealized gains on stockholding. To allow for its relatively risky nature, banks are allowed to count only up to 45 percent of unrealized gains as hidden reserves.

13. See Moreno and Kim (1993) for further details on window guidance and related procedures.

14. For instance, strict entry restrictions limited the number of city banks to a maximum 13 since 1953.

15. Own capital of a bank includes capital, legal reserves (capital reserves and profit reserves), surplus accounts (voluntary reserves and undistributed profits), and provisions for payment (reserve for loan loss, retirement pension payment, etc.).

16. To be sure, the book value capital to asset ratio would understate the market value capital to asset ratio to the extent that stock prices have been appreciating throughout most of the postwar period. However, this effect is likely to have been significant only towards the second half of the 1980s, when the regulatory environment had already shifted towards more stringent capital standards. According to a recent BOJ study (Shinagawa, 1993), hidden reserves represented over 2½ times the value of banks' own capital when the Nikkei stock index reached its peak in the fall of 1989.

17. The initial plan for the risk-based capital standards was proposed in 1986 and the Accord itself was reached among the Group of Ten countries in July 1988. The deadline for Japanese banks was March 31, 1993.

Questions for Empirical Analysis

Our review of the institutional features of the Japanese financial system and the process of regulatory change poses the following questions for empirical analysis.

First, does Japanese bank lending increase in response to an increase in the stock price, as predicted by either view of the relationship between stock price and lending (that stock price changes affect loan demand or loan supply)? This question will be addressed by examining the dynamic response of bank lending to innovations in the stock price.

Second, how significant is the effect of stock prices on bank lending and has this relationship changed over time? To address these questions, we proceed in three steps: (i) we examine the magnitude of impulse responses to unit shocks in the stock price; (ii) we assess the predictive ability of stock prices for bank lending according to exclusion restrictions and variance decompositions; (iii) we compare the magnitude of the response of bank lending to stock prices and the ability of stock prices to predict lending (according to exclusion restrictions and variance decompositions) over the sample periods 1970.1–1983.12 and 1984.1–1993.5.

Third, have fluctuations in Nikkei been important in explaining specific recent episodes of loan expansion or contraction? This question will be addressed by performing a historical decomposition of the forecast error in lending that allows us to determine the sources of loan fluctuations over the two samples.

III. EMPIRICAL ANALYSIS

The Model and Estimation

To address the empirical questions, we estimate a VAR model for Japan that includes macroeconomic variables that may be expected to affect lending as well as the Nikkei. The model may be expressed compactly as follows:

$$A(L)z_t = u_t$$

where $A(L)$ is a matrix of polynomials in the lag operator, $z_t = [l_t, y_t, p_t, i_t, s_t]$, in which l_t = bank loans, y_t = industrial production, p_t = consumer price index, i_t = call money rate, and s_t = Nikkei stock average, and u_t is a vector of residuals that may be contemporaneously correlated. While the primary focus of this paper is the relationship between the Nikkei stock price and bank lending, the inclusion of industrial production, the consumer price index and the call money rate is meant to control for cyclical factors that might affect bank lending.

To identify orthogonalized innovations in each of the variables and the dynamic responses to such innovations

we factor the variance-covariance matrix of the VAR using the Choleski decomposition to obtain the moving average representation:

$$z_t = A(L)^{-1} B B^{-1} u_t = C(L) \epsilon_t$$

where the variables in z_t are entered in the order described earlier, $\epsilon_t = [\epsilon_{1t}, \epsilon_{2t}, \epsilon_{3t}, \epsilon_{4t}, \epsilon_{5t}]$ and ϵ_{1t} to ϵ_{5t} respectively refer to orthogonalized innovations in bank loans, output, goods prices, short-term interest rates and stock prices. This ordering assumes that lending is contemporaneously unaffected by all the other variables in the system, whereas the stock price is affected by all these variables.

To estimate the model, data were collected for Japan over the period 1970.1–1993.5, which spans the years after Japan's "high growth period." Data and sources are described in the Appendix. The model was estimated over two subsamples, 1970.1–1983.12 and 1984.1–1993.5. As there is no reason to expect that any effect stock prices have on loan demand changed over the full period, the sample was broken to attempt to see how the changes in Japan's regulatory environment may have affected the relationship between stock prices and lending. While the choice of a date to break the sample is to some extent arbitrary, an effort was made to pick a date when Japanese banks became aware that capital adequacy was assuming priority in the minds of regulators, which would tend to strengthen the links between stock price changes and total lending. Plausible dates include 1984.1, the month after the Federal Reserve Board openly expressed concern about the capital adequacy of foreign banks in its approval of a Fuji Bank acquisition in the U.S., 1987.12, when the Basle risk-adjusted capital standards agreement was drafted, and 1988.7, when the standards were officially adopted. The date 1984.1 was selected, as it allows enough degrees of freedom to strengthen confidence in the results.

Unit root tests provide mixed evidence that the data in the model are non-stationary over the period 1970.1–1993.5.¹⁸ To account for such possible non-stationarity, the VAR model was estimated using the first difference of the logs of the variables (with the exception of the call money rate, where the first difference was used). Lag lengths were set at 9 in the first subsample and 7 in the second subsample. At these lag lengths, the null hypothesis of residual white noise could not be rejected according to the Q statistic.

18. Tests for unit roots are performed over the full period 1970.1–1993.5 because they attempt to identify long-run properties of the data that are not well captured by the smaller subsamples. The Phillips-Perron test (16 lags) fails to reject the unit root null for all the series in levels. However, the Augmented Dickey-Fuller test (12 lags) rejects the unit root null for the call money rate at 1% and for industrial production at 5%.

Dynamic Responses to Shocks

To assess the qualitative responses to shocks, Figure 1 reports the dynamic responses to innovations in the Nikkei stock price over the two subsamples. As expected, the response of loans to innovations in the stock price is positive.

Figure 1 reveals that two features distinguish the response of loans to Nikkei innovations over the two subsamples. First, the magnitude of the response of loans to Nikkei innovations is much smaller in the first period than in the second. Second, the response of loans is temporary in the first period and permanent in the second. The smaller response in the first sample is consistent with the interpretation offered earlier, namely, that the ability of banks to obtain funding from the BOJ reduced the importance of capital constraints on lending behavior. The transitory nature of the response in the first period suggests that window guidance may have effectively constrained lending decisions.

To conserve space, other impulse responses are not illustrated here. However, to facilitate interpretation of the historical decomposition later on, it is worth summarizing some of the responses of lending to innovations in other variables in the second sample period, when stock price effects are important. In this period, lending rises permanently in response to its own innovations as well as to

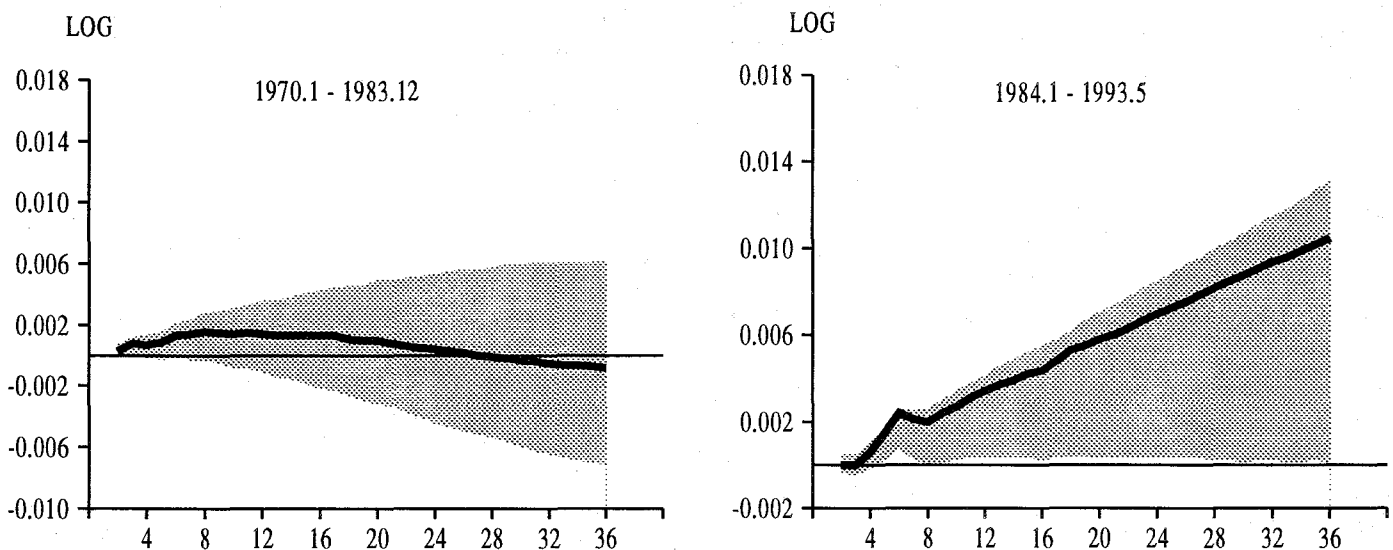
innovations in the Nikkei stock price. Lending falls permanently in response to innovations in the call money rate, industrial production, and the CPI.

The qualitative responses of lending to innovations in the Nikkei stock price, lending, or the call money rate do not clarify whether such responses reflect changes in loan demand or loan supply. It is also apparent that the countercyclical response of lending to macroeconomic activity (industrial production and CPI) is inconsistent with a change in loan demand. However, it may reflect changes in loan supply that in turn reflect monetary policy. This last interpretation is supported (or at least not contradicted) by the fact that interest rates also rise (temporarily) in response to innovations in industrial production and the CPI.¹⁹

19. In isolation, the rise in interest rate in response to innovations in industrial production and the CPI may be interpreted as reflecting increased demand. Together with a contraction in loan demand, however, it suggests that a countercyclical policy response has taken place. It is worth stressing, however, that innovations in interest rates or in aggregates such as lending cannot necessarily be interpreted as innovations in monetary policy over this period. See Moreno and Kim (1993).

FIGURE 1

RESPONSE OF LENDING TO INNOVATIONS IN THE STOCK PRICE



Exclusion Restrictions and Variance Decompositions

The importance of the various innovations in influencing lending will be apparent from the tests of predictive ability and the historical decomposition.²⁰ Table 1 reports the marginal significance levels of tests of exclusion restrictions on the lagged variables of the VAR model for the loan equation and the decomposition of the variance of the forecast error of lending at various forecast horizons. As can be seen, according to the exclusion restrictions, the Nikkei is a poor predictor of lending in the first subsample, 1970.1–1983.12, and a good predictor in the second subsample 1984.1–1993.5. In the second sample, the hypothesis that lagged changes in the Nikkei stock price do not affect bank lending is rejected at the 1 percent level. This is consistent with our findings that the response of lending to innovations of the stock price was small and temporary in the first subsample, and larger and more persistent in the second subsample.

A similar impression is conveyed by the variance decompositions. According to Table 1, at a two-year horizon, innovations in the stock price accounted for about 1 percent of the variance of the forecast error of lending in the first sample period, and 28 percent in the second sample. The success of the stock price as a predictor of loan behavior is remarkable, because in a four-variable VAR model that excludes stock prices, lending is predicted largely by its own lags. Thus, it appears that stock prices have had an important effect on loan behavior since the mid-1980s.

The VAR methodology used here does not allow us to determine whether stock prices affect loan supply or loan demand. However, the stock price exerts an influence on bank lending after a significant change in the regulatory regime that placed greater emphasis on the capital position of banks. This suggests that the effect of changes in the stock price on Japanese bank lending at least partly reflects the impact on loan supply. The view that loan supply effects may have been important is supported by the large magnitude of fluctuations in hidden reserves associated with fluctuations in stock prices. At the same time, the fact that stock prices do not predict lending prior to the mid-1980s suggests that any effects of stock prices on loan demand have historically been weak.²¹

20. The responses of other variables to the stock price suggest that innovations in the stock price reflect permanent supply shocks. The nominal interest rate, industrial production and the stock price rise permanently in response to a stock price innovation. The response of the CPI is small and erratic, initially falling, and then tending to rise.

21. We also ran a similar model for the U.S., where banks do not hold equity capital and hence any stock price effects would be through loan

TABLE 1

TESTS OF EXCLUSION RESTRICTIONS FOR LOAN EQUATIONS AND VARIANCE DECOMPOSITION OF THE FORECAST ERROR IN LENDING

	EXCLUSION RESTRICTIONS		VARIANCE DECOMPOSITION					
	70.1–83.12	84.1–93.5	Horizons (months)					
			12	24	36	12	24	36
LENDING	4.0×10^{-8}	6.9×10^{-8}	91	84	80	57	49	44
INT. RATE	0.5	0.5	1	2	1	0	1	2
OUTPUT	0.1	4.2×10^{-3}	4	12	17	27	11	15
CPI	0.7	2.2×10^{-2}	0	0	1	11	10	10
NIKKEI	0.4	9.2×10^{-7}	4	1	0	25	28	29

NOTE: Totals may not sum to 100 because of rounding.

The Nikkei's Contribution during Episodes of Loan Expansion and Contraction

To assess the Nikkei's contribution to loan behavior, we use the estimated coefficients to compute the forecast error in lending at a two-year horizon. A large forecast error means that lending was unexpectedly large or small, given the information available at the time the forecast was being made. A historical decomposition can be performed (using the coefficients of the moving average representation of the model) to determine the contribution of (orthogonalized) innovations in each of the components of the model to this forecast error. One advantage of this approach is that it controls for factors other than the Nikkei that may account for sluggish loan growth, including output.

Figures 2 and 3 report historical decompositions for the first and second subsamples respectively. (Note that some observations are lost in setting a 24-month forecast horizon.) Inspection of the figures indicates that in the first sample, a number of episodes involved relatively large "surprises" (forecast errors) in lending—positive errors around the time of the first oil shock and in 1982; and negative errors in 1975, 1977, and 1981. These episodes are largely attributable to unexpected innovations in lending. The exception is 1977, when unusually sluggish loan growth occurred in response to innovations in output. The Nikkei appeared to make some contribution to the large positive forecast errors in lending in the early 1970s and the subsequent contraction, but this contribution was very small in relative terms.

demand. We found that the stock price has little or no influence on bank lending. The U.S. evidence therefore suggests that the effects of the stock price on loan demand are unimportant.

FIGURE 2

HISTORICAL DECOMPOSITION OF THE FORECAST ERROR IN LENDING

(SAMPLE 1970.1–1983.12)

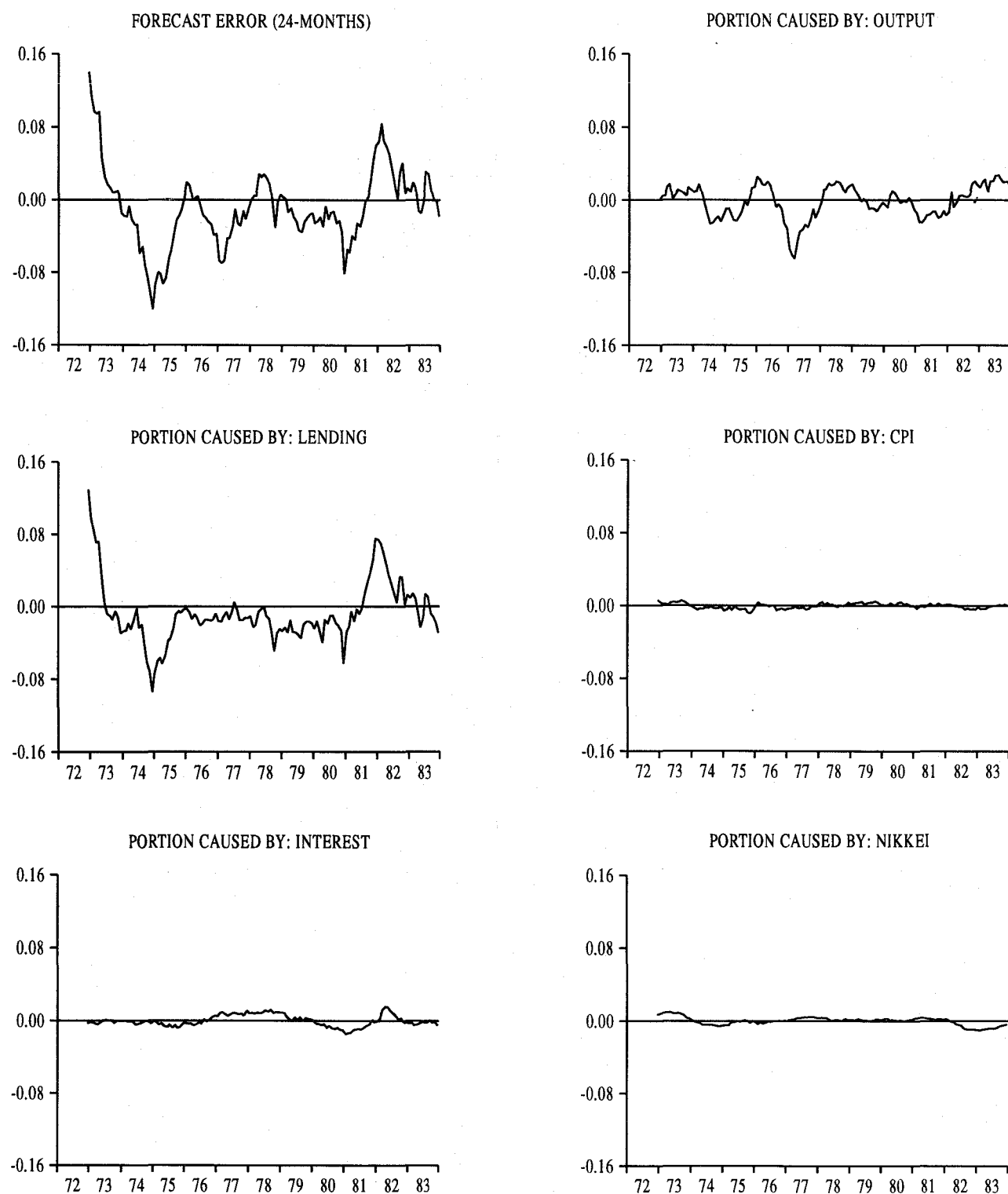
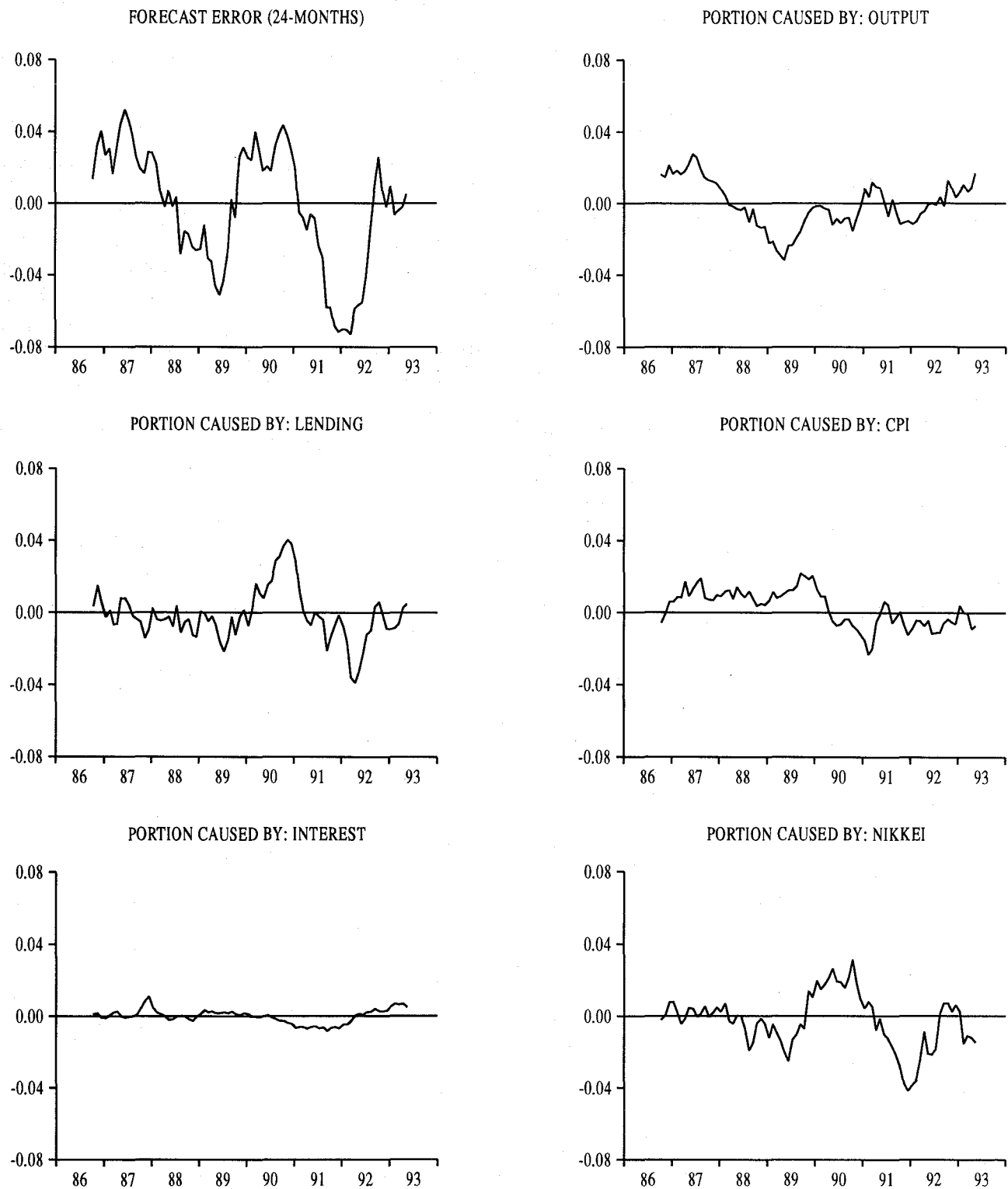


FIGURE 3

HISTORICAL DECOMPOSITION OF THE FORECAST ERROR IN LENDING
(SAMPLE 1984.1-1993.12)



The second historical decomposition is of more immediate interest, as it helps shed light on the factors that have affected recent loan behavior in Japan. We observe positive forecast errors (unusually robust lending) in 1986–1987 and 1990, and negative forecast errors (unusually weak lending) in 1988–1989 and 1991–1992.

Rapid loan growth in 1986 and 1987, and slower loan growth in 1988 and 1989 are in part attributable to fluctuations in output. As discussed previously, the response of lending to output fluctuations is negative in the second sample, so these loan movements may reflect the effects of countercyclical monetary policy. In particular, this historical decomposition is consistent with statements by the Japanese Ministry of Finance (1993, p. 6) that monetary conditions eased between 1986 and 1987. However, the historical decomposition suggests monetary tightening began in 1988, whereas policy actions that might reflect tightening (such as increases in the official discount rate) only became apparent in 1989 or 1990. Thus, some care needs to be taken in interpreting the responses of lending to output as entirely reflecting countercyclical policy.

Starting in 1989, a larger portion of the forecast error in lending is due to its own innovations. Innovations in the Nikkei account for little of robust lending in 1986–1987, but they make a distinct positive contribution in 1989–1990. Innovations in the Nikkei have contractionary effects in 1988–1989, and 1991–1992. In particular, the recent episode of sluggish growth in lending appears to be largely associated with negative innovations in lending and in the Nikkei stock price.

IV. CONCLUSIONS

The preceding empirical analysis allows us to shed some light on certain characteristics of the relationship between the Nikkei stock price and bank lending in Japan. First, the response of Japanese bank lending to an increase in the stock price is positive in the two sample periods (1970.1–1983.12 and 1984.1–1993.5) examined in this paper. This result is intuitive and is consistent with the stock price affecting loan demand or loan supply.

Second, there has been a change in the historical relationship between stock prices and bank lending. This relationship was weak until about the mid-1980s, but became quite significant subsequently.

Third, recent fluctuations in the Nikkei stock price appear to have contributed significantly to fluctuations in bank lending in Japan. In particular, the Nikkei stock price appears to have played an important role in accounting for the recent sluggish growth in lending in Japan.

While the techniques used in this paper do not allow us directly to isolate the effects of the stock price on loan

demand and loan supply, the stock price appears to exert an influence on Japanese bank lending following a significant change in the regulatory regime that placed greater emphasis on the capital position of banks. This suggests that the effect of changes in the stock price on Japanese bank lending at least partly reflect their impact on loan supply. At the same time, the weak relationship between stock prices and lending prior to the mid-1980s suggests that any effects of stock prices on loan demand have historically been weak. However, Japan's recent cyclical downturn is quite unusual, so we cannot rule out the possibility that the stock price has affected loan demand without further analysis.

Future research in two directions may shed further light on the relationship between stock prices and lending and the factors that underlie such a relationship: (i) developing structural models that distinguish explicitly between the loan demand and loan supply effects of stock prices; (ii) isolating the role of other asset prices, notably land prices, in influencing bank lending.

APPENDIX

DATA DESCRIPTION AND SOURCES

Consumer Price Index, Seasonally Adjusted. Index of consumer prices covering the whole country excluding single-person households and those engaged mainly in agriculture, forestry, and fishing. Base year is 1985. Seasonally adjusted by Federal Reserve Bank of San Francisco staff using X-11 filter. Source: International Monetary Fund, *International Financial Statistics* (IFS).

Industrial Production, Seasonally Adjusted. Index of monthly production by 9 mining and 523 manufacturing industries, weighted by 1985 value-added data. Base year is 1985. Seasonally adjusted by Federal Reserve Bank of San Francisco staff using X-11 filter. Source: IFS.

Call Money Rate. Rate in interbank call money market. Source: *Economic Statistics Monthly*, Bank of Japan.

Nikkei stock price index. Composite for 255 Companies. Monthly averages. Source: *Economic Statistics Monthly*, Bank of Japan.

Bank Loans, Seasonally Adjusted. Total loans and discounts, all banks to nonbank sector. Seasonally adjusted by Federal Reserve Bank of San Francisco staff using X-11 filter. Source: *Economic Statistics Monthly*, Bank of Japan.

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