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Portfolio Preference Uncertainty and Gains from Policy Coordination

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International policy coordination is generally considered to be made less likely—and less profitable—by uncertainty about how the economy works. This paper offers a counter example, in which investors' increased uncertainty about portfolio preference makes coordination more *beneficial. Without such coordination, monetary authorities may respond to financial market uncertainty by not fully accommodating demands for increased liquidity, for fear of inducing exchange rate depreciation. Coordinated monetary expansion would minimize this danger. This result is formalized in a model incorporating an equity market; then, the stock market crash of October 1987 and its implications for monetary policy coordination are discussed.* [JEL C73, E44, E52, F31]

A LARGE LITERATURE already exists that considers the conditions under which the international coordination of economic policies could be expected to be beneficial. Several factors have been shown to influence the gains, including the "reputation" of governments—that is, their ability to precommit to fully optimal, but possibly time-inconsistent, policies (Currie, Levine, and Vidalis (1988)), the size and nature of international spillovers (Cooper (1985), Oudiz and Sachs (1984)), the nature of governments' objective functions (Martinez Oliva and Sinn (1988)), and so forth. The likelihood of policy coordination being achieved has also been debated, and many observers have expressed

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skepticism about the possibility of agreement being reached on coordinated policies when there is disagreement on how the economy functions, and, in particular, on the effects of policies (Feldstein (1988), Frankel and Rockett (1988)).

It is important to distinguish between two types of uncertainty: *additive* uncertainty, which does not affect optimal policies in a linear model with a quadratic objective function;[1] and *multiplicative* uncertainty, which does affect them, because the incremental effects of policy changes are uncertain (Brainard (1967)). It is therefore natural to treat disagreement among policymakers about the appropriate model of the world economy in a framework of multiplicative, or model, uncertainty. This was done in Ghosh and Masson (1988), where disagreement about models was linked to uncertainty about key parameters of a general model that nests the various alternative views.[2] The empirical results in that paper confirmed the theoretical analysis of Ghosh and Ghosh (1991), who showed that uncertainty about parameter values can *increase* expected gains from coordination, especially when such uncertainty concerns the transmission effects of policies from one country to another, rather than their domestic effects.

This paper attempts to extend the intuition about the effects of uncertainty on expected gains from coordination[3] by considering a particular case of multiplicative uncertainty, one in which policymakers must take account of uncertainty concerning the preferences of investors across portfolio shares. These portfolio shares play the same role as model parameters, and they are assumed to be stochastic in the model used here.

This view of investment decisions—that they contain a random component—is consistent with observed behavior in financial markets. Fluctuations in asset prices are not explainable solely by news concerning fundamentals, but are plausibly also the result of shifts in asset preferences. This is one interpretation that can be given to the evidence of variance-bounds tests, which suggests that the volatility of asset prices exceeds that of fundamentals.[4] A recent example of sudden portfolio

[1] "Certainty equivalence" is said to apply in this case; see Simon (1956).

[2] However, disagreement over the correct model can exist even when each policymaker is certain that he or she is right. Conversely, uncertainty about parameter values does not imply that policymakers have different assessments of the distributions describing those parameters.

[3] Ex post, welfare may, of course, be lower when policies are coordinated than when they are not; however, policies are assumed to be chosen in order to maximize expected welfare, and, on average, ex post welfare is assumed to equal expected welfare.

[4] For such evidence, see Shiller (1981). Whether variance-bounds tests actually demonstrate the existence of excess volatility has been questioned, however; see, for instance, Flavin (1983) and Flood and Hodrick (1986).

shifts is associated with the generalized crash of all major stock markets in October 1987, during which many investors dumped their shares on the market in an attempt to shift out of stocks into other assets at virtually any price.

Moreover, shifts in portfolio preferences that lead to sudden declines in stock prices are often associated with increased uncertainty, as evidenced by increased volatility of stock prices. This was the experience in the days following October 19, 1987, and also in the August 1990 sell-off. From a macroeconomic policy perspective, the central concern in such an environment is that the real economy will be affected, owing to declines in real wealth and increases in the cost of capital to firms. However, the effects of monetary and fiscal policies on ultimate target variables are also increasingly uncertain, since these policies operate through financial markets. The effects of uncertainty in domestic financial markets are compounded by uncertainty in foreign exchange markets: a sharp depreciation will have unfavorable effects on inflation, for instance, and may exacerbate loss of confidence.

Greater uncertainty in financial markets may increase the need for policy coordination because of a dilemma facing a central bank when responding to shocks. For instance, if the central bank responded to a stock market crash by loosening monetary policy, it might bring about a collapse in the value of the currency. Fear of such a possibility might well lead to an inappropriately timid monetary policy, in which monetary expansion was kept too low. In contrast, a coordinated reduction in interest rates by central banks would diminish the risk of sharp exchange rate movements, while neutralizing the unfavorable effects of a generalized shift out of equities. Consistent with this, the October 1987 crash led to coordination among central banks, or at least some consultation among them about the need to increase liquidity, and interest rates were lowered simultaneously in all major industrial countries.

More generally, variation over time in the amount of financial market uncertainty may explain why coordination tends to be episodic, rather than institutionalized.[5] In times of crisis, the outlook is uncertain, as are the effects of policies; coordination of policies may decrease the danger of very bad outcomes. The incentives to pull together may be strengthened in such circumstances. It may be that in normal times gains from macroeconomic policy coordination are relatively small, consistent with estimates calculated using macroeconomic models (see, for instance, Oudiz and Sachs (1984)). However, great uncertainty about the effects of policies may make the gains from coordination larger, for instance when financial markets are turbulent and there is a danger that portfolio

[5] The terminology was used by Artis and Ostry (1986).

shifts may lead to large movements in asset prices and spillovers onto the real economy. Macroeconomic policy coordination may thus take on the character of "regime-preserving coordination" (Kenen (1988)), rather than a continuous attempt to maximize joint welfare, however defined.

This paper illustrates the effect of portfolio uncertainty on coordination with a simple model. Section I presents a two-country, two-good model in which the portfolio preferences of investors between domestic money and an international equity are random variables,[6] goods prices are sticky, and the value of financial wealth affects real output. It is shown in Section II that expected gains from policy coordination depend crucially on the perceived variances and covariances of the portfolio shifts. Policy at the time of the October 1987 crash is analyzed in the light of these results in Section III. Section IV presents conclusions.

I. The Model

In order to highlight the interaction between portfolio preferences, asset prices, and real activity, a simple, short-run model of two countries is specified. Portfolio preferences are stochastic, and can differ in the two countries. Longer-run questions such as wage adjustment and capital accumulation are ignored. Moreover, in this stylized model, there are only three assets: domestic money, foreign money, and a single equity, which is a claim to a composite consumption good (that is, the equity pays a real return, which is assumed exogenous).[7] A feature of this model is thus that there is a single world equity price; this assumption reflects in extreme form the reality that comovements of equity prices across countries have been very high in recent years—and especially so at the time of the October 1987 crash.

Each of the two countries is specialized in the production of a single good but consumes both. Utility is assumed to be Cobb-Douglas, so that consumption shares are constant; in the home country, expenditure falls in proportion, α, on home goods and $(1 - \alpha)$ on foreign goods. Consumption is assumed to be proportional to the real value of financial wealth (W, to be defined later), so that

[6] A number of articles have included equity markets in macroeconomic models; for instance, Diamond (1967) and Helpman and Razin (1978). This paper makes no attempt to model capital accumulation or to relate the riskiness of equities to technological uncertainty. What is at issue here is the risk related to shifts in portfolio preferences.

[7] Thus, the "fundamentals" are not the cause of asset price volatility. A more complicated model could make both production technology and portfolio preferences stochastic.

$$C = \rho W/P. \tag{1}$$

The consumption deflator, P, is a geometric average of the two goods prices, where p is the price of the home good, p^* is the price of the foreign good, and s is the price of foreign currency:

$$P = p^{\alpha}(sp^*)^{1-\alpha}. \tag{2}$$

Consistent with Cobb-Douglas utility, consumption is divided between the home good, C_1, and the foreign good, C_2, on the basis of fixed spending shares:

$$C_1 = \alpha(P/p)C \tag{3}$$

$$C_2 = (1-\alpha)(P/sp^*)C. \tag{4}$$

In what follows it is assumed that for both the home and foreign countries, spending falls equally on the two goods, so that $\alpha = \frac{1}{2}$. Therefore, equations (2) and (3) can be written as follows:

$$P = (psp^*)^{1/2} \tag{5}$$

$$C_1 = 0.5(P/p)C \tag{6}$$

$$C_2 = 0.5(P/sp^*)C. \tag{7}$$

Wealth is held in the form of money, M, which is nontraded, and in international equities, E, which are a promise to pay a given amount of the composite consumption good (which is the same in the two countries since $\alpha = \alpha^* = \frac{1}{2}$), and for which there is a single world market. Money and equities are held in proportions, m and $1-m$; these proportions are random variables. The price of a real equity claim is q:

$$M = mW \tag{8}$$

$$qPE = (1-m)W. \tag{9}$$

Uncertainty in portfolio preferences is reflected in the variance of m. Shifts in domestic portfolio preferences may or may not be correlated with shifts in the preferences of foreign investors; the degree of correlation is shown below to be crucial to gains from coordination.

A symmetric foreign country has a similar structure, indicated by starred variables. Parameters are assumed identical, except the random portfolio share parameter, m^*, which may not be equal to m (in the next section the *distributions* describing m and m^* are, however, assumed to be the same). There is a single world equity price (that is, $q^* = q$), since both home and foreign equities pay returns in the same consumption basket. The counterparts of equations (1) and (5)–(9) are

$$C^* = \rho W^*/P^* \tag{1'}$$

$$P^* = [(p/s)p^*]^{1/2} \tag{5'}$$

$$C_1^* = 0.5(sP^*/p)C^* \tag{6'}$$

$$C_2^* = 0.5(P^*/p^*)C^* \tag{7'}$$

$$M^* = m^*W^* \tag{8'}$$

$$qP^*E^* = (1 - m^*)W^*. \tag{9'}$$

It is assumed that output prices are sticky, and that p and p^* are fixed in the short run; output is determined by demand:

$$y = C_1 + C_1^* \tag{10}$$

and

$$y^* = C_2 + C_2^*. \tag{10'}$$

However, consumer prices can vary since the exchange rate, s, is flexible. Similarly, the price of equities, q, moves to equate the demand for equities and the outstanding stock of equity shares, $K + K^*$, where K and K^* are the initial endowments of equities at home and abroad:

$$K + K^* = E + E^*. \tag{11}$$

The exchange rate is determined by an equilibrium condition that the current account surplus equal the capital account outflow, which is equivalent to the condition that the distribution of equities between the two countries satisfy portfolio preferences. The net capital outflow, CAP, from the home country (that is, net purchases of equities) is equal to

$$CAP = qP(E - K), \tag{12}$$

(which is, of course, equal, from equation (11), to $-qP(E^* - K^*)$, the inflow to the foreign country, which corresponds to net sales of equities). The current account surplus, CUR, is the excess of domestic output over domestic absorption (that is, saving), or exports minus imports:

$$CUR = (y - C_1)p - s(y^* - C_2^*)p^*, \tag{13}$$

and the balance of payments condition is

$$CAP = CUR. \tag{14}$$

II. Optimal Government Policy

In the context of this model, monetary policy has a role in cushioning portfolio preference shifts, which have real effects because prices are sticky and consumption depends on wealth. Under consideration will be

the optimal monetary policy of a government, or central bank, that desires to minimize deviations from target output $\bar{y}$—presumably its full employment level—and from price stability, which implies that the price level equals its initial equilibrium value, $\bar{P}$. A quadratic objective function of deviations from bliss levels is postulated for tractability. Such a formulation implies a symmetric treatment of positive and negative deviations, which is probably not realistic; however, this analysis will only consider a portfolio shift out of equities into money that tends to depress output. In particular, the optimal response of the money supply to a shock to the mean value of investors' portfolio preferences is considered in the face of uncertainty about these preferences. Thus, the situation is one in which an initial portfolio shift is observed (such as the shift leading to the fall in equity prices on October 19, 1987), but there is uncertainty about *subsequent* shifts.

Suppose that the home government's objective function is

$$L = E\{(y/\bar{y} - 1)^2 + \phi(P/\bar{P} - 1)^2\} \tag{15}$$

and similarly, for the foreign government

$$L^* = E\{(y^*/\bar{y}^* - 1)^2 + \phi(P^*/\bar{P}^* - 1)^2\}. \tag{15'}$$

It is assumed that in initial equilibrium, money supplies and asset proportions are equal, so that $M = M^* = \bar{M}$ and $1/m = 1/m^* = \bar{n}$, and so $\bar{s} = 1$, and $p = p^* = 1$. Consider a shift out of equities at home and abroad, so that now

$$E(1/m) \equiv E(n) = E(n^*) = \theta\bar{n}, \tag{16}$$

with $\theta < 1$. How does the optimal setting for monetary policy in the two countries, if each takes the other's policy as given, compare to the case of joint maximization of an equally weighted global objective function, G, where $G = 0.5(L + L^*)$?

In the absence of uncertainty, it can be shown that the optimal response to such a shock will be—not surprisingly—to accommodate fully the increase in liquidity preference. In this case, the Appendix shows that cooperative and noncooperative policy settings are the same; they both involve an increase in money supply by the increase in money demand, so $M = M^* = \bar{M}/\theta$. If there is no uncertainty, then in this model monetary policy can completely neutralize the negative output effects of the portfolio preference shock, and the noncooperative and cooperative policies are the same. This is true because each government has as many targets as instruments; in this case, despite possible spillovers through the exchange rate, gains from policy coordination are zero.

However, if there exists uncertainty about portfolio preferences, then only in the case where the portfolio shifts in the two countries are

expected to be perfectly correlated will the two policies be the same. It can be shown (see Appendix) that, in general—unless the weight on inflation in the objective function is zero—the optimal noncooperative policy will be too contractionary, relative to the optimal, cooperative solution. The reason for this bias is the externality associated with the exchange rate (Sachs (1985)): appreciation helps in moderating domestic prices but exports inflation to the foreign country, and the latter effects are ignored in the absence of cooperation. The difference between the noncooperative and cooperative policies and, hence, the gains from policy coordination depend both on the common variance, σ^2, of portfolio preferences and on the correlation, κ, between the two countries' portfolio preference shifts—directly in the first case, and inversely in the second.

The difference between the two policies increases monotonically as the correlation declines, and is maximized when their correlation is minus unity; that is, they are perfectly negatively correlated. In this case, governments set policy with the risk that a monetary expansion may lead to a large exchange rate depreciation because portfolio preferences of domestic and foreign residents for money and equities are expected to shift in ways that reinforce their effects on the exchange rate. The depreciation is undesirable because of its price level effects.

This example provides an additional reason why policy coordination may be beneficial, compared to the traditional literature in which the effects of policies are assumed to be known. In Sachs (1985), for instance, noncooperative monetary policies are too contractionary in response to an inflation shock because exchange rate appreciation improves the output/inflation trade-off, and there are two targets and only one instrument. In the present example, the effects of policies are uncertain because of possible shifts in portfolio preference, so that even if each government has as many instruments as targets it still has an incentive to coordinate. The fact that portfolio preferences are uncertain and that they contribute to the variance of the exchange rate makes uncoordinated policies overcontractionary in the face of an increase in liquidity preference.

III. The Stock Market Crash of October 1987

On October 19–20, 1987, the world's stock markets declined in a sudden sell-off of shares by investors. In local currency terms, stock market indices declined during the period from September 30 to October 31 by 21.5 percent in the United States, 26.1 percent in the United

Kingdom, 22.9 percent in Germany, and 12.6 percent in Japan (see Figure 1 for a visual impression of the comovements of major market indices). Other declines were even more dramatic: 58.3 percent in Australia, and 56.3 percent in Hong Kong (Federal Reserve Bank of New York (1988, p. 18)). To a large extent, therefore, at least during this period world equity markets seemed globally integrated—as is assumed in the model described above, in which there is only one equity market—although the reasons for the common movement of prices are subject to dispute. To some extent, this comovement may have been the result of the gradual increase in interlisting of shares on different exchanges; however, correlations between the main trading zones increased by a factor of three from their levels in the previous nine months (Bertero and Mayer (1989)). Common movements in October 1987 did not seem to result from significant international investment flows, since cross-border selling was relatively small (Federal Reserve Bank of New York (1988, p. 34)). More fundamentally, then, increased economic integration and the globalization of information led to a common reassessment of equity prices in all major stock markets at the time of the stock market crash.

As is argued above, the question of whether equity prices move together (because they are good substitutes—for instance, because they are claims to similar income streams) is logically separate from whether portfolio preferences for equities shift in the same way in different countries. Confirming a generalized shift out of equities, as opposed to a shift in investor sentiment in some countries but not in others, the sharp decline in equity values was associated with relatively small exchange rate movements (Figure 2). In the October 1987 crash, exchange rate movements do not seem to have been a consideration in the setting of monetary policies.[8]

What does seem to have been a major concern influencing policy was that the 1987 stock crash might be a replay of the 1929 one, which was followed by the Great Depression (Schwartz (1988)). In this regard, a high degree of uncertainty was attached to the linkage between the stock market and the real economy—that is, the spending propensities of consumers, whose wealth had declined, and businesses, whose investment plans might be scaled back reflecting increased caution. Also subject to increased uncertainty was the stability of the financial system: whether the inability of individuals to cover margin calls, or of financial institutions to transact in financial markets, would lead to bankruptcies,

[8]They are not mentioned, for instance, in Alan Greenspan's testimony at hearings on "Black Monday," held by the U.S. Senate Committee on Banking, Housing, and Urban Affairs, February 2–5, 1988. See U.S. Congress (1988).

Figure 1. *Stock Market Prices, January 1985 to September 1990*
(Indices: 1985 = 100)

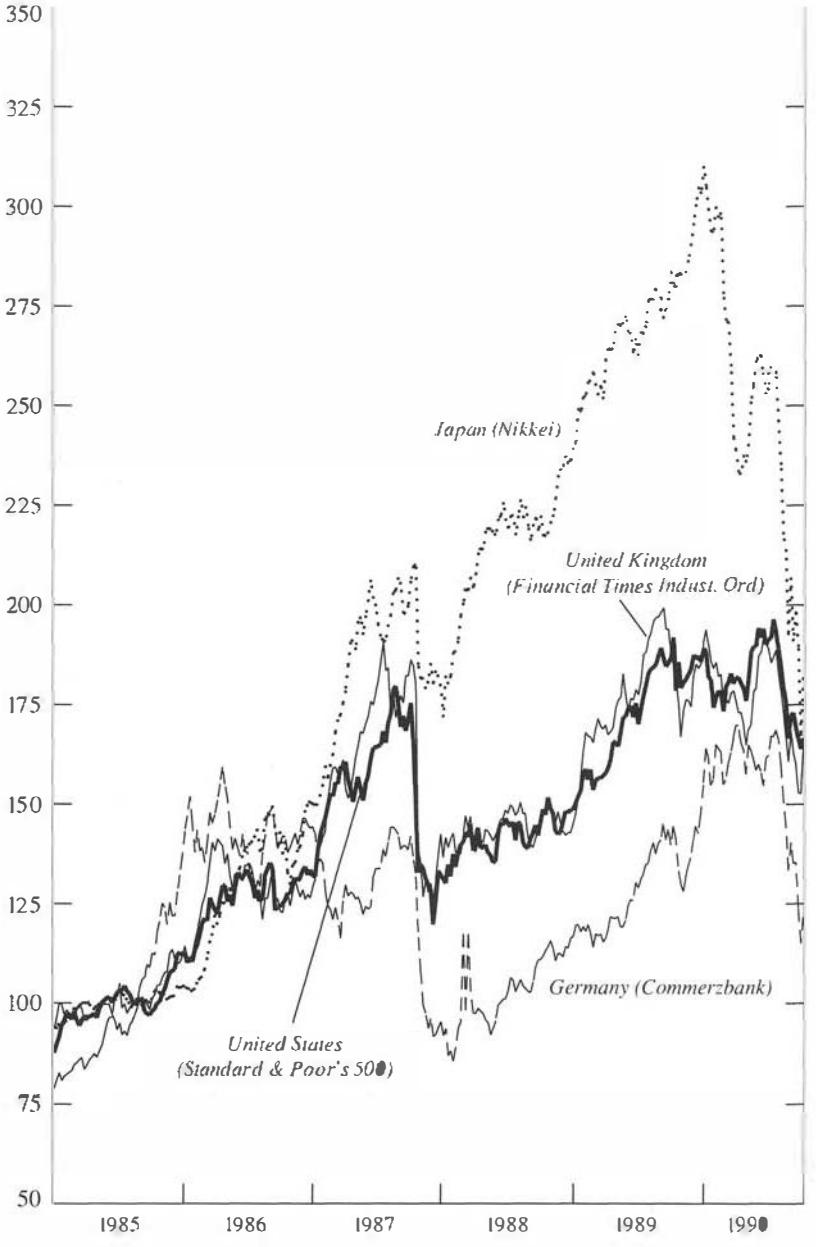
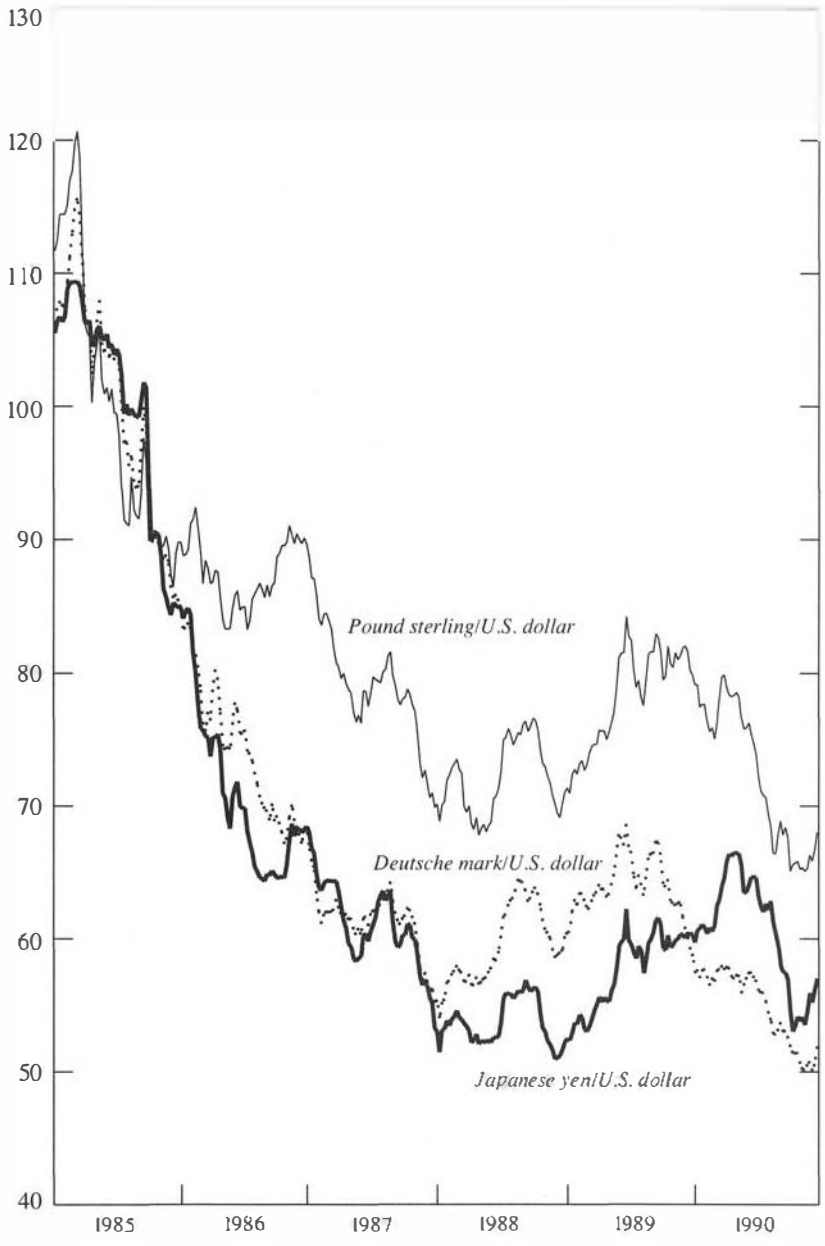


Figure 2. *U.S. Dollar Exchange Rates, January 1985 to December 1990*
(Indices: 1985 = 100)



and whether anticipation of such problems would cause the clearing and settlements system to collapse (Bernanke (1990)). It is hard to quantify the increase in uncertainty; however, one measure, the expected volatility implied by a comparison of equity and options prices, showed a dramatic increase in the United States in October 1987 (Figure 3).

Fear of financial collapse led governments and central banks to intervene by providing liquidity; moreover, they did so through closely coordinated actions. Of course, given the importance of the United States in world financial markets, the actions of the U.S. authorities were of paramount importance. The Federal Reserve reversed its tight monetary stance, flooding the system with liquidity; persuaded the banks to lend freely to securities firms; and closely monitored the situation, taking direct action where necessary (Bernanke (1990)). However, it did not act in isolation, according to Fed Chairman Alan Greenspan: "... we closely monitored the international ramifications of the stock market crash.... We communicated with officials of foreign central banks...." (U.S. Congress (1988, p. 92)). In describing the role of policy coordination among the major industrial countries in this period, Dobson (1991) says:

> The risk in 1987 was that, in the absence of close G-7 cooperation, the financial crisis could have turned into an economic crisis. Had the authorities turned their backs and refused to cooperate among themselves, it is very likely that the crisis would have deepened (p. 128).

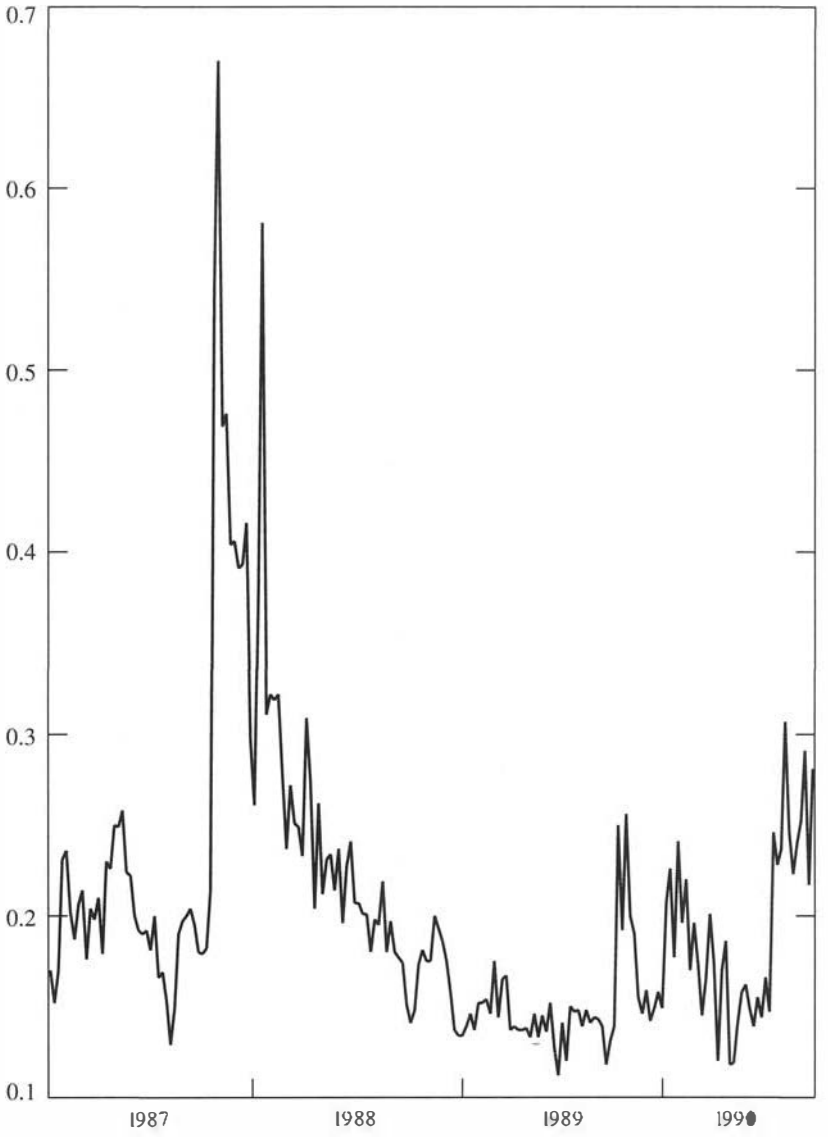
What occurred was a generalized decline in short-term interest rates as all central banks expanded liquidity (Figure 4). To some extent, a decline in interest rates on government paper (though not on private claims) might be expected from a "flight to quality," but central banks clearly favored a fall in rates, as indicated by Fed Chairman Alan Greenspan (U.S. Congress (1988)):

> By helping to reduce irrational liquidity demands, and accommodating the remainder, the Federal Reserve avoided a tightening in overall pressures on reserve positions and an increase in short-term interest rates. In fact, we went even further and eased policy moderately following the stock market collapse in light of the greater risk to continued economic expansion (p. 90).

In sum, therefore, the October 1987 stock market crash is an example of what appears to be a direct link between increased uncertainty and increased policy coordination. In describing the risks to the clearing and settlement system posed by the October 1987 crash and other events, the Governor of the Bank of Canada stated (Crow (1990)):

> These disturbances, and others since, were effectively contained through co-operation among major market participants... [T]he temporary injection of liquidity by central banks... helped to prevent the October 1987

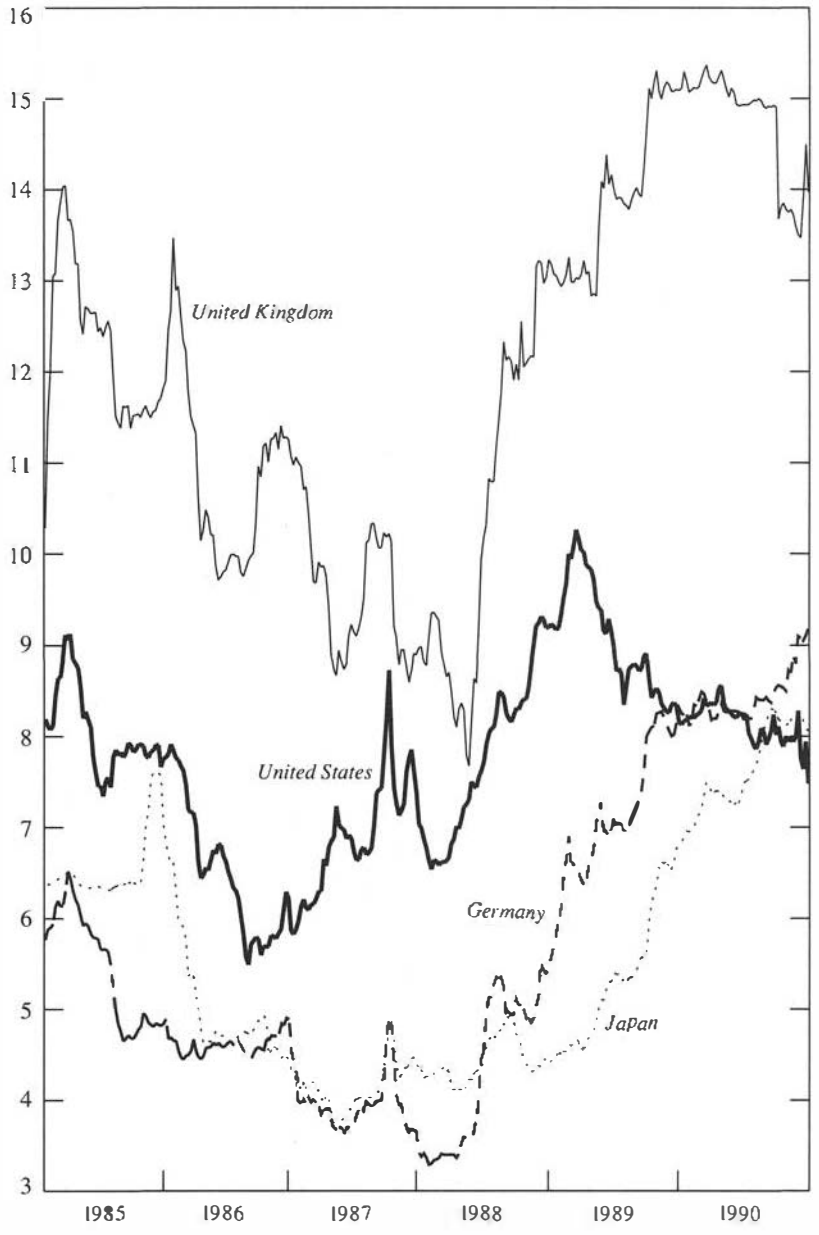
Figure 3. *Implied Volatility of Standard and Poor's 500, January 1, 1987 to October 12, 1990*



Source: Salomon Brothers.

Note: Calculated using the Black-Scholes option price formula, adjusted for dividend payments and using the price of a put option on the Standard and Poor's 500 Stock Index and the interest rate on U.S. Treasury Bills.

Figure 4. *Short-Term Interest Rates, January 1985 to December 1990*
(In percent per year)



> financial problems from degenerating into solvency problems. In retrospect, it is clear that the global community has come altogether too close to situations where market difficulties could have been severe enough to inflict lasting damage on financial markets and even on national economies (p. 2).

The model developed above has suggested that the need for policy coordination might have been even greater if the portfolio shifts had been less symmetric, for instance, if the fall in equity prices had been associated with severe weakness of the U.S. dollar. In this case, the Federal Reserve might have been much less willing to expand liquidity, for fear of adding to a run on the dollar. In cases such as these, a coordinated decline in interest rates in all countries would diminish the risk of disruptive exchange rate movements while minimizing the dangers of financial collapse.

IV. Conclusions

The paper has illustrated in a simple model the link between uncertain portfolio preferences of private investors and the difference between coordinated and uncoordinated policies. Greater uncertainty makes coordination more desirable in this example where portfolio shifts generate variations in output and exchange rates. The analysis suggests that if the perceived degree of uncertainty varies over time—perhaps as described in recent articles, for instance, by Flood, Bhandari, and Horne (1989)—then the incentives to coordinate policies will also vary. In particular, in situations of great uncertainty, where the prevailing international monetary system is threatened, policies are more likely to be influenced by shared goals.

In the particular source of uncertainty that is considered in the paper—uncertainty on the part of policymakers about the portfolio preferences of private investors—the degree of correlation across countries of portfolio shifts between equities and money is crucial in determining the gains from policy coordination. That conclusion is likely to remain in more general models with a wider menu of traded assets, in which portfolio shifts may also occur between different countries' equities and bonds. Paradoxically, if portfolio shifts are expected to be correlated across countries—as was the case with the shift out of equities at the time of the October 1987 crash—they may not require policy coordination to the extent that less symmetric portfolio preference shifts would. Of course, what is important is policymakers' anticipations of the degree of correlation of portfolio shifts; these anticipations are unlikely to involve perfect correlation. Thus, uncertainty about investors' preferences is at times likely to provide a powerful incentive to coordinate policies internationally.

APPENDIX

Solution of the Model

The solution for the variables that are of interest—it is assumed that policymakers have targets for domestic output and consumer prices—can be obtained as follows. Domestic output prices (but not consumer prices) are fixed in the current period. From equations (5) and (5′) in the text

$$P^* = P/s. \tag{17}$$

As a result, from equations (1), (8), and (17)

$$C = \rho(M/m)/P \tag{18}$$

$$C^* = s\rho(M^*/m^*)/P. \tag{18′}$$

From the conditions for goods market equilibrium, equations (10) and (10′)

$$y = 0.5[\rho M/m + s\rho M^*/m^*]/p \tag{19}$$

$$y^* = 0.5[\rho(M/m)/s + \rho M^*/m^*]/p^*. \tag{19′}$$

Turning to equilibrium in financial markets, substituting equations (9) and (9′) into (11) yields

$$qP = [(1 - m)M/m + (1 - m^*)sM^*/m^*]/(K + K^*). \tag{20}$$

Now the balance of payments equilibrium can also be expressed in terms of s and q; from equations (12)–(14)

$$qP(E - K) = 0.5\rho(sm^*/m^* - M/m). \tag{21}$$

Substitution of equations (9) and (20) into (21) yields an expression for s in terms of money supplies, portfolio preferences, and initial endowments of equities:

$$s = \{(1 - m)[K^*/(K + K^*)]M/m + 0.5\rho M/m\}/\{(1 - m^*) \cdot [K/(K + K^*)]M^*/m^* + 0.5\rho M^*/m^*\}. \tag{22}$$

In keeping with our assumption of symmetry, we further posit that initial endowments of the international equity are equal, so that $K/(K + K^*) = 0.5$. Therefore, the exchange rate can be written as

$$s = [(M/m)(1 - m + \rho)]/[(M^*/m^*)(1 - m^* + \rho)]. \tag{23}$$

Thus, for given portfolio preferences, the exchange rate is determined by relative money supplies; a shift out of equities into money (an increase in m) will tend to appreciate the currency (lower s).

Using the expression for s, reduced-form expressions can be derived for domestic and foreign outputs. From equation (19)

$$y = \rho(M/m)\{[1 - 0.5(m + m^*) + \rho]/(1 - m^* + \rho)\}/p \tag{24}$$

and from equation (19′)

$$y^* = \rho(M^*/m^*)\{[1 - 0.5(m + m^*) + \rho]/(1 - m + \rho)\}/p^*. \tag{24′}$$

It will be assumed that it is not possible to go short in equities, so that $1 - m > 0$ and $1 - m^* > 0$. Therefore, the terms in braces in (24) and (24′) are positive,

implying that an increase in the money supply in the home country increases output:

$$\partial y/\partial M > 0 \quad \text{and} \quad \partial y^*/\partial M^* > 0,$$

while an increase in the desire to hold domestic money decreases it:

$$\partial y/\partial m < 0 \quad \text{and} \quad \partial y^*/\partial m^* < 0.$$

In contrast, portfolio shifts abroad have the opposite effect (that is, they are negatively transmitted); it can be shown that

$$\partial y/\partial m^* > 0 \quad \text{and} \quad \partial y^*/\partial m > 0.$$

The first-order condition for optimal policy setting in the home country can be derived in the following way. Let $n = 1/m$, $n^* = 1/m^*$, and $F(n, n^*) = [(\rho + 1)n - 1]/[(\rho + 1)n^* - 1]$, and note that both the numerator and denominator of F are positive, from the assumption made above that portfolio shares must be positive. From equations (23) and (24) above

$$\begin{aligned}\partial L/\partial M = E\{&0.5M[n + n^*F(n,n^*)]^2/\overline{M}^2\overline{n}^2 \\ &-[n + n^*F(n,n^*)]/\overline{M}\overline{n} + \phi[F(n,n^*)/M^*] \\ &-\phi[F(n,n^*)/M^*M]^{1/2}\} = 0.\end{aligned} \tag{25}$$

Given the assumptions of symmetry, implying that $F(n^*, n) = 1/F(n, n^*)$, the foreign country's first-order condition is similar, and is not presented here.

Consider an equal change in the two countries in portfolio preferences, such that the desired wealth proportion held in the form of money rises equally—that is, n and n^* fall by the same amount. It is clear that, starting from the same position, the optimal policy response to the same portfolio shock will be the same in the two countries, so that $M = M^*$. Replacing M^* and M by M'', the common noncooperative policy setting, the following is obtained from (25):

$$\begin{aligned}M'' = &2[\overline{M}\overline{n}]E[n + n^*F(n,n^*)]/E[n + n^*F(n,n^*)]^2 \\ &-[2\phi/M'']\{EF(n,n^*) - E[F(n,n^*)]^{1/2}\} \\ &\cdot \overline{M}^2\overline{n}^2/E[n + n^*F(n,n^*)]^2.\end{aligned} \tag{26}$$

If, instead, the two governments coordinate and minimize a joint objective function, G, that gives equal weights to L and L^*, then the first-order condition for the use of the home country's money supply instrument is

$$\begin{aligned}\partial G/\partial M = E\{&0.5M[n + n^*F(n,n^*)]^2/\overline{M}^2\overline{n}^2 \\ &-[n + n^*F(n,n^*)]/\overline{M}\overline{n} + \phi[F(n,n^*)/M^*] \\ &-\phi[F(n,n^*)/M^*M]^{1/2} - \phi F(n^*,n)(M^*/M^2) \\ &+\phi(MM^*)^{1/2}[F(n^*,n)]^{1/2}/M\} = 0.\end{aligned} \tag{27}$$

Not surprisingly, the first-order condition for M^* is symmetrical, and therefore it will not be presented. Solving (27) for the common coordinated money supply setting M^c

$$\begin{aligned}M^c = &[2\overline{M}\overline{n}]E[n + n^*F(n,n^*)]/E[n + n^*F(n,n^*)]^2 \\ &-[\overline{M}^2\overline{n}^2\phi/M^c]\{E[F(n,n^*)] - E[F(n,n^*)]^{1/2} \\ &-E[F(n^*,n)] + E[F(n^*,n)]^{1/2}\}.\end{aligned} \tag{28}$$

Equation (28) simplifies further in the case (assumed here) where the distributions describing portfolio preference parameters are the same in the two countries, although not necessarily their realizations. In this case, $EF(n,n^*) = EF(n^*,n)$ and $EF(n,n^*)^2 = EF(n^*,n)^2$. Therefore, the term in equation (28) between braces is zero, and the cooperative monetary policy is given by

$$M^c = [2\overline{M}\bar{n}]E[n + n^*F(n,n^*)]/E[n + n^*F(n,n^*)]^2. \tag{29}$$

In this case, although each country's objective includes inflation and, hence indirectly, the exchange rate (and both countries' inflation targets are included symmetrically in G), the exchange rate plays no role in the cooperative monetary policy: the latter, given by equation (29), is independent of the value of ϕ.

What is the effect of increased liquidity preference in the two countries under each policy regime? First, assume *absence of uncertainty*. In this case, since $n = n^* = \theta\bar{n} < \bar{n}$

$$EF(n,n^*) = EF(n^*,n) = E[F(n,n^*)]^{1/2} = E[F(n^*,n)]^{1/2} = 1$$

and

$$E[n + n^*F(n,n^*)] = 2\theta n.$$

It can be verified from equations (26) and (29) that

$$M^n = M^c = \overline{M}/\theta, \tag{30}$$

so that both policy regimes fully accommodate the shift in liquidity preference. In the absence of uncertainty, no negative exchange rate repercussions are to be feared from a symmetric portfolio shift.

Next, consider the effect of an increase in uncertainty in the two policy regimes, starting from the initial position with a common monetary policy stance, $M = M^* = \overline{M}$, and letting $E(n) = E(n^*) = \bar{n}$. The only element of uncertainty will relate to the common variance of n; that is

$$E(n - \bar{n})^2 = E(n^* - \bar{n})^2 = \sigma^2.$$

In order to evaluate expressions on the right-hand sides of equations (26) and (29), first, take a second-order Taylor series expansion of $F(n,n^*)$ and $F(n,n^*)^{1/2}$ around $E(n) = \bar{n}$, and $E(n^*) = \bar{n}$, and take expectations (letting $\text{var}(n) = \text{var}(n^*) = \sigma^2$, $\text{cov}(n,n^*) = \kappa\sigma^2$, and $\beta = [(\rho + 1)\bar{n} - 1]^{-2}$):

$$EF(n,n^*) \doteq 1 + (\rho + 1)^2\beta(1 - \kappa)\sigma^2 \tag{31}$$

$$EF(n,n^*)^{1/2} \doteq 1 + (\rho + 1)^2\beta(1 - \kappa)\sigma^2/4. \tag{32}$$

From approximations (31) and (32) it can be shown that

$$EF(n,n^*) - EF(n,n^*)^{1/2} \doteq 3(\rho + 1)^2\beta\sigma^2(1 - \kappa)/4 \geq 0 \tag{33}$$

$$E[n + n^*F(n,n^*)] \doteq 2\bar{n} + (\rho + 1)\beta\sigma^2(1 - \mu) \tag{34}$$

$$E[n + n^*F(n,n^*)]^2 \doteq 4\bar{n}^2 + 4\sigma^2 + 2[4(\rho + 1)\bar{n} - 1]\beta\sigma^2(1 - \kappa). \tag{35}$$

From equations (26), (29), and (31)–(35), it can be shown that increased uncertainty (a larger σ^2) makes both noncooperative and cooperative policies more contractionary, but it increases the gap between them (unless $\kappa = 1$); evaluated at $\sigma^2 = 0$

$$\frac{dM^c}{d\sigma^2} - \frac{dM^n}{d\sigma^2} = \frac{(\phi/2)\overline{M}}{1 + \phi/2}[(3/4)(\rho + 1) + 1/2\bar{n}](\rho + 1)\beta(1 - \kappa) > 0.$$

Thus, a moderate amount of uncertainty will imply gains from coordination. The general case is ambiguous, however; starting from a position where $\sigma^2 > 0$, the effect of additional uncertainty cannot be signed.

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