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Conditions for an Active Exchange Rate Policy With a Predetermined Monetary Target

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Summary

Monetary policy in the large industrial countries has in recent years focused primarily on the achievement of predetermined growth rates for monetary aggregates. The authorities may also have an exchange rate objective, but the monetary target constrains their ability to influence the exchange rate unless they have two or more independent instruments at their disposal. For example, sterilized intervention in the foreign exchange market may be regarded as the combination of an expansionary and a contractionary transaction designed to affect the exchange rate while not altering the stock of money. This study treats such intervention as an example of a broader class of combination policies that, for convenience, may be called "sterilized policies." Another typical example would be the raising of bank reserve requirements in order to offset the monetary effects of open market security purchases.

In order to determine whether sterilized policies may be expected to be effective, this study examines the role of several specific types of monetary policy instruments in the context of a portfolio-balance model of financial markets. Each of the major countries employs a unique combination of policy instruments, ranging from market-oriented systems largely free of regulation to systems that rely heavily on quantitative ceilings and regulated interest rates. Therefore, solutions are derived for four different versions of the model, incorporating a total of 11 domestic policy instruments. It is shown that--if the financial markets are stable and display normal, nonperverse properties--sterilized changes in at least three of these instruments, as well as exchange market intervention, will have predictable effects on the exchange rate. The potentially effective instruments are reserve requirements on nonresident deposits or on deposits that are included in the targeted monetary aggregate, and controls on interest rates payable on such deposits.

I. Introduction

This paper examines the conditions under which the monetary authorities of a large industrial country can influence the exchange rate while keeping the growth rate of the money stock on a predetermined target. If the authorities had only one policy instrument available, such as open market operations, then any policy action that affected the exchange rate would alter monetary growth as well. In practice, the authorities may be able to use two or more instruments simultaneously, offsetting the expansionary effects of one with the contractionary effects of the other. Any combination of actions that leaves the stock of money unchanged may be described as at least potentially effective if it has predictable effects on another variable such as the exchange rate. Effectiveness in practice requires additionally that the magnitude of the effects be large enough to matter, but that issue is not within the scope of this study.

The most obvious example of this type of combination policy is sterilized exchange market intervention. The authorities may purchase foreign securities and sell domestic securities, expecting to depreciate the exchange rate without altering the stock of money. As is well known, the success of sterilized intervention requires that the public not view domestic and foreign securities as perfect substitutes; and there may be other impediments, especially if the authorities are unable to intervene on a large scale or if intervention has unanticipated effects on market expectations. In any event, sterilized changes in domestic policy instruments may provide a helpful supplement to or replacement for intervention policy. For example, a reduction in bank reserve requirements may be offset by open-market sales of domestic securities to keep the money stock constant. If the lowering of reserve requirements induces banks to pay higher returns on deposits, there may be a net capital inflow that will contribute to an appreciation of the exchange rate. In general, a "sterilized policy" may be defined as any change in an instrument that is offset by open market operations so as to affect the exchange rate without altering the money stock.

In order to determine the conditions under which sterilized policies are feasible, the task of this paper is to develop a theoretical analysis of the relationships between the exchange rate and a number of monetary instruments. Section II describes a model that combines the domestic and foreign sectors' portfolio allocation decisions with the domestic money supply process. The former is an extension of portfolio-balance exchange rate models to include several financial assets; the latter is an extension of models of commercial bank profit maximization to include the types of policy instruments that are in use in one or more of the major industrial countries. Because the institutional structure of the money supply process is country-specific, Section III of the paper describes several different versions of the banking model. The solution of the complete model is described in Section IV, and the conditions for the effectiveness of sterilized intervention and sterilized domestic policies are derived in Sections V and VI, respectively. Section VII summarizes the principal conclusions.

II. The Structural Model

Table 1 sets out a portfolio-balance model incorporating asset demand functions both for the non-bank domestic private sector (DPS) and for the rest of the world (ROW), profit-maximizing conditions for the domestic banks, and balance-sheet constraints for the central bank and the government as well as the three other sectors just mentioned. The stock of money is predetermined as a constraint on policy. 1/ The central bank's holdings of government securities (S^c) are assumed to respond passively, through open market operations, to changes in any other policy instrument in order to keep M at its targeted level.

It is assumed for simplicity that neither real income nor the rate of inflation is affected significantly by the application of sterilized policies. This dichotomy is not strictly realistic, because changes in interest rates or exchange rates are expected to affect these variables. However, it does not appear to be necessary to model these effects explicitly, especially for the medium-term focus of this analysis. To the extent that they are present, they will serve to amplify or attenuate the effects arising out of the financial model, but they would not constitute an independent source of effectiveness unless the implementation of sterilized policies affected incomes or prices directly rather than indirectly through the channels incorporated in the model.

The first nine equations describe the balance sheets of the five sectors. These stylized balance sheets omit most nonfinancial assets, miscellaneous accounts, and some institutional detail. They include, however, virtually all of the accounts that are relevant for the money supply process. Equation (1) describes the balance sheet of the central bank; the asset (left-hand) side of the equation comprises the sources of the monetary base, and the liability side shows the uses of the base. The sources include the net claims of the central bank against the government, which may be in the form of securities (S^c) or other claims (Z^g) such as the negative of government deposits at the central bank. The central bank also holds claims against commercial banks (Z^b), usually

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1/ This constraint may be self-imposed if the authorities believe that adherence to a monetary rule enhances market expectations; it may be externally imposed if the government believes that discretionary policy is error-prone or otherwise counterproductive.

Table 1. The Structural Model

I. Balance sheet identities

A. Central Bank

$$S^c + Z^f + Z^g + Z^b = R + C \qquad (1)$$

B. Government

$$G - Z^g + X^g = S^b + S^c + S^f + S^p \qquad (2)$$

C. Non-bank domestic private sector (DPS)

$$M + X^p + S^p + E.F^a = W^p + L^p + F^\ell \qquad (3)$$

$$M = D + C \qquad (4)$$

D. Commercial banks

$$R + S^b + L = D + X + Z^b \qquad (5)$$

$$L = L^p + L^f \qquad (6)$$

$$X = X^p + X^f + X^g \qquad (7)$$

E. Rest of World (ROW)

$$E.F^a + L^f + Z^f = K^d + S^f + X^f + F^\ell \qquad (8)$$

$$E.F^a + L^f + K^f = S^f + X^f + F^\ell \qquad (9)$$

II. Demand functions

A. DPS demands

$$M = M(\underset{+}{r^d}, \underset{-}{r^x}, \underset{-}{r^s}, \underset{-}{r^\ell}, \underset{-}{r^{f*}}, \underset{+}{W^p}) \qquad (10)$$

$$X^p = X(\underset{-}{r^d}, \underset{+}{r^x}, \underset{-}{r^s}, \underset{-}{r^\ell}, \underset{-}{r^{f*}}, \underset{+}{W^p}) \qquad (11)$$

$$S^p = S(\underset{-}{r^d}, \underset{-}{r^x}, \underset{+}{r^s}, \underset{-}{r^\ell}, \underset{-}{r^{f*}}, \underset{+}{W^p}) \qquad (12)$$

$$L^p = L(\underset{+}{r^d}, \underset{+}{r^x}, \underset{+}{r^s}, \underset{-}{r^\ell}, \underset{+}{r^{f*}}, \underset{-}{W^p}) \qquad (13)$$

Table 1. The Structural Model (continued)

$$E \cdot F^a = F(\underset{-}{r^d}, \underset{-}{r^x}, \underset{-}{r^s}, \underset{-}{r^\ell}, \underset{+}{r^{f*}}, \underset{+}{W^p}) \quad (14)$$

$$D/M = \delta(\underset{+}{r^d}) \quad (15)$$

B. ROW demands

$$X^f = \chi(\underset{+}{r^n}, \underset{-}{r^s}, \underset{-}{r^\ell}, \underset{-}{r^{f*}}, \underset{+}{K^f}) \quad (16)$$

$$S^f = \sigma(\underset{-}{r^n}, \underset{+}{r^s}, \underset{-}{r^\ell}, \underset{-}{r^{f*}}, \underset{+}{K^f}) \quad (17)$$

$$L^f = \lambda(\underset{+}{r^n}, \underset{+}{r^s}, \underset{-}{r^\ell}, \underset{+}{r^{f*}}, \underset{-}{K^f}) \quad (18)$$

$$E \cdot F^a = \phi(\underset{+}{r^n}, \underset{+}{r^s}, \underset{+}{r^\ell}, \underset{-}{r^{f*}}, \underset{-}{K^f}) \quad (19)$$

III. The banking system

$$P = r^\ell \cdot L + r^s \cdot S^b - r^d \cdot D - r^x \cdot X - r^b \cdot Z^b \quad (20)$$

$$R > q^d \cdot D + q^x \cdot (X^p + X^g) + q^f \cdot X^f \quad (21)$$

$$S^b > q^s \cdot (D + X) \quad (22)$$

$$Z^b < q^b \quad (23)$$

$$r^d < q^r \quad (24)$$

$$r^\ell < q^\ell \quad (25)$$

$$L < q^c \quad (26)$$

IV. Other relationships

A. Foreign interest rates

$$r^{f*} = (1 + r^f)/(1 - \dot{E}^e) - 1 \quad (27)$$

$$r^f = f(\underset{+}{r^s}) \quad (28)$$

Table 1. The Structural Model (continued)

$$\dot{E}^e = \underset{+}{E}(\overline{E}/E) \quad (29)$$

B. Changes in DPS wealth

$$K^d = \underset{+}{K}(E) \quad (30)$$

$$G = \underset{+}{G}(r^s) \quad (31)$$

V. Variables

A. Endogenous

B monetary base

C currency component of M

D deposit component of M

E exchange rate (domestic price of foreign currency)

$\dot{E}^e$ expected rate of change in E

F^a foreign assets held by domestic private sectors (DPS), measured in foreign currency

F^ℓ DPS liabilities held by the rest of the world (ROW)

G stock of government debt, less government holdings of currency other than at the central bank

K^d cumulative sum of current and past current account surpluses and net direct investment from abroad

K^f net nonofficial assets of the ROW held in the home country

L bank loans

L^f bank loans to ROW

L^p bank loans to DPS

Table 1. The Structural Model (continued)

P	net profit of banking system
R	total bank reserves
r^d	interest rate paid on D
r^f	interest rate on F
r^{f*}	value of r^f in domestic currency (uncovered yield)
r^ℓ	interest rate on L
r^n	interest rate on X^f
r^s	interest rate on S
r^x	interest rate on X^p
S	government securities outstanding
S^b	bank holdings of S
S^c	central bank holdings of S
S^f	ROW holdings of S
S^p	DPS holdings of S
W^p	financial wealth of DPS
X	bank liabilities, other than those included in M
X^f	X held by ROW
X^p	X held by DPS
Z^b	bank liabilities to the central bank

B. Policy instruments

q^b	ceiling on Z^b
q^c	ceiling on L

Table 1. The Structural Model (concluded)

q^d	reserve ratio against D
q^ℓ	ceiling on r^ℓ
q^n	reserve ratio against X^f
q^r	ceiling on r^d
q^s	secondary reserve ratio
q^x	reserve ratio against X^p
r^b	discount rate
X^g	X held by government
Z^f	net claims by central bank on ROW
Z^g	net claims by central bank on government, other than S^c

C. Other exogenous variables

$\bar{E}$	expected level of E
$\acute{M}$	stock of money

in the form of loans to the banks, 1/ and claims (Z^f) against the rest of the world (ROW). 2/ Uses of the base comprise bank reserves (R) and the currency component of the money stock (C). 3/

Financial claims of the government are divided into those against the central bank ($-Z^g$) and those (if any) against commercial banks (X^g). The sum of these claims plus the government's cumulative deficit position (G) must equal the sum of the stocks of government debt held by the other four sectors, as described in equation (2). The nonbank domestic private sector (DPS) holds four types of financial assets: money (M)--further divided into bank deposits (D) and currency (C)--, bank liabilities (X) that are excluded from the money stock as defined for policy control, government securities, and foreign currency assets (F^a). Equation (3) defines DPS financial wealth (W^p) as the sum of these assets minus borrowings from banks (L^p) and liabilities to the ROW (F^ℓ).

The balance sheet for the banking system (equation [5]) includes three principal assets: reserves, government securities, and loans (L). Loans are made both to the DPS (L^p) and to the ROW (L^f); these categories might also include bonds issued by those sectors. The liability side includes monetary deposits, nonmonetary liabilities, and borrowings from the central bank. The nonmonetary liabilities, which may be held by the government, the DPS, and the ROW, include deposits that the authorities choose to exclude from their targeted monetary aggregate, as well as non-deposit liabilities. Since national money stocks are generally defined to exclude deposits held by the government or by nonresidents, D is held only by the DPS.

The financial position of the ROW vis-à-vis the home country is summarized in equations (8) and (9). The first of these relates outstanding claims to the cumulative net external asset position of the home country (K^d); the second relates the same set of claims to the net asset position of the ROW vis-à-vis the home country, net of official claims (K^f). Home-country claims on the ROW comprise those of the DPS

1/ In this context, the term "commercial banks" refers broadly to depository institutions other than the central bank.

2/ The claims and liabilities included in Z^f may be dominated either in the home currency or in foreign currency units. In the latter case, exchange rate changes produce valuation effects that alter the net worth of the central bank. Those effects are not modeled explicitly, as they have no effect on the properties of the model.

3/ If currency is issued as a liability of the government rather than of the central bank, then equation (1) represents the consolidated balance sheet of the central bank and the currency department of the Treasury; the distinction is of no consequence for the subject at hand.

(F^a), the commercial banks (L^f), and the central bank (Z^f). Official exchange-market intervention results in changes in Z^f. 1/ The net home-country position equals the sum of these claims less ROW holdings of government and private securities and bank liabilities. The net ROW position is the mirror image of K^d, less the official claims.

Part II of the model comprises two sets of demand functions, each of which is subject to the usual additive constraints. For the DPS, it is assumed that asset demands depend on financial wealth as defined in equation (3) as well as on relative interest rates. The demands may be homogeneous in W^p or subject to symmetry conditions, but neither of those constraints is necessary for the results derived in this paper. In addition to these five demand functions, the DPS has a supply function for F^ℓ; the additive constraint imposed by equation (3) implies that this supply function may be treated as redundant.

The DPS allocates its holdings of M between D and C according to equation (15). The specification of the allocation function as depending only on r^d follows directly from the specification of the demand system (equations [9] through [14]). The hypothesis that generates this system is that the allocation of M between D and C is at least weakly separable from the allocation of W^p between M and nonmoney assets. This hypothesis implies both that a demand function (10) exists for M as a composite good and that the allocation of M is independent of the relative prices between M and other assets. 2/

The ROW asset demands are assumed to be a function of K^f, as defined in equation (9). Recall that K^f represents the net asset position of the ROW vis-à-vis the home country, minus any allocations absorbed by official claims. This balance is allocated among the several available assets and liabilities according to the system (16) through (19); the implicit demand function for F^ℓ is treated as redundant. Equation (19) is actually a supply function for F^a. Throughout the model, demands for assets depend positively on own yields and negatively on substitute yields; demands for liabilities (equations [13], [18], and [19]) depend negatively on own yields and positively on substitute yields. Yields on assets that are not held by the specified group of investors are omitted from the demand

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1/ Alternatively, intervention could be treated as affecting a set of accounts that are independent of the central bank's balance sheet. The implications are exactly the same as those described here.

2/ In the absence of this restriction, money would have no economic meaning, and the imposition of a predetermined monetary target would be less of a binding constraint. For a description of separability conditions in utility functions for financial asset models, see Boughton (1981).

functions; notably, the rate paid on domestic money balances (r^d) is absent from the ROW functions, and the discount rate (r^b) is absent from the DPS and ROW functions. The own yield on F^ℓ, the omitted market, is assumed to be equal to the yield on government securities plus a constant risk premium; r^s thus serves as a proxy. 1/

The signs of the coefficients on W^p and K^f reflect the assumption that increases in wealth are allocated partly to increased holdings of assets and partly to decreases in indebtedness. A full specification of ROW demand functions would include total ROW wealth as the constraint on asset demands; the present model assumes that the demand functions allocating K^f are separable from those allocating domestic or third-country assets.

Part III determines the structure of domestic interest rates. It is hypothesized that the banks act to maximize profits subject to one or more constraints. The specification of this constraint system varies substantially from country to country, so the discussion of this part of the model is reserved for the next section.

The final part of the model (equations [27] to [31]) describes the determination of foreign interest rates ([27] to [29]) and of linkages between the financial and real sectors of the economy ([30] to [31]). Equation (27) describes the uncovered yield on foreign assets in terms of domestic currency (r^{f*}). This yield depends on both the foreign interest rate (r^f) and the expected rate of depreciation of the home currency ($\dot{E}^e$). The foreign interest rate is assumed to respond to changes in the level of domestic rates (equation [28]), the size of the response depending on the relative importance of the home country and the policy objectives of the authorities in other countries. The expected rate of change of the exchange rate is assumed to depend monotonically on the relationship between the current exchange rate and the rate expected to prevail in the future (equation [29]). 2/ The assumption that $\bar{E}$ is exogenous may be relaxed without altering the properties of the model, as long as $\dot{E}^e$ is inversely related to the current level of E.

The net financial position of the home country vis-à-vis the ROW (K^d), which is equivalent to the accumulated balance from the current account and direct investment, is affected by the exchange rate (equation [30]) to the extent that price elasticities of demand for goods and real

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1/ F^ℓ is ROW holdings of DPS liabilities, so the yield on F^ℓ is equal to the yield on private domestic securities.

2/ The specification of these three equations is discussed in more detail in Boughton (1982). A function similar to (29) is derived in terms of rational expectations in Frenkel and Rodriguez (1982).

assets differ from unity. Assuming that the Marshall-Lerner condition holds, 1/ this effect is expected to be positive. Finally, the stock of government debt outstanding depends on the interest rate (equation [31]), a rise in r^s adding to the interest payments of the government and therefore to the borrowing requirement. Both of these effects--the price-elasticity effect on K^d and the interest-cost effect on G--are likely to be small in the short run, relative to their long-run values; they may nonetheless be large in relation to the net responses of asset demands to changes in relative prices.

III. The Banking System

As noted above, the banking system is assumed to maximize profits subject to one or more constraints imposed by banking regulations. Changes in these regulations may provide additional policy instruments with which the authorities can exert independent pressures on interest rates and exchange rates.

Equation (20) states that bank profits (P) are the difference between income on assets and expenses on liabilities. This specification assumes that the banks are always able to meet any of the legal or institutional requirements placed upon them, by obtaining funds either from the market (by selling assets or attracting liabilities) or from the central bank at the known discount rate, r^b. 2/ The possibility of stochastic reserve losses imposing additional penalties is ignored; it is essentially anachronistic and in any event would add little to the model. 3/

The first constraint (equation [21]) is a cash reserve requirement, specified as a set of minimum percentages against deposit liabilities. The percentages may be identical for all types of deposits, but in some

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1/ In this context, the Marshall-Lerner condition requires that the sum of the price elasticities of demand for exported and imported goods, services, and real assets exceed unity.

2/ The term "discount rate" is intended here to apply to all central bank lending, regardless of whether bank assets are discounted in the process. It thus covers such terms as "bank" rate (Bank of Canada and, until 1972, Bank of England), "minimum lending" rate (Bank of England from 1972 until 1981), and "Lombard" rate (Deutsche Bundesbank, applied to borrowing in excess of basic quotas).

3/ With stochastic reserve flows, bank reserves in excess of legal requirements provide liquidity to the banks. In that case the banks have a demand for excess reserves that is positively related to returns on assets and negatively to the cost of funds, including the discount rate. But this addition to the model does not alter any of the results derived below except through very indirect channels.

countries the requirement against X is lower than that against D, since X includes deposits of longer maturities as well as nonreservable liabilities. 1/ Separate requirements may also be imposed against foreign deposits. 2/ Some form of the cash reserve requirement is in effect in almost all of the major industrial countries, but its importance as a policy instrument is less uniform.

Second, banks may be subject to a liquid-asset requirement such as equation (22). Some portion of bank loans (call money or commercial bills) could also be included along with bank holdings of government securities in the list of assets meeting this requirement, but the present model abstracts from that complication. It is assumed here that the requirement applies uniformly to all bank liabilities. This type of requirement has been important at various times in Canada and the United Kingdom.

The third possible constraint is a quantitative limitation on bank borrowing from the central bank (equation [23]). Most central banks restrict access to this source of funds by some means other than the explicit interest rate charged. These restrictions range from the informal guidelines of the U.S. Federal Reserve System to the explicit quotas that have frequently been invoked as a policy instrument in the Federal Republic of Germany. The Bank of England's new procedures for monetary control, which were implemented in August 1981, limit borrowing to exceptional circumstances; previously, the Bank had extended funds freely to the London discount houses at a fixed rate. 3/ Quantitative

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1/ Reserve requirements in the United States range upward from zero for some longer-term deposits and some nondeposit liabilities; the highest requirements apply to transactions balances at large banks. In the Federal Republic of Germany, reserve requirements are similarly structured; in addition, higher requirements apply to nonresident than to resident deposits. In most other countries, requirements are assessed uniformly in reference to the aggregate of eligible liabilities.

2/ An alternative method of modeling reserve requirements on nonresident deposits would be to assume that banks of one country establish offices in other countries (Eurobanks) and hold deposits of those countries' residents denominated in the home currency, those deposits being subject to separate reserve requirements. The implications of the two approaches would be quite similar. For an exposition, see Henderson and Waldo (1981).

3/ By longstanding tradition, the Bank of England does not lend directly to banks. For purposes of this paper, it is useful to treat the London discount houses as part of the banking system; Howard (1982) presents the arguments in support of this aggregation. The old and new lending arrangements are described in Bank of England (1982).

restrictions on borrowing have been a fixture of the financial systems of France, Italy, and Japan as well. This latter group of countries has also made use of each of the remaining constraints, at least implicitly: restrictions on interest rates payable on deposits (equation [24]) or chargeable on loans (25), and quantitative credit ceilings (26). Ceilings on deposit rates have also been an important instrument at times in the United States. It is assumed for simplicity that ceilings apply only to monetary deposits, although restrictions in practice have been applied to other liabilities as well.

The constraint systems actually in place in the major countries cannot be represented precisely by a small equation system, but this model does represent most of the essential features of the different systems for purposes of determining the structure of interest rates. For example, consider a system in which banks maximize profits subject only to cash reserve requirements and restricted access to central bank lending. This system, in which market forces predominate in determining the rate structure, is indicative of the systems toward which the United States and the United Kingdom are moving, 1/ and of the German system. If both constraints are effective, the banks' decisions can be expressed by the following Lagrangian function: 2/

$$\pi = r^{\ell}\cdot L + r^{s}\cdot S^{b} - r^{d}\cdot D - r^{x}\cdot X^{p} - r^{n}\cdot X^{f} - r^{b}\cdot q^{b}$$

$$+ \lambda(D + X + q^{b} - L - S^{b} - q^{d}\cdot D - q^{x}\cdot X^{p} - q^{n}\cdot X^{f}) \qquad (32)$$

Banks maximize constrained profits (π) by setting the interest rates r^{ℓ}, r^{d}, r^{n}, and r^{x} and by finding the optimum quantity of S^{b} to hold. The optimum interest rates depend on the demand functions for L, D, and X as seen by the individual banks. Assuming that the banks act as a single monopoly bank, they will treat these demands as negative functions of the own prices. 3/ Let L', D', X', and N' denote the slopes

1/ Under the Depository Institutions Deregulation and Monetary Control Act of 1980, the Federal Reserve System is phasing out the system of controls over deposit interest rates that had been in place in the United States since 1933. The 1981 reforms implemented by the Bank of England are reducing the importance of the liquid assets requirement in the United Kingdom. At present no legal cash reserve requirement is regularly imposed in the United Kingdom, but policy actions are predicated on the existence of a stable ratio for voluntarily held reserves.

2/ For simplicity, government deposits in commercial banks (X^{g}) are ignored in this example.

3/ This discussion ignores the possibility that banks also react to the cross effects of other interest rates on demands for L, D, and X. This assumption greatly simplifies the subsequent notation with little effect on the conclusions. For a review of the literature on models of bank profit maximization, see Baltensperger (1980). The form of the solution derived here is similar to that in Miller (1975).

of the demand functions for L, D, X^p, and X^f. Then the relevant partials of equation (32) are as follows:

$$\partial\pi/\partial S^b = r^s - \lambda = 0 \quad (33)$$

$$\partial\pi/\partial r^\ell = L + (r^\ell - \lambda)\cdot L' = 0 \quad (34)$$

$$\partial\pi/\partial r^d = -D - [r^d - (1 - q^d)\lambda]D' = 0 \quad (35)$$

$$\partial\pi/\partial r^x = -X^p - [r^x - (1 - q^x)\lambda]X' = 0 \quad (36)$$

$$\partial\pi/\partial r^n = -X^f - [r^n - (1 - q^n)\lambda]N' = 0 \quad (37)$$

Equation (33) states that the Lagrangian multiplier (λ) is equal to the yield on government securities; the remaining equations give the values of r^ℓ, r^d, r^x, and r^n in relation to r^s:

$$r^\ell = r^s - \varepsilon_\ell \quad (38)$$

$$r^d = (1 - q^d)r^s - \varepsilon_d \quad (39)$$

$$r^x = (1 - q^x)r^s - \varepsilon_x \quad (40)$$

$$r^n = (1 - q^n)r^s - \varepsilon_n \quad (41)$$

where the ε's are the reciprocals of the own elasticities of the demand functions. For simplicity, these elasticities are regarded here as constants. An implication of equations (39) to (41) is that if reserve requirements are uniform for all types of deposits, then the interest rates on D, X^p, and X^f will be equal except for the additive constants. Note, however, that these results do not explicitly recognize differences in rates that reflect risk premiums or any cost differentials other than reserve requirements. If those omitted terms are approximately invariant with respect to the level of interest rates, then it is appropriate to regard them as included in the constant terms along with the ε's.

It is also possible that banks may be able to adjust their borrowing from the central bank (Z^b) in order to maximize profits. In that case, the Lagrangian has an additional partial, of the form

$$\partial\pi/\partial Z^b = \lambda - r^b = 0 \quad (42)$$

This condition implies that $r^b = r^s$ (cf. equation [33]). That is, in the absence of other quantitative restrictions (see below), if the central bank permits banks to borrow freely from it, the discount rate must be set equal to the level of market rates that will permit the authorities to achieve their monetary target. In practice, there may be a range for Z^b within which the banks may exercise some discretion and initiative.

Two conclusions may be drawn at this stage with respect to the effectiveness of the discount rate as a sterilized policy instrument. First, if the central bank is adhering to a monetary target, the discount rate cannot be set independently unless the constraint on bank borrowing is effective. Otherwise, equation (42) implies that the banks will adjust Z^b in response to a change in r^b, altering r^s and other market interest rates. The system is overdetermined, and the demand for money cannot be made equal to the targeted supply; the stock of money thus becomes an endogenous variable. Second, if the borrowing constraint is effective but the banking system is otherwise constrained only by a cash reserve requirement as in the version of the model described so far in this section, then the discount rate is still ineffective as a sterilized instrument, because it does not appear in any of the functions of the model. It does not enter the public's demand functions directly, because the public does not have access to central bank credit; that privilege extends only to the banking system. Neither does the discount rate appear in the rate-setting functions of the banks (equations [38] to [41]), because a change in the discount rate does not affect the marginal profit-maximizing conditions faced by the banks. Finally, assuming that the public and the banks form expectations rationally, a change in r^b--with a fixed monetary target--can have no "announcement" or other expectational effects except insofar as the change creates a false expectation that the monetary growth target will also be changed or abandoned. The role of the discount rate is thus strictly circumscribed in this system.

A second type of system, in which banks face ceilings or other restrictions on r^d and r^ℓ and quantitative restrictions on lending (in addition to the constraints described above), is representative of the systems that have been employed in France, Italy, and Japan. 1/ The forms of the restrictions have varied over time and across countries, and some of the restrictions have been absent or ineffective at least part of the time in each country. This credit-control version of the model thus should be viewed as indicating the general direction of policy implementation in those three countries, just as the market version indicates the policy direction for the United States and the United Kingdom.

Administrative controls on interest rates (equations [24] and [25]) have little effect on the solution of the model except to replace the profit-maximizing functions (equations [38] and [39]) with the constrained values of r^ℓ and r^d. The imposition of credit ceilings (equation [26]) implies that the public (both the DPS and the ROW) will be unable to satisfy their demands for L, eliminating equations (13) and (18). The implications of this change are explored below.

1/ These controls also were employed in the United Kingdom prior to the September 1971 reforms known as "Competition and Credit Control." See Bank of England (1971).

A third system, intermediate to the market-oriented and credit-control versions, arises when the banks are subject to a secondary-reserve or liquid-asset requirement, as in Canada and the United Kingdom. 1/ The Lagrangian expression for this system is 2/

$$\pi = r^{\ell}\cdot L + r^{s}\cdot q^{s}(D + X) - r^{d}\cdot D - r^{x}\cdot X - r^{b}\cdot Z^{b}$$

$$+ \lambda[(1 - q^{s} - q^{d})D + (1 - q^{s} - q^{x})X + Z^{b} - L] \qquad (32')$$

Two subsystems may be distinguished, depending on whether the banks are free to adjust their indebtedness to the central bank. If they are, then the relevant partial derivatives of equation (32') are given by equations (33) and (42), plus the following:

$$\partial\pi/\partial r^{d} = -D + [q^{s}\cdot r^{s} - r^{d} + (1 - q^{s} - q^{d})\lambda]D' = 0 \qquad (35')$$

$$\partial\pi/\partial r^{x} = -X + [q^{s}\cdot r^{s} - r^{x} + (1 - q^{s} - q^{x})\lambda]X' = 0 \qquad (36')$$

In this case, the liquid-asset requirement serves as a rationing instrument in place of restrictions on bank borrowing. The profit-maximizing interest rates are determined both by the level of the discount rate and by its relationship to security yields:

$$r^{\ell} = r^{b} - \varepsilon_{\ell} \qquad (38')$$

$$r^{d} = (1 - q^{d})r^{b} - q^{s}(r^{b} - r^{s}) - \varepsilon_{d} \qquad (39')$$

$$r^{x} = (1 - q^{x})r^{b} - q^{s}(r^{b} - r^{s}) - \varepsilon_{x} \qquad (40')$$

Therefore, an increase in either r^{b} or r^{s} induces increases in the interest rates controlled by the banks. For a given level of r^{s}, an increase in r^{b} gives the banks an incentive to reduce borrowing, to raise r^{ℓ} to

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1/ Prior to August 1981, banks in the United Kingdom were subject to a "reserve asset ratio," which could be held in interest-bearing assets such as short-term government debt, commercial bills, and loans to discount houses (call money). Under the new procedures, certain banks are required to maintain an asset ratio held in the form of call loans to discount houses or other securities dealers. These loans are secured primarily by government debt. Therefore, for the consolidated banking sector, the requirement is similar to the form specified in equation (22). For a general analysis of the role of secondary reserve requirements as a policy instrument, see Dean (1975).

2/ For simplicity, it is assumed for this example that a uniform reserve requirement (q^{x}) and a single interest rate (r^{x}) apply to X regardless of ownership.

reduce loan demand, and to raise r^d and r^x to attract additional deposits as a substitute for borrowing from the central bank. This process is characteristic of the functioning of the secondary reserve requirement in Canada.

In the second subsystem, Z^b is assumed to be restricted as in the other two systems described above. In that case, the banks control only their interest rates and have no direct quantitative control over any of the items on their balance sheets. The Lagrangian expression (32') gives only the relationships between lending rates and deposit rates, but not the optimum lending rate:

$$r^d = (1 - q^d)r^\ell - q^s(r^\ell - r^s) - \varepsilon_d \qquad (39'')$$

$$r^x = (1 - q^x)r^\ell - q^s(r^\ell - r^s) - \varepsilon_x \qquad (40'')$$

which is characteristic of the role of lending to discount houses by the Bank of England.

Because the banks in this system do not directly control any quantities, there is no simple counterpart to equation (38'). Instead, the banks are expected to set r^ℓ so as to maximize profits subject to the balance sheet constraint and to the demand functions faced by the banks:

$$L(r^\ell) = (1 - q^d - q^s)\cdot D(r^d) + (1 - q^x - q^s)\cdot X(r^x, X^g) + q^b \qquad (43)$$

In this system, r^ℓ is determined simultaneously with r^d and r^x. The full solution of this model is quite involved, but the relevant properties may be readily derived. First, because the banks by assumption are unable to adjust their borrowing in response to changes in the discount rate $(Z^b = q^b)$, r^b does not affect the profit-maximizing interest rates set by the banks. Second, an increase in q^b provides additional lendable funds to the banks, placing downward pressure on r^ℓ via equation (43). Third, an increase in government deposits (X^g) at commercial banks has effects that are comparable to those of an increase in q^b, differing only in that X^g is diluted by reserve requirements. In other versions of the model, changes in X^g affect the level of bank profits but not the marginal conditions. With these observations in mind, and ignoring the influences of other variables that are present in the other functions of the model, one may close this version with a truncated function for r^ℓ:

$$r^\ell = \ell(\underset{-}{q^b}, \underset{-}{X^g}, \ldots) \qquad (38'')$$

IV. The Semi-reduced Form

As an aid in comprehending the structure of this model, it is useful to consolidate the financial markets. The profit-maximizing conditions for the banking system determine the relationships between government security yields (r^s) and other domestic interest rates (r^d, r^x, r^n, and r^ℓ). Equations (27) through (29) determine the relationships among r^s, r^{f*}, and the exchange rate (E). These relationships may be combined with the structural demand functions to derive a set of semi-reduced-form (SRF) demand functions. For example, using the market-oriented version of the banking model, the money demand function may be expressed as

$$M = M'(\underset{-}{r^s}, \underset{+}{E}, \underset{+}{W^p}; \underset{-}{q^d}, \underset{+}{q^x})$$

with the following partial derivatives: 1/

$$M'_{rs} = M_{rs} + (1 - q^d) \cdot M_{rd} + (1 - q^x) \cdot M_{rx} + M_{r\ell} + f_{rs} \cdot M_{rf}$$

$$M'_e = (1 + r^f) \cdot E_e \cdot M_{rf}$$

$$M'_w = M_w$$

$$M'_{qd} = -r^s \cdot M_{rd}$$

$$M'_{qx} = -r^s \cdot M_{rx}$$

The signs of these partials follow directly from the signs in the structural model, except for M'_{rs}. Because the response to the own yield (M_{rd}) is positive, the sign of M'_{rs} is formally ambiguous. Nonetheless, it is reasonable to assume that M and S are gross substitutes in DPS portfolio decisions, in which case $M'_{rs} < 0$. 2/ If r^d is highly sensitive to changes in market interest rates, and if the demand for money is highly sensitive to changes in r^d, then M'_{rs} may be approximately zero. The consequences of this condition, which is more likely to exist if the targeted aggregate is broadly defined than if it is confined to transactions accounts, are examined below.

The several versions of the banking model imply different structures for the partial derivatives of the SRF demand functions, but the general form will be the same in each case:

$$M = M'(r^s, E, W^p; q)$$

1/ The notation $X_i = \partial X/\partial i$ is used throughout this paper. For legibility, all subscripts are in lower case; where the independent variable has a superscript, the derivative is written either with both elements on the same line or with the superscript omitted.

2/ The assumption of gross substitutability is essential for the stability of most portfolio balance models, and it has formed an implicit or explicit element in all such models. See, in particular, Tobin (1969).

where q is the vector of the relevant policy instruments. The full structural model may be consolidated into the following four equations:

$$W^p = G(r^s) + K(E) + q^c \tag{44}$$

$$K^f = - K(E) + Z^f \tag{45}$$

$$M = M'(r^s, E, W^p; q) \tag{46}$$

$$F'(r^s, E, W^p; q) = \phi'(r^s, E, K^f; q) \tag{47}$$

Equation (44) is a consolidation of equations (1) through (8). The term q^c is relevant only for the credit-control version of the banking model. Otherwise, this equation indicates that private-sector financial wealth is the sum of the government debt and the external surplus; i.e., the net assets of the DPS are the mirror image of the net liabilities of the government and the ROW. One could, of course, add an additional net-worth component to equation (3), which would then appear in equation (44) as well. In the credit-control model, the DPS and the ROW are assumed to be unable to satisfy their demands for bank loans. For notational simplicity, it is also assumed that in this case all bank loans are domestic ($L^f = 0$); any other distribution of L could equally well be assumed without affecting the qualitative properties of the model. An expansion of the credit ceiling (q^c) relaxes the constraint on the DPS and provides it with additional funds that can be allocated among the several assets that it holds. The effect of that increase is the same as an increase in net wealth, so q^c appears in the wealth constraint. 1/

Equation (45) states that a sterilized increase in the home country's net official claims increases the stock of financial assets available to the ROW. This equation is simply a stock version of the balance-of-payments constraint: the current, private capital, and official capital accounts must sum to zero. For a given current account balance, an increase in the official balance is matched by a decrease in the private capital balance. From the perspective of the ROW, there is an increase in the private balance. There is no effect on DPS wealth; the official balance does not appear in equation (44). Models that examine only the portfolio decisions of the domestic sectors therefore omit one of the important effects on the exchange markets from official intervention.

1/ This addition involves redefining W^p so that it is no longer net of bank loans. Equivalently, one could rewrite the demand functions with W^p replaced by $W^p + q^c$. If $L^f \neq 0$, let c = the fraction of L allocated to the DPS. Then $W^p = G(r^s) + K(E) + c \cdot q^c$ and $K^f = -K(E) + E(G^f + Z^f) + (1 - c) \cdot q^c$.

Equations (46) and (47) state that the money and foreign exchange markets must be in equilibrium. Since changes in all relative prices are determined by changes in r^s and E, general equilibrium is attained once these two (or any two) markets are equilibrated. The functions F' and ϕ' are derived in the same manner as M'.

The SRF model may be solved in differential form, giving the following multiplier expressions for changes in the exchange rate and in domestic interest rates:

$$dE/dZ^f = M_r \cdot \phi_k / J \tag{48}$$

$$dE/dq = [F_r \cdot M'_q - M_r \cdot (F'_q - \phi'_q)]/J \tag{49}$$

$$dE/dq^c = (F_r \cdot M_w - M_r \cdot F_w)/J \tag{50}$$

$$dr^s/dZ^f = -M_e \cdot \phi_k / J \tag{51}$$

$$dr^s/dq = -[F_e \cdot M'_q - M_e \cdot (F'_q - \phi'_q)]/J \tag{52}$$

and

$$dr^s/dq^c = -(F_e \cdot M_w - M_e \cdot F_w)/J \tag{53}$$

where

$$M_r \equiv M'_{rs} + M_w \cdot G_{rs}$$

$$F_r \equiv F'_{rs} - \phi'_{rs} + F_w \cdot G_{rs}$$

$$M_e \equiv M'_e + M_w \cdot K_e$$

$$F_e \equiv (F'_e - \phi'_e) + (F_w + \phi_k) \cdot K_e$$

and

$$J \equiv M_r \cdot F_e - F_r \cdot M_e$$

J is the Jacobian for the system (44) through (47); it may be shown that a positive value for J is a necessary condition for the stability of the model. The dynamic system corresponding to the static model may be described by letting the time derivatives of r^s and E be increasing functions (k_1, $k_2 > 0$) of the excess demands for M and F^a, respectively:

$$\dot{r}^s = k_1 \cdot (M')$$

$$\dot{E} = k_2 \cdot (F' - \phi')$$

The necessary conditions for stability of this system are 1/

$$k_1 \cdot M_r + k_2 \cdot F_e < 0 \qquad (54)$$

and

$$M_r \cdot F_e - F_r \cdot M_e > 0 \qquad (55)$$

The expression in inequality (55) is J.

M_r and F_r are the total derivatives of the demands for M and F^a with respect to r^s. These total derivatives allow for indirect effects on other interest rates (included in M'_{rs}) and for the effect of r^s on W^p via the stock of government debt. If one again invokes the assumption of gross substitutability, both of these total derivatives will be negative. It is not clear, however, that the assumption is valid in this context; in particular, if M'_{rs} is close to zero, M_r may be dominated by the positive wealth effect. M_e and F_e are the total derivatives of the demand for M and the excess demand for F^a with respect to E. M_e is unambiguously positive, but F_e could be positive or negative. The stability condition (55) may be written as a restriction on the value of F_e:

$$F_e \gtrless F_r \cdot M_e / M_r \quad \text{as } M_r \gtrless 0.$$

F_e is expected to be negative, but it could be positive if the wealth effect is positive and relatively large. This wealth effect arises in the following manner. A depreciation (increase) in E increases K^d (and thus W^p) and decreases K^f, assuming that the Marshall-Lerner condition holds. These effects lead to an increase in both the demand for F^a and its supply. The net effect on the excess demand for F^a is unclear. If the demand and supply elasticities for F^a are equal in absolute values, then the sign of the net effect will in general be the opposite of the sign of K^f. 2/ As a first approximation, the wealth effect may be assumed to be positive for surplus countries and negative for deficit countries. 3/

1/ Samuelson (1947) describes the proofs of these conditions in their general form. For an example of an application with a similar model structure, see Ott, Ott, and Yoo (1975).

2/ Let η^d and η^s represent the demand and supply elasticities, respectively. Then $F_{W^p} + \phi_{K^f} = F^a \cdot (\eta^d / W^p + \eta^s / K^f)$. If $\eta^s = -\eta^d$, then $F_w + \phi_k = F^a \cdot \eta^d \cdot (1/W^p - 1/K^f)$. The sign of this expression is the same as the sign of $-K^f$ unless $K^f = 0$ (where the function is discontinuous, and the assumption of equal elasticities would be nonsensical) or $K^f > W^p$ (where the home-country external deficit equals or exceeds its total financial wealth).

3/ These relationships are reversed if $K_e < 0$.

V. Exchange Market Intervention

The effect of sterilized exchange-market intervention on the exchange rate is captured in the multiplier dE/dZ^f (equation [48]). This multiplier is expected to be positive, implying that a purchase of foreign securities by the central bank, offset by sales of domestic securities, will depreciate the exchange rate. This normal result holds as long as the system is stable ($J > 0$) and substitution effects dominate in the demand for money. Specifically, whenever M_r is negative, the numerator of dE/dZ^f is positive; the denominator is also positive unless F_e is positive and large enough to render the model unstable. Assuming stability, intervention also raises domestic interest rates via equation (51).

Two special cases help to illustrate the circumstances under which exchange market intervention may not be an effective sterilized policy: (1) the case where domestic and foreign securities are perfect substitutes, and (2) the case where the demand for money is not interest elastic. In the first case, the yields on S and F^a (r^s and r^{f*}) will be equalized. The SRF model will be altered in that E will disappear as a direct argument in equations (46) and (47), and the derivatives of the F' and ϕ' functions with respect to r^s will reverse signs ($F_r > 0$); i.e., r^s will serve as the own yield on F^a as well as on S. The exchange rate will still be determined by the excess demand pressures in the markets for money and foreign exchange, but E will enter these functions only through the wealth effect. For surplus countries (as defined earlier), exchange rate movements will then generate perverse effects on the excess demand for foreign exchange: $F_e > 0$. Regardless of the sign of M_r, the system will in this case be dynamically unstable. For $M_r < 0$, condition (55) will be violated; for $M_r > 0$, that condition may be satisfied, but condition (54) cannot. For deficit countries, the system will also be unstable in all but extreme circumstances. 1/

Effective sterilization of exchange-market intervention is practically impossible if domestic and foreign securities are perfect substitutes, not because it would leave the exchange rate unchanged but because the financial markets would be destabilized by the attempted sterilization. A corollary of this finding is that effective sterilized intervention requires not just that domestic and foreign securities be imperfect substitutes, but that the degree of imperfection must be great enough to overcome the destabilizing influence of the wealth effect.

1/ For deficit countries, as noted earlier, $F_w + \phi_k < 0$; therefore, with $F_e' = \phi_e' = 0$, $F_e < 0$. If $M_r > 0$, condition (55) will be violated; if $M_r < 0$, that condition will still be violated unless $-(F_w + \phi_k) > F_r \cdot M_w/(-M_r)$.

Next consider the case in which domestic and foreign securities are imperfect substitutes, but in which the demand for money is not interest elastic. Even if money demand has some small negative response to interest rates ($M'_{rs} < 0$), M_r will be positive if this effect is outweighed by the wealth effect ($M_w \cdot G_{rs} > 0$). It is immediately apparent from equation (48) that if $M_r = 0$, then $dE/DZ^f = 0$. If $M_r > 0$, then F_e must be negative in order to satisfy stability condition (54). For $F_e < 0$, condition (55) may be solved in terms of M_r, giving $M_r < F_r \cdot M_e / F_e$. Thus M_r may be be positive but not too large. Within this range, the model is stable, but the effect of sterilized intervention on the exchange rate is perverse.

The logic of this result is that the effectiveness of sterilized intervention rests on the creation (at the initial exchange rate) of an excess supply of money and an excess demand for foreign exchange, both of which normally are equilibrated by a depreciation of the exchange rate (i.e., an increase in the price of foreign exchange and a decrease in the anticipated return on it). But if an increase in interest rates leads (indirectly) to an excess demand for money, then DPS wealth must be reduced through an appreciation ($dE < 0$) in order to equilibrate the money market. If the excess demand is large, the system will be unstable; if it is small enough, E will appreciate. It therefore is important for the authorities to target a monetary aggregate that has an interest-sensitive demand function. If the own rate on money balances is highly correlated with market interest rates, this condition is unlikely to hold. Sterilized intervention is more likely to be effective if the targeted aggregate is restricted to currency and transactions balances or if interest rates paid on deposits are effectively controlled.

VI. Domestic Policy Instruments

Sterilized policy can be implemented by a change in one (or more) of the domestic policy instruments, offset by a passive adjustment of bank reserves through open market operations. In order for such a policy to be effective, it is necessary for the financial system to be stable; i.e., the model must satisfy the stability conditions described in Section IV. If the sterilization of exchange-market intervention is destabilizing, then so will be the sterilization of domestic policy actions. If wealth effects dominate substitution effects but not by enough to destabilize the system, then perverse responses may be generated that also are analogous to those described above for exchange-market intervention. The present discussion will abstract from those conditions in order to determine whether sterilized domestic policies can be effective in normal conditions.

The overall pattern of effects is summarized in Table 2. There are eleven instruments, although only part of that set appears in any single version of the model. Four versions of the model are considered, corresponding to the different emphasis given to each type of instrument in the major industrial countries. These versions are the same as those described in Section III, above.

In a number of instances, policy instruments that appear in the full model cancel out, either in the consolidation of balance sheets or in the derivation of the SRF demand functions. Two instruments vanish completely: net claims of the central bank on the government other than securities (Z^g), which cancels out in the consolidation of accounts; and the ceiling on bank lending rates (q^ℓ). The latter instrument is essential in the credit-control model in order to prevent banks from nullifying the effectiveness of quantitative credit ceilings (q^c) by raising interest rates enough to equilibrate the loan market at the constrained supply of credit. As long as r^ℓ is constrained below that level, changes in q^ℓ alter the level of bank profits but do not affect the banks' marginal profit-maximizing conditions. Similarly, it has already been noted that neither the discount rate (r^b) nor the supply of central-bank credit to commercial banks (q^b) is an effective sterilized policy instrument in the market-oriented or credit-control versions of the model, but one or the other may be important when a secondary-reserve requirement is imposed. In most other cases, the general effects of sterilized policies are nonzero, indicated by X's in Table 2.

Where policies do have an effect, the sign of the effect generally is determinate either for the exchange rate or for interest rates, but not for both. This relationship--which may be observed in the right-hand columns of Table 2--may appear to be paradoxical. It is easily demonstrated, however, by reference to the diagram in Figure 1. The curve MM represents equilibrium in the market for domestic money balances (equation [46]); its slope ($-M_e/M_r$) is positive if substitution effects dominate. The region of excess demand for money lies below and to the right of this curve. Similarly, FF represents equilibrium in the market for foreign assets (equation [47]), with negative slope ($-F_e/F_r$) and with excess demand for F^a lying below and to the left. Assuming normal slopes, the intersection of MM and FF (point A) will be a stable equilibrium.

In general, any sterilized domestic policy action will shift both of these curves. If they shift in the same direction (vis-à-vis the interest rate axis), then the net effect on domestic interest rates will be ambiguous; if they shift in opposite directions, then the effect on the exchange rate will be ambiguous. This ambiguity does not arise with respect to exchange-market intervention (Z^F) or to changes in reserve requirements on ROW bank deposits (q^n) because these instruments do not appear in the money-market equilibrium condition. For example, an

Table 2. Normal Effects of Sterilized Policies 1/

Instruments	Nature of Constraints on Banks: Market oriented	Secondary reserves	Secondary reserves and quotas	Credit controls	Sign of Effect on: E	r^s		
q^d	x	x	x	--	+	?		
q^x	x	x	x	x	?	-		
q^n, z^f	x	x	x	x	+	+		
q^r				x	-	?		
q^c				x	?	+		
q^ℓ				--	0	0		
z^g	--	--	--	--	0	0		
					r^d fixed		r^d flexible 2/	
					E	r^s	E	r^s
q^s		x	x		?	-	+	?
r^b	--	x	--	--	?	-	-	?
q^b	--		x	--	?	+	+	?
x^g	--	--	x	--	?	+	+	?

1/ X indicates that the instrument appears in the solution of the model for E and r^s; a double dash indicates that the instrument appears in the model but not in the solution; a blank indicates that the instrument is not in the model. The nonzero signs listed for each instrument apply to the versions marked with an X.

2/ The columns under "r^d fixed" indicate the responses where the direction of shift in MM (see Figure 1) is the same as it would be if r^d were completely fixed. The entries under "r^d flexible" indicate the responses where flexibility of r^d is great enough to reverse the shift in MM but not so great as to destabilize the model.

increase in the central bank's holdings of foreign-currency assets shifts the FF curve upward. At the initial exchange rate, there is an excess demand for foreign-currency assets, which brings a depreciation of the exchange rate and an increase in domestic interest rates (point B), as described in Section V.

The pattern of effects of domestic instruments on E and r^s can be illustrated by the role of changes in reserve requirements on domestic deposits. First, consider an increase in cash reserve requirements on bank liabilities that are included in the targeted monetary aggregate (q^d). The direct impact is to reduce the equilibrium yield (implicit or explicit) on monetary liabilities (r^d) relative to r^s, according to equation (39). 1/ This reduction decreases the demand for money at the initial values of r^s and E and increases the DPS demand for other assets, including foreign assets. In terms of Figure 1, MM and FF both shift to the right, and the new equilibrium is at point C. Both shifts contribute to a depreciation of the exchange rate, but they generate conflicting pressures on domestic interest rates. Without quantitative information about the magnitudes of the shifts, one cannot determine the net effect on r^s.

The implications of an increase in reserve requirements on excluded bank liabilities are rather different. An increase in q^x directly reduces r^x relative to r^s, according to equation (40). This decrease initially raises the demand for money as well as the demand for foreign assets, since r^x is a substitute yield in both functions. FF again shifts to the right, but now MM shifts to the left. The new equilibrium is at point D. Domestic interest rates rise, but the exchange rate in this case may be higher or lower than initially.

Changes in secondary reserve (or liquid asset) requirements have effects that are intermediate between those of q^d and q^x. An increase in q^s reduces both r^d and r^x, shifting FF to the right. The direction in which MM shifts depends on the relative importance of changes in r^d. If the return on money balances is relatively fixed or if the demand for money is relatively insensitive to changes in r^d, then an increase in q^s will work like an increase in q^x, shifting MM to the right. If $M_{rd}=-M_{rx}$, then MM will not shift, and changes in secondary-reserve requirements will operate in the same fashion as exchange-market intervention. If changes in r^d dominate those in r^x in the money demand function, then the effects of q^s will be similar to those of q^d.

1/ If a secondary-reserve requirement is in place, the effect of q^d or r^d works through equation (39') or (39"). If r^d is controlled effectively ($r^d=q^r$), then sterilized changes in q^d do not affect the banks' marginal conditions.

The only circumstance in which sterilized changes in the discount rate affect E or r^s is when a secondary reserve requirement is effective and banks are free to adjust the level of their borrowings from the central bank. In that case, an increase in r^b leads to increases in r^d, r^x, and r^ℓ relative to r^s according to equations (38') through (40'). 1/ These increases initially reduce the excess demand for foreign assets; depending on the relative importance of changes in r^d, the demand for money could increase or decrease (as in the response to q^s). If changes in r^d are not important, then the exchange rate change will be ambiguous but r^s will decline. This result, too, may appear to be paradoxical: is it reasonable to expect an increase in the discount rate--offset by expansionary open market operations--to lead to a decrease in yields on government securities? If the yield on money is flexible enough that the asset markets can be equilibrated through an increase in r^d, then no decline in r^s will be necessary. But with the yield on money relatively fixed, an initial increase in lending and deposit rates will reduce the demand for money and exert downward pressure on security yields (r^s). 2/

Other domestic policy actions may be effective in specific circumstances. First, in the constrained secondary-reserve version of the model, an increase in the availability of funds to the banks via an increase in borrowing quotas (q^b) or in government deposits at commercial banks (X^g) is expected to lead to a decrease in bank lending rates (see equation [38"]) and thereby to a decrease in rates paid on bank deposits. The effects of these changes on E and r^s are exactly analogous to the effects of a decrease in the discount rate in the unconstrained secondary-reserve version. Second, whenever the authorities have effective control over the interest rates paid on deposits, an increase in the allowed rate (q^r) will have effects that are analogous to those of decreases in reserve requirements (q^d). 3/ Finally, an increase in quantitative credit ceilings (q^c) provides additional credit to the public, raising the demands for all assets. The MM and FF curves respectively shift to the right and to the left, raising interest rates and having an ambiguous effect on the exchange rate.

1/ If a separate reserve requirement on ROW deposits (q^n) is in effect, then r^n will also rise relative to r^s.

2/ As can be seen from equations (38') through (40'), r^ℓ will rise, but the net effect on r^d and r^x will be indeterminate.

3/ By assumption, q^r applies to r^d but not to r^x. A regulated increase in the rate paid on X would have effects comparable to a decrease in q^x.

VII. Conclusions

The monetary authorities of large industrial countries have available a number of instruments, each of which can affect the supply of money and the demands for money and other financial assets. Because the instruments have different effects on asset demands, they may affect asset prices even if they are combined so as to have no net effect on the supply of money. The analysis in this paper is primarily theoretical: it evaluates the relationships between institutional structure in several countries and the effects of sterilized policies, but it does not attempt to estimate the empirical importance of these effects. Nor does it attempt to evaluate the efficiency of the several instruments in the context of national economies. The following conclusions could, however, serve as the basis for empirical studies by helping to define the testable conditions that are necessary for the effectiveness of sterilized policies and by narrowing the range of instruments that one could reasonably expect to be effective.

The general conditions for the effectiveness of any of these sterilized policies are that domestic and foreign securities be sufficiently imperfect substitutes and that the demand for money be sufficiently interest-elastic. These conditions cannot be stated rigorously, since they interact with other conditions in the financial system. In general, however, the analysis in the paper suggests that the necessary conditions are stronger than those implied by most studies of the effectiveness of exchange market intervention. If domestic and foreign securities are perfect or simply very close substitutes, then any attempt by the authorities to sterilize their intervention in foreign exchange markets or to sterilize changes in domestic policy instruments will tend to produce destabilizing movements in the exchange rate. If the demand for the targeted monetary aggregate is insensitive to interest rate movements, then the system may again be unstable or the responses of the exchange rate or interest rates may be perverse.

The effectiveness of sterilized changes in domestic instruments depends additionally on the condition that the policy action alter the profit-maximizing interest rates faced by the banks (lending and deposit rates) relative to yields on securities. This condition depends in turn on the framework of the monetary system. Except in the one case where banks are free to borrow as much as they demand at the given discount rate but are constrained by a secondary reserve requirement, sterilized changes in the discount rate are not effective. Changes in reserve requirements, credit ceilings, or interest rate ceilings generally do affect the banks' profit-maximizing conditions, but the direction of the effects on the exchange rate is not always clear. A number of domestic instruments generate shifts in the money and foreign exchange markets that are offsetting in their influences on the exchange rate, so the net effect cannot be determined qualitatively.

The circumstances in which sterilized domestic instruments have determinate effects on the exchange rate are as follows. First, if banks are subject to a secondary reserve requirement and if the interest rate paid on monetary liabilities is sufficiently flexible, then any one of several instruments will have unambiguous effects on the exchange rate. These instruments include sterilized changes in the secondary reserve requirement, in quotas on bank borrowing or--in the absence of quotas--the discount rate, or in the volume of government deposits at commercial banks. The stated conditions for these instruments, however, are quite strict: if deposit rates are relatively fixed, then the exchange rate effects will be ambiguous in sign, while excessive flexibility could destabilize the system. Second, and more generally, changes in reserve requirements on monetary liabilities (bank deposits that are included in the targeted aggregate) or in controls on the interest rates that banks may pay on those liabilities have unambiguous effects on the exchange rate. Either a decrease in reserve requirements or an increase in interest rate ceilings leads to an increase in the yield on money balances, increasing the demand for money, decreasing the net demand for foreign assets, and thus appreciating the exchange rate. Third, changes in reserve requirements on non-resident bank deposits (or, equivalently, in controls on interest rates payable on such deposits) have unambiguous effects that are similar to those of exchange market intervention. A decrease in these reserve requirements leads to an increase in interest rates available to nonresident depositors and thus to an appreciation of the exchange rate.

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