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Macroeconomic Policies and the Balance of Payments

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Stockholm in January, 1988
Anders Vredin

Contents

1. Macroeconomic Policies and the Balance of Payments: Background and Summary*

1.1 INTRODUCTION

This thesis contains a collection of papers which study different aspects of the relation between macroeconomic policies and the balance of payments. The latter is normally defined as the change in the foreign exchange reserves, but the studies are not restricted to the item "below the line"; the balances on the current and capital accounts are sometimes in focus. The macroeconomic policies considered are normally described as monetary, fiscal, or exchange rate policies. Institutional factors and empirical regularities pertaining to the Swedish economy are given relatively much attention, while purely theoretical issues play a minor role.

The studies are focused on two different questions. The first, which is the common theme of Chapters 2-4, concerns the degree

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* I am indebted to Staffan Viotti, Lars Hörngren, Peter Englund, and Jonas Agell for helpful comments on earlier drafts.

of substitutability between assets denominated in different currencies and how asset substitutability affects the scope for monetary policy in a small open economy like Sweden. The second question is treated in Chapter 5 and concerns the empirical evidence on the determinants of the Swedish current account. The two questions are related, in the sense that they both concern problems associated with international capital mobility. However, the separate studies make use of quite different methods and data, and no attempt is made to present the results in an integrated theoretical framework.[1]

Chapter 2 is focused on the question about the relation between capital mobility and monetary autonomy. In particular, the role of the forward foreign exchange market is analyzed in the context of a simple portfolio balance model, under the maintained assumption of imperfect substitutability between domestic and (uncovered) foreign securities. Chapter 3 contains a review of theoretical and empirical evidence on the degree of international asset substitutability. Unlike the portfolio balance model used in Chapter 2, the theoretical models reviewed in Chapter 3 are based on explicit assumptions about the optimization problem and the nature of the fundamental uncertainty that investors face. Empirical tests on spot and forward exchange rate data for the Swedish krona are presented in Chapter 4, which also contains a description of the Swedish currency basket system. Chapter 5, finally, is focused on the co-movements of the current account and other real aggregates. A four-variable vector-autoregressive model is estimated and interpreted.

One purpose of this chapter is to give a summary of the main results of the thesis. Before summarizing, however, I would like to present some arguments as to why economists or policy makers should be concerned with questions of monetary autonomy,

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1 See Boothe et al (1985) for a similar approach to macroeconomic policies and balance of payments problems in Canada.

balance of payments determination, and international capital mobility in general. In their review of recent developments in international monetary economics, Frenkel and Mussa (1985) argue that balance of payments and exchange rate issues now "are regarded as important in their own right, rather than as subsidiary concerns of policy management" (p. 680). Since the work underlying Chapters 2-5 of this thesis has been undertaken on the assumption that the issues dealt with are of interest not only "in their own right", another purpose of this chapter is to provide a background and some motivations for the studies in question. Section 1.2 is thus devoted to the question whether exchange rates and the balance of payments matter. The Swedish experiences of stabilization policy under different exchange rate regimes are discussed in Section 1.3. Section 1.4 contains the summary of the thesis.[2]

1.2 DO EXCHANGE RATES AND THE BALANCE OF PAYMENTS MATTER?

In principle, policy makers may be concerned with the development of exchange rates and the balance of payments for two different reasons. First, a given policy may bring about changes in exchange rates and/or the balance of payments - e.g., through private capital movements - that in turn influence the effectiveness of that policy. Second, fluctuations in exchange rates and the balance of payments may initiate changes in policy, to the extent that they are associated with movements in some target variable.

As a starting point for a discussion of these issues, I will use a simple stochastic IS-LM model of the options for monetary policy. The model, which is presented in Section 1.2.1, is due to Henderson (1979, 1984), and is a generalization of Poole's

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[2] It is not necessary for an understanding of Chapters 2-5 to read the background material in this chapter. Many - in fact, most - of the questions raised in this introductory survey are left unanswered by the subsequent chapters in the book. A reader who just wants a summary of the main results is referred to Section 1.4.

(1970) analysis to the case of an open economy. Three features of the model are worth emphasizing. First, assumptions are chosen so that monetary and exchange rate policies would be non-neutral, i.e., have real effects, if the economy were closed. Second, the model is intended to shed light on the relation between "targets" and "instruments" of macroeconomic policy. Third, the analysis is confined to a static and short run perspective where the economy's nominal wealth and, in particular, expectations are constant and independent of current policies.

The first and second features make the model suitable for the purposes of this chapter. In order to focus on the consequences of international capital mobility for policy-making in an open economy, it seems natural to make assumptions that ensure that monetary and exchange rate policies - or, more generally, financial disturbances - can be transmitted to real variables in a closed economy.[3] More precisely, it is (implicitly) assumed that nominal wages are less than fully flexible, and that private decisions are affected by the supply of government bonds.[4]

It is fairly common that problems of monetary and exchange rate policies are analyzed in terms of models that are partial in the sense that they treat all real (as opposed to financial) variables as exogenous. The (monetary) authorities are thus assumed to have their objectives defined in terms of "intermediate targets" such as the money stock, foreign exchange reserves or interest rates, but the mechanisms through which the effects of monetary policies are transmitted to "ultimate targets", such as employment or production, are not modelled. Such an approach permits a more thorough treatment of strictly financial problems, but cannot, of course, lead to any

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3 This is the approach taken by Frenkel and Mussa (1981).

4 See, e.g., Obstfeld (1982) and Stockman (1983) for discussions about the relevance or irrelevance of monetary policies in open economies.

conclusions as to why balance of payments and exchange rate issues may be important for other reasons than "their own right".

Although the model discussed in Section 1.2.1 is a useful reference model for some purposes, the static and short run IS-LM framework is clearly insufficient for an analysis of some important issues of macroeconomic policies and the balance of payments. Theoretical models which allow wealth, expectations, etc., to be endogenously determined are thus discussed in Sections 1.2.2 - 1.2.4.

1.2.1 A stochastic IS-LM framework

Consider the following open-economy IS-LM portfolio-balance model:

$$x\left[Y,\ r,\ r^*,\ S;\ u^x\right] = 0, \tag{1.1}$$

$$M = L\left[Y,\ r,\ r^*,\ S;\ u^z,\ u^l\right], \tag{1.2}$$

$$T = K\left[Y,\ r,\ r^*,\ S;\ u^z,\ u^k\right]. \tag{1.3}$$

The first equation is the condition for equilibrium in the domestic goods market. Y denotes real national income, r and r^* are the domestic and foreign nominal interest rates, and S is the exchange rate (units of domestic currency per unit of foreign currency). The model includes domestic and foreign goods, which are assumed to be less than perfect substitutes, and wages are assumed to be less than perfectly flexible in the short period of time which is considered. Henderson's original (1984) model is presented in a rational expectations framework, where variables are expressed in terms of deviations from expected values, and equilibrium is defined in terms of the labor market instead of the goods market. For our purposes, however, (1.1) may be treated as a conventional IS curve. The money market equilibrium condition (the LM curve) is given by (1.2), and (1.3) is the equilibrium condition for the domestic securities market. M is the domestic nominal money stock, and T denotes private holdings of domestic securities.[5]

The nominal exchange rate enters (1.1) because of substitution as well as wealth effects from changes in the exchange rate on the domestic and foreign demand for the domestic good. It is assumed that a depreciation (an increase in S) increases demand. The presence of S in the asset demand functions in (1.2) and (1.3) reflects that a change in the current exchange rate, given the expected future rate, involves a change in the (expected) relative returns on domestic and foreign assets. An instantaneous depreciation involves a lower expected rate of depreciation, a lower demand for foreign securities, and a correspondingly higher demand for money and domestic securities. In addition, asset demands may respond to "real balance" effects associated with a change in the exchange rate.

u^x represents a disturbance to the goods market which involves a change in the demand for the domestic good and a corresponding (but opposite) change in the demand for the foreign good. u^z represents a disturbance to the demand for money which is matched by a corresponding (but opposite) disturbance to the demand for domestic securities. u^l (u^k) is a disturbance to the demand for money (domestic securities) which is matched by a disturbance to the demand for foreign securities. Note that important exogenous variables such as foreign income and price levels, domestic and foreign nominal wealth, etc. have been suppressed, on the assumption that they

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5 Elementary textbook models of stabilization policy in open economies often include a balance-of-payments equilibrium curve in addition to the IS and LM curves. The instantaneous equilibrium in Henderson's (1984) model does not require the trade balance to equal the capital balance, but that there is equality between the supply of and demand for domestic securities. The difference between the flow and stock equilibrium approaches becomes unimportant only in the case of perfect substitutability between domestic and foreign securities.

(like r^*) are held, and are expected to be held, constant.

Suppose that the disturbances are not observed when the optimal policy is to be chosen, and that the objective is to minimize the variance of output, given the distributions for the u's. Henderson (1984) distinguishes between two strategies for monetary policy (fiscal policies are not considered):

(i) a "rates constant" policy which involves fixing the exchange and interest rates, while allowing the monetary aggregates to be varied in accommodating operations (interventions) in the markets for domestic and foreign securities. Under this strategy, (1.1) - (1.3) determine Y, M and T, given r and S.

(ii) an "aggregates constant" policy which involves fixing the monetary aggregates, while allowing the exchange and interest rates to vary. (1.1) - (1.3) then determine Y, r and S, given M and T.

It is easily seen that if only disturbances to the goods market are present, an "aggregates constant" policy, which allows r and S to adjust to the movements in u^x, will be the proper strategy. If, on the other hand, only disturbances to the asset markets occur, a "rates constant" policy will effectively insulate the goods market by not allowing r and S to vary. In the case of disturbances to both goods and asset markets, fixed exchange and interest rates will be the optimal strategy if financial disturbances dominate.[6]

We may rephrase the question "do exchange rates matter" as "does it matter whether exchange rates are fixed or flexible", and relate some common arguments in favor of fixed or flexible exchange rates (see, e.g., Tower and Willett (1976)) to the

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6 Note that pure "rates constant" and "aggregates constant" policies may, in principle, be dominated by a policy where one aggregate and one rate (e.g., T and S) are fixed.

above model. It has been argued that a fixed exchange rate imposes a constraint on stabilization policy, since the exchange rate cannot be used to correct balance of payments disequilibria. This argument is based on the (in most cases implicit) assumptions (i) that balance of payments equilibrium (a constant level of foreign exchange reserves) is desirable, (ii) that the benefits of stabilization policy are related to the number of policy instruments at hand, and (iii) that a fixed exchange rate policy restricts the monetary authorities' opportunity set by excluding the use of a potentially important instrument. In Henderson's (1979, 1984) analysis, in contrast, the level of reserves does not enter the authorities' objective function; the maximum number of instruments in the model is limited to two; and there is need for only one instrument. Monetary aggregates and exchange and interest rates are alternative instruments of monetary policy, for which the only ultimate goal is to stabilize output. It may be optimal to keep the monetary aggregates constant, and let the exchange rate vary, or it may not. Constant levels of monetary aggregates (or flexible exchange rates) have no independent value. It should also be noted that an aggregates constant policy, where the exchange rate is fully flexible, does not imply that the latter can be used as a policy tool.

It has also been argued that flexible exchange rates will lead to higher price level variability and to "vicious circles" of depreciation and inflation. Henderson (1984) uses a version of his model (where wages are indexed to the general price level) to show that for a given level of output variability, price level variability may be higher under floating than under fixed rates. This may thus be a disadvantage of a flexible-rates system, if price stability is a target for policy makers.[7] On the other hand, an argument in favor of flexible exchange rates has been that exchange rate flexibility may be a substitute for

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7 Stabilization of the price level may under certain conditions be equivalent to output stabilization, although this does not imply that a flexible exchange rate regime is necessarily optimal (cf. Flood (1979)).

price and wage flexibility. For example, money wage disturbances may be neutralized by exchange rate movements, so that "competitiveness" is automatically maintained.[8] In Henderson's model, exchange rate flexibility may limit the output (employment) effects of various disturbances, but the optimal exchange rate policy will depend on which type of disturbances dominates. As shown by Dornbusch (1976), a characteristic feature of a sticky-price flexible-exchange-rate economy may be that the short run behavior of the exchange rate involves an "overshooting" of the long run equilibrium level. It should be emphasized that "excessive" variability does not constitute an argument against a flexible rates system, if it is associated with a low and desired variability of employment.[9]

A more thorough discussion of the stabilizing properties of flexible exchange rates is contained in the survey by Marston (1985). For our purposes, it is particularly noteworthy that the above model makes clear that the optimal stabilization policy will depend, among other things, on the degree of capital mobility or, more precisely, on the degree of substitutability between domestic and foreign securities. In particular, if they are perfect substitutes, i and S are constrained by the uncovered interest parity condition. This means that the authorities' opportunity set is limited to <u>three</u> variables, <u>one</u> of which may be chosen as the instrument for financial policy. Without further assumptions it cannot be determined whether it is optimal, e.g., to peg the exchange rate rather than the money stock. What <u>can</u> be said is that <u>if</u> the exchange rate is chosen to be predetermined, neither the

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8 If nominal prices and wages were perfectly flexible, nominal exchange rates might be irrelevant for real variables; see, e.g., Kareken and Wallace (1981), Stockman (1983), and Corden (1985).

9 Note that flexibility in one price (the exchange rate) hardly can be expected to compensate for sluggish adjustment in a larger number of relative prices in goods (and asset) markets; cf. Chipman (1980).

money stock nor the interest rate can be determined independently of that choice.[10]

The foregoing discussion suggests that exchange rate changes may be one ingredient in an optimal policy geared at stabilizing output, and that the optimal exchange rate policy depends on the degree of capital mobility. In this sense, this theoretical framework offers some arguments to the effect that the balance of payments and exchange rates should indeed be "concerns of policy management", just like interest rates and the money stock. On the other hand, the simple IS-LM model cannot lend any support to Mundell's (1962) recommendation that once a fixed exchange rate policy has been chosen, monetary policy should be directed towards "external balance", i.e., a constant level of foreign exchange reserves.

In the present framework, it is optimal either to fix the exchange rate or to let it fluctuate freely. In the latter ("aggregates constant") case M and T are the instruments of monetary policy, while in the former ("rates constant") case the exchange and interest rates are the preferred instruments (to be predetermined by the authorities). In either case, one instrument can be fixed arbitrarily, while the other is set so as to minimize the variance of output. Unless domestic and foreign securities are perfect substitutes, one instrument is thus redundant in Henderson's (1984) analysis. This means that the fixed exchange rate/external balance combination is <u>feasible</u>, although nothing can be said as to why it should be <u>desirable</u>.

Henderson (1984) shows that in the (perhaps more realistic) case when the authorities can observe current movements in the financial variables not chosen as policy instruments, which may then be labelled "information variables", or "intermediate

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[10] Boyer (1978b) studies the authorities' optimization problem in a model where capital is perfectly mobile, but where the budget deficit may be used as an additional instrument.

targets", a feedback rule is generally optimal. It may be optimal to follow a "managed float" policy in which the monetary aggregates are varied in response to observed movements in the exchange and interest rates. This argument is analogous to that of Frenkel and Mussa (1981), who argue that the exchange rate is a useful "indicator" for monetary policy. Alternatively, it may be optimal to follow a policy where an exchange rate instrument is adjusted in response to changes in monetary aggregates, such as the foreign exchange reserves. It still remains to be shown why short run balance of payments equilibrium, in the sense of a constant level of reserves, should be an optimal intermediate target.

The fact that the foreign exchange reserves position (like the stability of the price level) does not enter the authorities objective function in Henderson's (1979, 1984) model does not, of course, mean that "external balance" generally is an unimportant concept. On the contrary, policy makers seem to feel that they are faced with an "external balance constraint". Since this notion is not, apparently, warranted by the IS-LM model, we will turn to models that take a longer run perspective on economic policy.

1.2.2 The monetary approach to the balance of payments

It is well known that the combination of international capital mobility and a fixed exchange rate policy makes the money stock endogenous. This observation, which can be made from the model in Section 1.2.1, is also one of the messages of the monetary approach to the balance of payments. Proponents of the monetary approach sometimes argue that domestic and foreign securities can be viewed as perfect substitutes, which - as seen above - implies that the money stock is not even controllable (if the exchange rate is fixed). The most important message, however, may be summarized in the statement that the balance of payments is a monetary phenomenon.[11]

[11] Cf. Frenkel and Johnson (1976), who summarize the history of

The basic ingredients in the monetary approach to the balance of payments can be captured by a fixed-exchange-rate non-stochastic version of the model in the previous section:

$$Y = X\left[Y,r,r^*,S,W/S\right] + NX\left[Y,r,r^*,S,W/S\right], \qquad (1.4)$$

$$M/S = l\left[Y,r,r^*,S,W/S\right], \qquad (1.5)$$

$$T/S = k\left[Y,r,r^*,S,W/S\right]. \qquad (1.6)$$

For future reference, we express the goods market equlibrium condition (1.4) in terms of total domestic expenditures X(.) and the trade balance NX(.), and explicitly make clear that demand is a function of domestic wealth, W, which in turn is defined as

$$W = M + T + F, \qquad (1.7)$$

where F denotes (net) domestic holdings of foreign securities. The money market and securities market equilibrium conditions are now expressed in terms of real stocks. It is assumed that the domestic and foreign price levels are linked through purchasing power parity, $P = SP^*$, and units are chosen so that $P^* = 1$.

It is further assumed that the monetary authorities let T and S be predetermined, which means that neither a pure "rates constant" nor a pure "aggregates constant" is followed. Monetary policy takes the form of open market operations where the monetary authorities exchange domestic securities for money or foreign securities. As noted above, the consequence of capital mobility and the fixed exchange rate policy is to make the money stock endogenous. Capital mobility allows the private agents to exchange domestic money for foreign securities; the

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the ideas in the tradition of the monetary approach.

associated excess supply of domestic currency is accommodated by the central bank at a fixed exchange rate.

The model thus determines the instantaneous equilibrium values of Y, i, and M. The equilibrium conditions for the goods market (1.4) and the domestic securities market (1.6) jointly determine Y and i, while M is recursively determined by the money market equilibrium condition (1.5).

A crucial point in the monetary approach to the balance of payments is the central bank's balance sheet, which shows that the foreign exchange reserves, R, are part of the (base) money supply:

$$M = R + T^C - J, \qquad (1.8)$$

where J is the bank's net worth, and T^C its holdings of domestic securities, i.e.,

$$T^C = \bar{T} - T, \qquad (1.9)$$

where $\bar{T}$ is the total stock of domestic (government) securities.

Long run equilibrium in this model may be taken to imply that Y is equal to the full employment level $\bar{Y}$, and that the current account is balanced, i.e., that

$$NX\left[\bar{Y}, r, r^*, S, W/S\right] + r^* \frac{F}{S} = 0. \qquad (1.10)$$

Using (1.5), (1.7) and (1.9) this condition can be written on reduced form as

$$n\left[\bar{Y}, r^*, (\bar{T}-T^C)/S, W/S\right] = 0, \qquad (1.11)$$

which determines the long run equilibrium value of W.

Frenkel and Mussa (1985) consider the adjustment to long run equilibrium under two extreme assumptions about capital mobility. If there is <u>no capital mobility</u>, the long run equilibrium levels of r and M will be given by suitably modified versions of the money market equilibrium condition (1.5) and the "external balance" condition (1.10):[12]

$$M/S = \bar{l}\left[\bar{Y},\ r,\ S,(M+\bar{T}-T^{c})/S\right], \tag{1.12}$$

$$\bar{NX}\left[\bar{Y},\ r,\ S,\ (M+\bar{T}-T^{c})/S\right] = 0. \tag{1.13}$$

In the case of <u>perfect capital mobility</u>, which is here taken to mean that $r = r^{*}$, the conditions corresponding to (1.12) - (1.13) determine W and M and will read

$$M/S = \tilde{l}\left[\bar{Y},\ r^{*},\ S,\ W/S\right], \tag{1.14}$$

$$\tilde{n}\left[\bar{Y},\ r^{*},\ (\bar{T}-T^{c})/S,\ S,\ W/S\right] = 0. \tag{1.15}$$

As in the case of no capital mobility, the long run equilibrium value of M is independent of the central bank's net worth, J. From the central bank's balance sheet (1.8) it is then obvious that any change in J will involve a corresponding change in R.

According to Frenkel and Mussa (1985), an essential feature of the monetary mechanism of balance of payments adjustment is that "any change in the supply of domestic money demand leads to an equivalent change in foreign exchange reserves and to a corresponding cumulative payments surplus (or deficit)" (p. 691). Suppose that there is an increase in the fiat issue of the central bank, which decreases the bank's net worth, i.e., lowers J. From the reasoning above it follows that dR = dJ. Another, completely analogous, feature of the monetary approach

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[12] Complete capital immobility here implies that F = 0 (and, hence, W = M + T), and that r* is not an argument in demand functions.

to the balance of payments is that "any change in the long-run equilibrium level of domestic money demand that is not offset by changes in the domestic assets component of the money supply ultimately leads to a corresponding change in the foreign exchange reserve" (Frenkel and Mussa (1985), p. 691). It is in this sense that "the balance of payments is regarded as a monetary phenomenon" (Frenkel and Johnson (1976)).

The effects of an open market operation that changes T^c differ from the "helicopter" operation considered by Frenkel and Mussa (1985), since the former operation affects private wealth. This result hinges on the assumption that "Ricardian equivalence" does not hold (cf. Obstfeld (1982)). It should also be noted that the recursivity of the model breaks down if the monetary authorities systematically sterilize the movements in R by offsetting changes in T^c. The economy's adjustment towards long run equilibrium can be prolonged by sterilization, provided that capital is less than perfectly mobile.[13]

If capital is less than perfectly mobile, so that the money stock is controllable, the question arises whether it <u>should</u> be manipulated, e.g., in attempts to stabilize output in the short run. Swoboda (1973) argues that "though monetary policy is rarely appropriate as a counter-cyclical device and taken by itself, unless the level of reserves is of no concern, it does represent a very powerful instrument of balance-of-payments policy" (p. 258). Following Mundell (1962), Swoboda suggests that monetary policy should be assigned to external balance and fiscal policy to internal balance.[14] Frenkel and Johnson (1976) state that "monetary processes will bring about a cure (for

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[13] The model with some but less than perfect capital mobility is more thoroughly discussed in the survey by Marston (1985). For analyses of sterilization (in the short run as well as in the long run), see Boyer (1979) and Obstfeld (1980).

[14] See Boyer (1978a), Henderson (1977), and Marston (1985) for discussions and references to more recent literature on the "assignment problem".

balance of payments problems) of some kind - not necessarily very attractive - unless frustrated by deliberate monetary policy action" (p. 24, parenthesis added). The message seems to be that neither systematic sterilization, nor discrete open market operations, should be undertaken.

When going from the positive conclusion that the balance of payments is a monetary phenomenon (in the long run) to normative ideas for (short run) monetary policy, Swoboda and Frenkel and Johnson obviously presume that the balance of payments should be of concern to policy makers, and that a balance of payments deficit (or surplus) constitutes a problem (for some other reason than its effect on the monetary base). I believe that this presumption must be based on some of the following arguments. Corden (1985, Ch. 3) suggests that the reserves may be used to "provide for emergencies", that there may be an optimal level of reserves, and that the authorities may want to stabilize reserves because of costs of adjustment. At an informal level, the argument is consistent with the discussion in the previous section. It is natural to think of the foreign exchange reserves as a buffer which absorbs the short run fluctuations in money demand (or supply) in a fixed exchange rate economy. But if there are significant costs associated with changes in reserves, or with satisfying the non-negativity restriction, this should be taken into account when the optimal policy is selected. In effect, the proper policy may be to let the exchange rate float, rather than to follow the fixed exchange rate policy analyzed by Mundell (1962), Swoboda (1973) and others in the tradition of the monetary approach.

Another argument relies on the assumption of complete capital immobility, in which case balance of payments deficits correspond to current account deficits. Mundell (1962) explicitly states that he "assumed away ... concern about the precise composition of the balance of payments" and that the suggested policy mix therefore may be "desirable only in the short run" (p. 234n). Mundell is nevertheless criticized by Williamson (1971), who argues that "there are no circumstances in which it would be desirable to pursue Mundell's strategy" (p. 236). An economy's welfare (future consumption possibilities) is more directly related to its total stock of foreign assets than to its reserve position, Williamson argues. He criticizes the ad hoc use of a balance of payments target in an analysis which is intended to be normative, and suggests that "an efficient adjustment mechanism must include a means of adjusting the current account" (p. 237). The current account is explicitly recognized as an "external balance constraint" in the monetary approach to the balance of payments, in the sense that a long run equilibrium is assumed to be characterized by a zero balance on current account. The important message, however, is that the monetary mechanism of balance of payments adjustment is a stable, equilibrating process. The theoretical framework associated with the monetary approach does not, in itself, offer any ground for an assertion that the current account is an important target variable.

Finally, arguments have been made to the effect that the balance of payments may have a direct influence on exchange rate expectations. For instance, Swoboda (1973) argues that the reserve stock should be "large enough relative to disturbances to finance temporary deficits without causing anticipations of devaluation" (p. 257).

The next subsection will be devoted to a discussion of the role of expectations, while the current account as an "external balance constraint" is discussed in Section 1.2.4.

1.2.3 Expectations and credibility

In simple non-stochastic and static IS-LM models, macroeconomic policy is treated as completely exogenous. Poole (1970) and Henderson (1979, 1984) consider the problem of selecting optimal policies when the economy is subjected to stochastic disturbances. Policy instruments are still predetermined in these models, if they have to be set before any disturbances are realized. If, on the other hand, the authorities have some information about the outcome of the stochastic processes, e.g., through observations of movements in some "information variables", feedback rules are generally optimal.

Once policy is made endogenous (and purposeful), it seems very restrictive to assume private agents' expectations to be invariant to changes in policy. Since expectations, in turn, affect equilibrium outcomes, the problems of policy making become quite complex. For example, if there is some degree of international capital mobility, international interest rate differentials will depend on expected changes in exchange rates. Modern theory teaches that since interest rates via capital movements in turn affect equilibrium levels of exchange rates, the latter will depend on current as well as the entire expected future paths of all exogenous variables which influence asset demands or supplies.[15] In other words, the short run behavior of exchange rates in a flexible rates system will not be independent of long run economic policies. In analogy, a fixed exchange rate policy is feasible only insofar as agents expect future monetary and fiscal policies to be consistent with a constant exchange rate in the long run.

Recent research about the role of expectations in a world of international capital mobility and rational agents does not deny that balance of payments and exchange rate issues are "concerns of policy management", although it stresses that there is no simple relation between, e.g., monetary policies

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[15] See, e.g., Obstfeld and Stockman (1985), who define movements in exchange rates caused by expected future changes in exogenous variables as "extrinsic" exchange-rate dynamics. "Intrinsic" dynamics are defined as adjustments towards long run equilibrium. (The economy may be out of long run equilibrium because of, e.g., price stickiness or imperfect information.) It should also be noted that there are models in which the exchange rate does <u>not</u> depend on expectations (cf. Lucas (1982)).

and the behavior of exchange rates over a given time interval. The "external balance constraint" that a fixed exchange rate policy has to satisfy is that no expected excess supply of money (loss of reserves) at any future date is larger than a certain maximum level (given by the requirement that the level of reserves cannot be negative). If this constraint is violated, one may experience a run on reserves, a "balance of payments crisis", and an immediate adjustment of the exchange rate. Expectations about the fiscal and monetary policies that the authorities will follow after the breakdown will affect both the timing of the crisis (cf. Obstfeld (1984)) and the behavior of important macroeconomic variables between the date when the crisis is foreseen and that of the eventual occurrence. Drazen and Helpman (1986) suggest that money stock, current account and exchange rate movements contain information about expected future policies.

An important question is how (if) policies gain <u>credibility</u>. For example, the presence of nominal wage (and other) contracts may create an ex post incentive for deviations from an ex ante policy of a fixed exchange rate, since discrete devaluations (or, more generally, unexpected increases in the price level) will lower real wages and stimulate employment, raise tax revenues, etc. In the literature on the credibility issue in this context, it is often assumed that the government's loss function (or the social welfare function) contains inflation as an argument besides unemployment. The ex post incentive to inflate imposes a real cost on society, since expectations of inflation will be reflected in nominal wage contracts. A game between the government and wage earners (or a trade union) may thus imply that inflation rises, without any gain in terms of employment. If the game is repeated over time, there is a trade-off between current employment and future inflation. Repeated games, on the other hand, open the possibility that credibility can be established through "reputation".[16]

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[16] The literature on the "time-inconsistency" of monetary policy in a closed economy has been reviewed by, e.g.,

In a closed-economy framework, Rogoff (1985a) shows that the costs from lack of credibility may be reduced by the appointment of a central banker who puts more weight to inflation than the government (and society as a whole), or to some nominal "intermediary target", such as the money supply. To my knowledge, this result has not been generalized to an open economy context, or to the effect that the exchange rate (or the level of foreign exchange reserves) is a useful target. Even if such a generalization is possible, it should be noted that Rogoff's analysis also shows that rigid targeting (an infinite weight on inflation) is not optimal, since the gain from reduced inflation is achieved at the cost of higher variability in employment. In other words, the observations that expectations are important, and that inflation may reduce welfare, do not warrant the conclusion that the price level should be insulated from real shocks.

International cooperation within a fixed exchange rate system may be beneficial, to the extent that it lowers the costs that are due to lack of credibility. On the other hand, a fixed rates system also involves a real cost in the sense that countries will not be free to choose their preferred level of inflation taxation (if purchasing power parity is a reasonable description of the long run relationship between national price levels). It is also possible that international cooperation creates new credibility problems. Rogoff (1985b) provides a theoretical example where a fixed rates system is counterproductive and lowers welfare.[17] Empirically, it does not seem as if systems of pegged exchange rates lower the

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Cukierman (1986) and Persson (1987). It has been applied to exchange rate economics by Horn and Persson (1987) and Andersen and Risager (1987a). These studies offer game-theoretic analyses of the "vicious circles" argument against flexible exchange rates.

17 For a brief discussion of the general problems involved, in a game-theoretic context, see Persson (1987). See also Kareken and Wallace (1978) for a discussion of the feasibility of different exchange rates systems.

probability of speculative attacks against an individual currency; not surprisingly, credibility problems seem to be more dependent on domestic fiscal and monetary policies than on official exchange rate targets. For example, Helpman and Leiderman (1987) interpret the experiences of Israel, Argentina, Bolivia, and Brazil as indicating that an immediate reduction of a budget deficit is important for a successful (credible) disinflation policy, whereas the role of exchange rate policy in this context is not clear. Andersen and Risager (1987b) argue that the credibility of the Danish government's exchange rate policy explains the decline in domestic interest rates 1982-1984. Credibility, in turn, was established first of all by keeping the exchange rate fixed despite external disturbances, and by supporting this policy with fiscal and labor market policies. Although these empirical studies offer some support for the notion that exchange rate and balance of payments issues are "concerns of policy management", they do not offer any clear-cut answers to questions about the desirability of disinflation or fixed exchange rates, etc.

Before turning to the Swedish experiences of stabilization policy under different exchange rate regimes, which will be discussed in Section 1.3, I will briefly discuss the role of the current account as an "external balance constraint" on stabilization policy.

1.2.4 The current account

In IS-LM-analyses the trade balance opens a "leakage" through which the effects of monetary policy (under a fixed exchange rate regime) are dampened. To the extent that private capital movements should be sterilized, monetary policy should also be concerned with the currency flows that result from net exports or imports. In the well-known paper by Mundell (1962), however, it is assumed that policy makers are not only concerned with internal balance, but also with external balance. Any tendency towards a currency outflow should thus not be sterilized through expansive monetary policy, but rather be met by contractive measures (irrespectively of the composition of the balance of payments). If no such measures are undertaken, wealth effects secure that the external imbalance is self-correcting, according to the monetary approach of the balance of payments.

When policy makers try to resist demands for more expansionary policies and attempt to avoid external imbalance in the sense of (an increase in) a current account deficit, they seem to be more concerned with the future interest rate burden associated with an increase in national debt, than with the immediate "leakage" effects. Furthermore, they do not seem to be convinced that imbalances will correct themselves. Quite the contrary, the current account is often explicitly given the status of a target for stabilization policy. The question is whether such a policy can be justified.

The authorities' concern over the current account may reflect that they are concerned about the long run development of production and consumption, over and above the short run variability of employment and/or price levels. As pointed out by, e.g., Williamson (1971) and Persson and Svensson (1987), the current account in any given year is not a good indicator of welfare, which is more directly related to the total stock of (domestic and foreign) assets. For instance, a current account deficit may increase future consumption possibilities if it is associated with an increase in the capital stock; and even if the increase in foreign debt is mainly caused by a consumption boom, this may be consistent with an optimal intertemporal allocation of consumption. External balance in the sense of a zero balance on current account thus does not seem to be a proper ultimate target for economic policy.[18]

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[18] It is well known that exchange rate changes under certain conditions are equivalent to tariffs and export subsidies. Trade liberalization may thus be of limited value if trade wars through exchange rate policies are permitted. Williamson (1971) discusses the external balance constraint

Unless capital is perfectly mobile, or "Ricardian equivalence" holds, private savings and investments will be dependent on the government's debt management. For a given government budget deficit, there will be less crowding-out effects the more the foreign debt increases. One may thus argue that the government should allocate its consumption and investment optimally over time, after due consideration of crowding-out effects, but not be particularly concerned with the total public and private foreign borrowing, i.e., the current account. Corden (1985) suggests that policy makers should only be concerned with the government budget deficit and not with the aggregate of government and private savings and investments. Whether the current account is useful as an <u>intermediary</u> target thus hinges on whether it contains some useful information that is not reflected already in the government budget balance.

As shown by, e.g., Svensson and Razin (1983), the effects on national savings of a change in the terms of trade are generally ambiguous; wealth and substitution effects tend to go in different directions. This is also true for many other exogenous changes, which would seem to disqualify aggregate savings as an information variable. It is furthermore true, of course, that the current account, which equals savings minus investments, cannot contain more information than these separate aggregates together (or than total exports and imports).

As noted in the previous subsection, Drazen and Helpman (1986) show that expectations about future policies will be reflected in the current account. This is not to say, however, that policies geared at the current account can affect expectations in any useful way. While the development of the current account, empirically, seems to affect the government's

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in this context, and Vinals (1986) suggests that measures undertaken in order to "improve" the current account may be rationalized as an attempt to limit the pressures for protectionist measures.

reputation - in the ordinary sense of the word - no formal analysis of the mechanisms involved has, to my knowledge, been conducted.

1.2.5 Conclusions

Why do exchange rates and the balance of payments matter, according to theoretical open economy models? If conditions for monetary policy to have real effects are satisfied, exchange rate and balance of payments issues should indeed matter. At least, exchange rates are no less "concerns of policy management" than interest rates or the money stock, as illustrated by the simple stochastic IS-LM model in Section 1.2.1. The exchange rate is one element in a set of potential instruments for monetary policy. How policy instruments should be optimally determined is primarily a question of the ultimate objectives of the government (or, rather, of the society).

Given certain ultimate targets, such as employment and price stability, the optimal policy will depend on the relative importance of various disturbances, and on the general properties of the economic system, such as the degrees of wage flexibility and international capital mobility. The formation of expectations is particularly important in this context. However, the rational-expectations game-theoretic models discussed in Section 1.2.3 do not deny that exchange rates and the balance of payments are "concerns of policy management".

On the other hand, neither the stochastic IS-LM model nor the rational expectations models offer any arguments to the effect that "external balance" is a useful intermediate (let alone ultimate) target. Rational expectations theories suggest that expectations about future policies will be reflected in the actual development of exchange rates, the current account and the money stock, but this does not imply that these variables are candidates for targets. Game-theoretic models have shown that some intermediate targeting may be useful, but also that, e.g., fixed exchange rates may be counterproductive.

The use of the current account as an information variable can be questioned on the grounds of the logical argument that it cannot contain any other information than is already contained in savings and investments (or exports and imports) figures. Likewise, since the balance of payments is a "monetary phenomenon", it cannot be expected to contain any other information than exchange and interest rates, the money stock, etc. (if such data are available).

The "external balance constraint" thus seems to play a less important role (if any) in theoretical analyses than in discussions about actual stabilization policies. A brief discussion of the Swedish experiences may serve as an illustration of the practical importance of exchange-rate and balance-of-payments issues.

1.3 SWEDISH STABILIZATION POLICY

In this section, I will summarize the Swedish experiences from the last six or seven decades' stabilization policies. The descriptive parts draw on earlier work by Jonung (1979), Lundberg (1983, 1985), Lindbeck (1975), and Söderström et al. (1985a,b), to which the reader is referred for more detailed treatments.

In an international comparison, Sweden was hit relatively harder by the depression in the early 1920's than in the early 1930's. During the 1920's, economic policy was deliberately deflationary, and the krona appreciated against the dollar between 1920 and 1922. It is nevertheless believed that it became "undervalued" if the development over a longer time period and relative to a larger number of currencies is considered. It has been estimated that the relative purchasing power of the krona fell by around 10 per cent between 1914 and 1924.

Sweden returned to the gold standard, at pre-war parity, in 1924. During the remainder of the 1920's there was a steady growth in output and the domestic price level fell slowly. As a consequence of the international depression there was a more marked fall in the price level between 1929 and 1931, when Sweden abandoned the gold standard after a loss of foreign exchange reserves. The krona immediately depreciated, and its relative purchasing power fell by around 15 percent until the domestic price level reached a bottom in 1933. It has been argued that the krona once again became undervalued, and that this was the main cause behind the recovery of the Swedish economy after 1933. In June that year the monetary authorities decided to peg the krona to the pound, and that policy was followed until the outbreak of World War II.

The exchange rate policies during the 1920's and the 1930's seem to have been governed by a price level target; a fixed rate policy was followed when the development of international prices was expected to be consistent with the price level goal, and a flexible rate policy otherwise. By the end of the 1930's economists within the "Stockholm School", as well as policy makers, stated that the primary target of stabilization policy should be employment, rather than the price level. The full employment target became even more pronounced after the Second World War, due to expectations of an immediate recession, but this did not mean that inflation was neglected altogether. For example, the krona was allowed to appreciate in 1946 in an attempt to insulate the Swedish price level from the international inflationary tendencies.

Between 1951 and 1971 the value of the krona was pegged within the cooperative system of internationally fixed exchange rates. The domestic nominal wage and price levels thus had to be adjusted to the international development. An interesting question is whether the stable development of the Swedish economy during the 1950's and 1960's was due to a successful general stabilization policy, the exchange rate policy in particular, or some exogenous factors outside the scope of domestic macroeconomic policy.

Lundberg (1985) attributes the relatively stable development of Swedish wages and prices during the 1950's and 1960's to the consensus between employers and employees. This consensus was formalized in 1969, in a report by three economists, representing the employers' federation and the unions of blue and white collar workers, the so called EFO report (cf. Edgren, Faxén and Odhner (1969)). According to the EFO model, the domestic wage (in the tradables as well as the nontradables sector) should adjust to the exogenous price increases and technical progress in the tradables sector.[19] Söderström and Viotti (1979) question whether this is a correct picture of how the Swedish economy developed in the period 1950-70. They prefer to model wages as exogenously determined.

In Söderström's and Viotti's model, labor market equilibrium (full employment) is the result of accommodating fiscal (public employment) policy. Money wage disturbances (wage increases in excess of price and productivity changes) create deficits in the government budget as well as the current account. Söderström and Viotti argue that their model is consistent with the empirical record.

When the world economy, following the first oil crisis, turned into a recession, Swedish economic policy was aimed at preserving a high level of employment. International inflation, in combination with the design of economic policy, gave rise to extreme increases in nominal wages: more than 40 percent during 1975-76. The second half of the 1970's was characterized by inflation and by government budget and current account

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[19] The Heckscher-Ohlin model offers a theoretical foundation for the EFO model. For a presentation and a critical discussion of the EFO model, see Lindbeck (1979). Chipman (1985) presents some tests of the empirical relevance of some of the ideas in the EFO and similar models.

deficits. Devaluations were undertaken in 1976 and 1977. In connection with the devaluation in August 1977, Sweden left the European system of cooperatively fixed exchange rates. The value of the krona is now managed in terms of an official "currency basket", an index of fifteen foreign currencies. The krona has been devalued twice against the currency basket, in September 1981 and in October 1982.

Bruno and Sachs (1985, Ch. 11) find that Sweden's economy has performed relatively well in terms of the change in a "misery index". Specifically, Sweden experienced a relatively small rise in inflation and a relatively small slowdown in growth between 1965-73 and 1973-79. Bruno and Sachs attribute this development of the Swedish economy to its high degree of "corporatism", which involves high degrees of unionization and centralization of negotiations, low strike activity, and Social Democratic power.

Many Swedish policy makers and economists have drawn conclusions which are quite the opposite of those of Bruno and Sachs. For example, Calmfors (1985) points out that Sweden, Austria, the Netherlands, Germany, and Norway - which are all characterized as corporatist countries by Bruno and Sachs - chose quite different policy strategies after the first oil price shock. Interestingly, Sweden experienced a higher increase in its misery index than the other corporatist countries. Furthermore, a comparison of levels of growth and inflation comes out less favorable to Sweden than an analysis based on the change in the misery index. Sweden's growth was below the OECD average during 1960-73 and 1973-81, and inflation was higher than average in the latter period. Sachs (1981) has shown that while Sweden showed a relation between the current account and GNP which was identical to the average relation for developed countries during 1965-73, the subsequent deterioration of the current account was much stronger in Sweden than on average - despite a stronger-than-average drop in the rate of investment in Sweden. In comparison with other small countries, the industrial production as well as the current account balance has been lower than average in Sweden during the second half of the 1970's and during the early 1980's (cf. Söderström et al. (1985a)).

The discussions in Section 1.2 may be used to shed some light on the experiences from Swedish stabilization policy. In Henderson's (1984) analysis the objective of the authorities is to stabilize output, which probably is a correct representation of Swedish policy since World War II. During the 1920's and 1930's in contrast, the price level seems to have been the main target; whether a fixed or flexible exchange rate policy was followed, depended on the nature of various disturbances (cf. Jonung (1979)). It is tempting to characterize the policies in Sweden during the 1950's and the 1960's as a "rates constant" policy. The exchange rate was pegged within the Bretton Woods system, and the interest rate was kept fairly stable (and low). However, it is probably farfetched to argue that the rates constant policy was based on considerations of the relative importance of financial (asset market) and real (goods market) disturbances. It seems more reasonable to view the willingness to adhere to a fixed exchange rate policy as reflecting a general feeling that there was more to gain from international cooperation than from an independent monetary policy. It should also be noted that farreaching capital controls and credit market regulations were in effect, which means that the Swedish economy of the 1950's and the 1960's perhaps cannot be accurately captured by Henderson's (1984) equilibrium framework. As in the case of the labor market, there are different views on the significance of imperfections in the credit market. For example, Ettlin and Lybeck (1975) prefer to characterize this market by disequilibrium, while Myhrman (1973, 1975) and Genberg (1976) view the behavior of interest rates as consistent with equilibrium in a small open economy.

Under the Bretton Woods regime the long run constraints imposed by a fixed exchange rate policy were clearly recognized. The contractive measures undertaken in 1969-1971 constitute an example of the attention to the "external balance constraint". In contrast, it is fairly obvious that the design of stabilization policy (at least until 1982) under the fixed rates system(s) following Bretton Woods, was not consistent with a fixed exchange rate in the long run. The monetary expansion and the official foreign borrowing that were associated with the government budget deficits would hardly have been accepted within a cooperative system of fixed exchange rates. Although the monetary authorities officially stuck with the fixed exchange rate policy, their actions seemed to reveal an increased preference for inflation taxation and a corresponding (but opposite) change in the taste for international cooperation. Alternatively, one may interpret the stabilization policies in general, and the devaluations in particular, as a purposeful policy aimed at insulating employment from the real shocks to the economy. Whether the changes in policy reflect changes in the government's objective function, or unusual disturbances to given objectives (or both) is an open question.

Söderström et al. (1985a,b) suggest that Sweden should stick to a "hard" fixed exchange rate policy. The case made in favor of fixed exchange rates is, however, quite different from the conditions that yield a rates constant policy as the optimal strategy in Henderson's model. In the latter case the proper exchange rate policy depends, among other things, on the relative importance of financial and real disturbances, and on the degree of wage flexibility. Söderström et al., on the other hand, seem to argue that the functioning of the economy as a whole and the labor market in particular depends on the degree of exchange rate flexibility. In the 1970's, when the labor force perceived that the government had shifted to an inflationary policy rule, wage growth accelerated. This observation is consistent with the game-theoretic analyses of, e.g., Calmfors and Horn (1986), Andersen and Risager (1987a), and Horn and Persson (1987). The full-employment policy caused the government budget balance as well as the current account to deteriorate for reasons described by Söderström and Viotti (1979). Attempts to adjust the real wage by changes in the exchange rate had limited success in the late 1970's, while it had been possible to keep the krona undervalued for long periods in the 1930's and the 1950's. This decrease in the "money illusion" of the labor force can, just like the higher wage demands, be understood as an adjustment to the change in the stabilization policy regime.

Söderström et al. recommend that the authorities, in order to increase the credibility of the fixed-rates policy, should commit themselves to abstain from foreign borrowing and to gradually loosen the restrictions on capital flows. To my knowledge, it has not been shown, theoretically, how credibility is affected by capital controls and foreign borrowing.[20] As a matter of fact, however, the design of economic policy after the latest devaluation has been largely in line with the recommendations of Söderström et al. The fixed exchange rate policy has become more pronounced, and policy is no longer obviously inconsistent with a fixed exchange rate in the long run. The currency basket policy involves less international cooperation than the Bretton Woods and EMS systems, but there has been a substantial ease of the various capital controls. The authorities have also declared that they will not increase the government's net foreign debt.

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20 Recall that Rogoff (1985b) has shown that a fixed exchange rate policy may be counterproductive. Buiter (1987) shows how the likelihood of a balance of payments crisis is affected by official foreign borrowing, but he does not use a game-theoretic framework. Bosworth and Rivlin (1987) argue that the Swedish krona should be flexible, since no inflation target can be credible, given the weight to unemployment in the government's objective function. Fischer (1986) gives a very brief but extremely enlightening summary of the main arguments in the American discussion on similar issues.

1.4 SUMMARY

The background material in this chapter should have made it clear that international capital mobility should be a concern of policy management, and that empirical studies of capital mobility are valuable. At the same time, it is obvious that knowledge of the degree of capital mobility would not, in itself, be decisive for whether the exchange rate should be fixed or flexible, or whether "external balance" (in some sense) should be an intermediate or ultimate target for macroeconomic policies.

In principle, empirical studies of capital mobility on Swedish data could be used to shed light on the questions whether domestic and foreign securities are regarded as perfect substitutes; whether the Bretton Woods era was characterized by low or high capital mobility; whether capital mobility has become higher or lower; whether the stronger-than-average deterioration of the Swedish current account after the first oil crisis was due to labor market and fiscal disturbances, etc. Some of these questions will be dealt with in Chapters 2-5.

The purpose of Chapter 2 is to analyze the role of the forward foreign exchange market in a simple portfolio balance model. The forward market has been neglected in the models reviewed in this chapter, but capital mobility is often discussed with reference to the conditions on this particular market (see, e.g., Boothe et al.(1985)). In a world of some variance in exchange rates, perfect capital mobility cannot be taken to mean that nominal interest rates are necessarily equalized, i.e., that $r = r^*$. Frankel (1983) suggests that perfect capital mobility should be identified with covered interest parity (CIP), i.e.,

$$r = r^* + fp, \qquad (1.16)$$

where fp is the forward premium (in percent) on the foreign currency (for the holding period which r and r^* refer to).

In Chapter 2 the earlier analysis of the Swedish money market by Englund, Hörngren, and Viotti (1985) is extended to incorporate the forward foreign exchange market. The portfolio balance model is designed so as to capture important institutional features, such as capital controls, the central bank's supply of borrowed reserves, etc. In other respects, the model relies on restrictive but simplifying assumptions. Income, prices, and wealth are treated as exogenous variables, which means that questions about the transmission mechanism cannot be studied. Exchange rate expectations are similarly assumed to be exogenous.

Chapter 2 contains a discussion about the relation between (as well as the definitions of) capital mobility and monetary autonomy. It is suggested that the higher the degree of capital mobility, the lower is the degree of monetary autonomy; but also that perfect capital mobility does <u>not</u> imply that there is no autonomy at all. CIP implies that domestic securities and foreign securities that are covered in the forward market are perfect substitutes. However, unless the net supply of forward foreign exchange is infinitely elastic, the central bank can affect the forward premium and the domestic interest rate through interventions in the forward market as well as through conventional open market operations. Furthermore, unless the net supply is completely inelastic, it will not be true that foreign borrowing which is covered in the forward market leaves the foreign exchange reserves unaltered, as has sometimes been suggested. The analysis in Chapter 2 also suggests that the Swedish capital controls that put restrictions on foreigners' holdings of domestic securities may be ineffective.

The question of the elasticity of the net supply on the forward market is related to whether domestic and foreign securities are perfect substitutes on an uncovered basis. If they are, it must be that their expected returns are equal, i.e., uncovered interest parity (UIP) must hold:

$$r = r^* + \hat{s}^e, \quad (1.17)$$

where $\hat{s}^e$ is the expected rate of depreciation of the domestic currency. Note that (1.16) and (1.17) together imply that

$$\hat{s}^e = fp \quad (1.18)$$

which says that the forward premium is an unbiased predictor of the rate of change of the spot exchange rate. In effect, perfect substitutability on an uncovered basis must imply that there is an infinitely elastic supply of forward foreign exchange, given the expected rate of change of the exchange rate.

Chapter 3 reviews theoretical and empirical results on the degree of substitutability between assets that are denominated in different currencies. Unlike the discussions in Chapters 1 and 2, the analyses in Chapter 3 do not rely on postulated asset demand functions. Since the latter chapter is devoted to investigations of what determines asset substitability, it can be said to offer some micro foundations for the monetary and portfolio balance approaches.

A central theme in the discussions in Chapters 3 and 4 is that the degree of asset substitutability depends on the design of the ruling exchange rate system. This idea marks an important difference compared to the models which have been discussed in this chapter. Mundell (1963) analyzes the effects of monetary and fiscal policies under different exchange rate regimes with perfect capital mobility as the maintained assumption; and Henderson (1984) argues that the optimal exchange rate policy depends on the degree of asset substitutability. However, when the micro foundations of the postulated asset demand functions are examined, it turns out that asset substitutability also is a function of the degree of exchange rate flexibility. This idea is not new, of course; see, e.g., Aliber (1972).

The empirical studies summarized in Chapter 3 lead to the conclusion that UIP (or unbiasedness) usually can be rejected, which means that imperfect asset substitutability may leave some scope for independent national monetary policies. The exact nature of this independence has not been clarified, however, since attempts to explain observed deviations from UIP (or unbiasedness) in terms of structural forms often fail.

Tests of (1.17) and (1.18) are most often carried out in terms of bilateral exchange and interest rates, without any analysis of the properties of actual exchange rate systems. In Chapter 4 we apply some of the methods presented in Chapter 3 to the Swedish currency basket system. The chapter offers a characterization of the currency basket regime and derives some implications for empirical analyses of asset substitutability in currency basket systems. It is suggested that bilateral studies of exchange rates which are governed by basket policies offer little (if any) insights into the question about the scope for monetary policy. When applied to the Swedish krona in relation to the official basket currencies, an empirical test of (1.18) points to the conclusion that domestic and foreign assets are not viewed as perfect substitutes.

The empirical analysis in Chapter 4 is confined to monthly data from the 1980's. To limit the study to this period seems reasonable in view of the deregulations of the Swedish credit market that have taken place only recently. One may even argue that the empirical analysis should be confined to the period after the latest devaluation in October 1982.

The empirical study of the Swedish current account, in Chapter 5, makes use of a substantially larger data set (quarterly data, 1947-1985). The results in Chapter 5 are based on an estimated vector autoregressive (VAR) model of four variables, including the current account. VAR models are generally of limited use for policy analysis or for testing the relevance of competing theories. Our primary purpose is to investigate how various shocks to the economy interact in the determination of the current account. We ask, e.g., how the current account evolves over time after a terms of trade shock, and whether labor supply shocks are relatively more important to the development than shocks to fiscal policy. Following Sims (1980) and others, these questions are adressed by techniques of "impulse response" analyses and "innovation accounting".

Intertemporal general equilibrium models teach that the qualitative effects on the current account of autonomous movements in, e.g., terms of trade are generally ambiguous; substitution and wealth effects tend to go in different directions. An empirical study should therefore be useful. Information on the quantitative effects of various disturbances may also give some indications about the optimal policy in response to current account imbalances.

A principal finding in Chapter 5 is that the forecast error variance in the current account is to a very limited extent (less than 20 percent over a couple of years) explained by innovations to the wage, terms of trade, or government consumption. This is in contrast with the "conventional wisdom" (cf. Section 1.3) and also with the results for some of the other variables. For example, innovations in the wage equation explain less than half of the variance of the wage.

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2. Capital Mobility and Monetary Autonomy*

2.1 INTRODUCTION

In this chapter, I discuss the relation between capital movements and monetary policy in the context of a simple portfolio balance model that incorporates the forward foreign exchange market. This market is seldom explicitly treated in portfolio balance models intended for analysis of monetary policy, but can be shown to be crucial for discussions about the importance of capital mobility and various capital controls.

The importance of the forward market stems from the fact that in a world of perfect capital mobility, arbitrage activities should guarantee that international differences in nominal interest rates are matched by differences between spot and forward exchange rates. If capital is perfectly mobile, the monetary authorities in a small open economy can affect the domestic interest rate only insofar as they can affect forward premia. The determination of equilibrium in the forward market, and its interaction with the money market, is thus crucial for

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questions of capital mobility and monetary autonomy. These concepts are discussed at a general level in Section 2.2.

In order to analyze the scope for monetary policy in an economy like Sweden more formally, a portfolio balance model is set out in Section 2.3. The model is intended to capture important institutional features of the Swedish credit market - such as the pegged exchange rate and discount window policies, and capital controls - and is, basically, an extension of the model presented by Englund, Hörngren, and Viotti (1985). The extension refers to the forward foreign exchange market. Although the model is designed to capture specific Swedish features, it should be of relevance to other economies as well.

In Section 2.4 the model is analyzed under the assumptions of imperfect and perfect capital mobility. It is shown that if capital mobility is taken to mean the degree of substitutability between domestic securities and foreign securities which are covered in the forward foreign exchange market, perfect capital mobility does not imply that there is no monetary autonomy, although higher capital mobility implies lower autonomy. If domestic and foreign securities are perfect substitutes also on an uncovered basis, or, equivalently, if the supply of forward foreign currency is infinitely elastic, there will be no autonomy.

These results are not new. As they are presented within a theoretical model of the Swedish credit market, the analysis still has important implications for policy as well as empirical research. For instance, the analysis in Section 2.4 - in combination with earlier empirical results, discussed in Section 2.5 - suggests that the capital controls which restrict foreign holdings of domestic securities are ineffective.

While the absolute degree of monetary autonomy in any individual country may be hard to measure (and even to define), comparisons of empirical studies of different countries may give some information about relative degrees of autonomy. Section 2.5 thus reports the results of a review of the evidence in the cases of Sweden and West Germany.

The theoretical analysis in Section 2.4 and the review of empirical results in Section 2.5 together lead to the conclusion that single-equation empirical studies cannot offer any measures of the degree of monetary autonomy. This result is perhaps not surprising, but the model in Section 2.3 may serve as a useful starting point for further empirical studies of the Swedish money and forward foreign exchange markets.

2.2 THE CONCEPTUAL FRAMEWORK

The actual size of international capital flows does not tell us anything about the degree of capital mobility: small movements of capital at given international differences in assets returns do not imply that there is low mobility in the sense of small sensitivity to changes in such differences. We do expect, however, a high degree of capital mobility to imply that similar assets yield about the same return, irrespectively of where they are issued.

In the seminal paper by Mundell (1963), perfect capital mobility is taken to mean that the level of the domestic interest rate (r) equals the general level prevailing abroad (r^*). It is assumed that these interest rates refer to assets with identical characteristics (e.g., with respect to default risk) except for currency denomination.

In a world of some variance in exchange rates, interest rate differentials do not constitute evidence of imperfect capital mobility. However, if there are no prohibitive capital controls and if transaction costs are negligible, we expect arbitrage activities to bring about covered interest parity (CIP):

$$r = r^* + fp, \qquad (2.1)$$

where r and r^* are the domestic and foreign interest rates on nominally safe securities, and fp is the forward premium (in percent) on foreign exchange. If r and r^* refer to assets with identical characteristics, except for currency denomination, a purchase of foreign securities coupled with a sale of forward foreign currency does not involve any risk over and above that of a purchase of domestic securities. In the absence of capital controls, transaction costs and other obstacles to mobility, there are no reasons to expect default-free domestic and covered foreign-currency securities to be less than perfect substitutes, i.e., to expect (2.1) to be violated. Following Frankel (1983) we may, therefore, identify perfect capital mobility with CIP.[1]

Whether domestic and uncovered foreign securities are regarded as perfect substitutes is not primarily a question of the degree of capital mobility, however. If there is some variance in the exchange rate, a purchase of a foreign security which is not combined with a matching sale of forward foreign currency will have different characteristics than a purchase of a domestic security. Perfect substitutability between domestic and uncovered foreign securities would imply uncovered interest parity (UIP):

$$r = r^* + \hat{S}^e, \qquad (2.2)$$

where $\hat{S}^e$ is the expected rate of depreciation of the domestic currency. Capital controls and transaction costs may be explanations for deviations from UIP, but even in the absence

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1 Let S denote the spot exchange rate (units of domestic currency per units of foreign currency) and F the forward exchange rate. A purchase of a foreign security, with nominal value X and interest rate r^*, coupled with a sale of foreign currency forward, yields gross return $(1+r^*)FX$. A purchase of a domestic security, with nominal value SX and interest rate r, yields $(1+r)SX$. CIP implies that these transactions give the same return, i.e., that $F/S = (1+r)/(1+r^*)$. (2.1) relies on the approximations $\ln(1+r) \approx r$, $\ln(1+r^*) \approx r^*$, and $fp \equiv (F-S)/S \approx \ln F - \ln S$.

of such obstacles to capital mobility there is a possibility that UIP is violated due to exchange risk.

There does not, of course, exist any single acceptable definition of the concept capital mobility. Different definitions may be appropriate in different circumstances, and Frankel's (1983) definition has obvious disadvantages, since it is not operational for discussions about the mobility of nominally risky assets or (long term) assets which may be impossible to cover in the forward market.[2] The mobility concept nevertheless has to be explicitly defined in any discussion of how capital mobility affects the scope for monetary policy.[3] Since deviations from CIP are more directly related to the degree of capital mobility than deviations from UIP, I will henceforth identify capital mobility with the degree of substitutability between domestic and covered (rather than uncovered) foreign-currency securities. It deserves to be emphasized, however, that CIP is only implied by, and does not imply, perfect capital mobility.

As is the case with "capital mobility", there does not, to my knowledge, exist any unanimously accepted definition of the concept "monetary autonomy". Kareken and Wallace (1978), Obstfeld (1980a) and Laidler (1986) seem to identify monetary independence with the possibility to control the domestic <u>price level</u> (primarily in the long run). It is easily seen that with this definition some flexibility in the exchange rate is a sufficient condition for autonomy. If the small-open-economy and purchasing-power-parity hypotheses are valid for the economy in question, exchange rate flexibility even becomes

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2 Mobility is sometimes measured by how <u>fast</u> portfolios are adjusted - cf. Dornbusch and Krugman (1976), Dornbusch (1980), and Cumby and Obstfeld (1983). It may also be argued that exchange rate risk hampers mobility - see Aliber (1978) and Eaton and Turnovsky (1983). For a general discussion of the mobility concept, see Stulz (1986).

3 Frenkel and Mussa (1981) identify high capital mobility with CIP, but their policy conclusions seem to be based on a model which is also characterized by UIP.

necessary.

A flexible exchange rate generally allows the monetary authorities to affect the short run equilibrium levels of, e.g., interest rate(s) and the money stock. Monetary policy can be designed so as to change rational agents' expectations about (the distribution of) the future exchange rate. Such a change will affect the private sector's portfolio choice, and will lead to changes in the equilibrium values of nominal interest rates and asset stocks, irrespectively of the degree of international capital mobility and asset substitutability. Furthermore, a flexible exchange rate policy gives the monetary authorities a freedom to determine their activities in the foreign exchange market in consideration of the development of the foreign exchange reserves. In a fully flexible system there is no intervention at all, which implies that the level of reserves will be constant (and possibly equal to zero). Hence, if monetary autonomy is taken to mean the possibility to achieve some target levels of the nominal interest rate, the money stock and the foreign exchange reserves, adherence to a flexible exchange rate policy would be sufficient to guarantee monetary autonomy (in the short as well as in the long run). In practice, fully flexible or completely fixed exchange rates are rare phenomena. Under either regime, monetary authorities seem to worry about the degree of monetary autonomy, which indicates that they do not view exchange rate flexibility as the key to autonomy.

In the theoretical framework set out by Henderson (1984), which was discussed in Chapter 1, the only ultimate target for (short run) stabilization policy is to stabilize employment. Henderson shows that a fixed, flexible, or managed float exchange rate policy may be optimal, depending on the structure of the economy. The optimal strategy depends, among other things, on the nature of the disturbances that hit the economy and on the authorities' information about these disturbances. In the terminology of Henderson, the exchange rate (and the interest rate and money stock as well) is either used as an "instrument" (if fixed) or an "information variable" (if flexible, and if, e.g., the money stock is changed in response to observed movements in it). The exchange rate, the money stock, and the interest rate are thus alternative instruments of monetary policy; the achievement of specific levels for these variables is of no independent value for stabilization policy.

With the background of Henderson's theoretical analysis as well as of practical experiences, one may thus question the idea that a flexible exchange rate would guarantee monetary autonomy.[4] I believe that the latter concept can be taken to mean the possibility to influence the other instruments or information variables (in particular, the interest rate) given a specific (predetermined) value of the exchange rate. (Alternatively, we may identify monetary independence with the possibility to influence the exchange rate, given a specific value of the domestic interest rate.)

It is clear that under this interpretation of the autonomy concept, imperfect substitutability between domestic and uncovered foreign securities is crucial for monetary independence. Unless UIP is violated, interest and exchange rates cannot be independently determined, and there can be no monetary autonomy in a small open economy. Perfect capital mobility (CIP), however, need not imply total lack of autonomy since the authorities may have the possibility to affect the forward premium associated with any given expected rate of currency depreciation. A portfolio balance model which incorporates the forward foreign exchange market provides a theoretical framework for an analysis of these issues.

2.3 THE MODEL

The portfolio balance model presented in this section is a short term model of the financial sector. Following common

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4 See also Aliber (1972).

practice in portfolio balance models (see, e.g., Henderson (1977)) I take "short term" and "financial" to mean that financial wealth, income and nominal goods prices can be treated as exogenous variables, and that the markets for long term financial assets, equity, real assets, etc., can be neglected. Since the transmission mechanisms between the real and financial sectors are not modelled, the question about the scope for monetary policy can only be discussed in terms of the effects of, e.g., open market operations on <u>financial</u> variables such as the interest rate on domestic securities, the money stock, the balance of payments, etc. No attempt will be made to relate such "intermediate targets" (or "information variables") to "ultimate targets" such as consumption and employment. In comparison with the models reviewed in Chapter 1, therefore, the portfolio balance model in this chapter gives a more limited description of the effects of monetary policy. This cost is hopefully balanced by the benefit of a more detailed analysis of various credit market institutions. The limitations of the model will become clear as it is presented, but I believe that it captures important features of the Swedish credit market.

The Swedish exchange rate policy is one of a basically fixed exchange rate (cf. Chapter 1). In this chapter, the spot exchange rate as well as exchange rate expectations will be treated as exogenous; a thorough discussion of the currency basket policy is postponed until Chapter 4. Another important feature of the Swedish credit market is the capital controls which, in particular, prohibit foreign investors from holding domestic securities. A third characteristic feature is the central bank's "discount window" policy, which has been analyzed in a sequence of papers by Englund et al. (see Hörngren (1986)). Englund, Hörngren and Viotti (1985) follow Mundell (1963) in that they neglect the forward foreign exchange market and identify perfect capital mobility with the condition $r = r^*$. In this chapter their analysis is extended to incorporate a forward foreign exchange market, which in turn is modelled as in previous studies by Black (1973) and Herring and Marston (1977).

Four domestic sectors are identified - the government, the central bank (CB), the public, and the banking sectors. The balance sheets for these sectors are listed below. (All stocks are measured in terms of the domestic currency.)

$$B + F^g = T, \qquad \text{(government)} \qquad (2.3)$$

$$T^c + RB + R = RR, \qquad \text{(CB)} \qquad (2.4)$$

$$T^b + RR + F^b = D + RB, \qquad \text{(banks)} \qquad (2.5)$$

$$T^p + D + F^u + F^c = W. \qquad \text{(public)} \qquad (2.6)$$

The variables are defined as follows:

B = accumulated government debt;
F^g = government net holdings of securities denominated in foreign currency;
T = stock of treasury bills;
T^i = net holdings of domestic securities by sector i ($i = c, b, p$);
RB = borrowed reserves;
RR = required reserves;
R = foreign exchange reserves;
F^b, F^c = the banks' and the public's net holdings of foreign-currency securities which are <u>covered</u> in the forward foreign exchange market;
F^u = the public's net holdings of <u>uncovered</u> foreign-currency securities;
D = bank deposits;
W = private net financial wealth.

The public's demand for deposits, domestic securities, and foreign-currency securities are defined by the following functions:

$$T^p = t^p\left[r,\ r^* + fp,\ r* + \hat{S}^e,\ r^D,\ S\right]; \qquad (2.7)$$

$$D = d\left[r,\ r^* + fp,\ r^* + \hat{S}^e,\ r^D,\ S\right]; \qquad (2.8)$$

$$F^u = f^u\left[r,\ r^* + fp,\ r^* + \hat{S}^e,\ r^D,\ S\right]; \qquad (2.9)$$

$$F^c = f^c\left[r,\ r^* + fp,\ r^* + \hat{S}^e,\ r^D,\ S\right]; \qquad (2.10)$$

where r, r^*, and r^D are the (nominally safe) interest rates on domestic securities, foreign-currency securities, and deposits, respectively. fp is the forward premium (in percent), and $\hat{S}^e$ is the expected rate of depreciation of the domestic currency. S is the current level of the exchange rate (units of domestic currency per unit of foreign currency). It enters the asset demand functions since changes in the exchange rate affect the real value of asset stocks. Note that important additional (exogenous) variables have been suppressed. For example, financial wealth (W) should be an argument in each of the functions above, along with the levels of income, prices, etc. The assets are assumed to be gross substitutes, and the listed functions are subject to the adding up constraint that total holdings amount to total wealth. The former assumption implies that the partial derivatives t_1^p, f_2^c, f_3^u, $d_4 > 0$, and that the cross effects (t_i^p, i=2,3,4, etc.) are negative.

Like portfolio balance models in general, our model rests on an implicit and ad hoc assumption of imperfect asset substitutability. Since asset demand functions have just been postulated and not derived from maximizing behavior, there is nothing in the model that explains why domestic deposits and securities, or domestic and foreign securities, are not viewed as perfect substitutes. In particular, one may question why domestic and covered foreign-currency securities should be treated as imperfectly substitutable. The question of the degree of substitutability between different assets denominated in the same currency is a fundamental problem in monetary economics which we will not try to discuss here.[5] As to the substitutability between assets denominated in different currencies, we will examine the consequences of perfect substitutability in Section 2.4. The degree of substitutability between domestic and uncovered foreign-currency securities is further discussed in Chapters 3-4.

We follow Englund, Hörngren, and Viotti (1985) and make the assumption that the interest rate on deposits can be treated as a predetermined variable in a short term model of interest rate determination. The banks are thus assumed to passively accept deposits from the public at the predetermined interest rate r^D, and are subject to a reserve ratio requirement,

$$RR = aD. \tag{2.11}$$

Banks allocate their remaining funds, (1-a)D, to domestic and foreign-currency securities. Capital controls prohibit banks from taking open net positions in foreign currency, which means that all purchases or sales of foreign-currency securities are covered in the forward foreign exchange market (and vice versa). As in Englund, Hörngren, and Viotti (1985), banks have the option to borrow from the CB at the market rate r (and to issue certificates of deposits, which we model as negative holdings of domestic securities). Borrowed reserves (and certificates of deposits) are thus perfect substitutes to other short term papers (t-bills) in domestic currency, and term structure problems are neglected. The banks' behavior can be summarized as follows:

$$T^b - RB = t^b\left[r,\ r^* + fp,\ S\right], \tag{2.12}$$

5 For a discussion of this issue, see, e.g., Wallace (1983).

$$F^b = f^b\left[r,\ r^* + fp,\ S\right], \tag{2.13}$$

where $t_1^b = -f_1^b > 0$, $t_2^b = -f_2^b < 0$.

The CB's behavior is given by the following two functions:

$$T^c = h\left[R,\ F^g\right] + \bar{T}^c, \tag{2.14}$$

$$RB = g\left[r - \bar{r}\right], \tag{2.15}$$

where $\bar{r}$ is an exogenous "benchmark" level of the interest rate. We can describe the Riksbank's policy until December 1985 as characterized by $g_1 = \infty$. This is the case of a completely open discount window, with an infinitely elastic supply of borrowed reserves at the "penalty rate" $\bar{r}$. It should be noted that such a policy is sufficient to guarantee that $r = \bar{r}$ only if the demand for borrowed reserves is positive. Since December 1985, g(.) is a discontinuous step function (cf. Hörngren (1986), Ch. 3), but in the analyses below it will be assumed that it can be approximated by a continuous function, and that $0 < g_1 < \infty$.[6]

The reaction function (2.14) allows for complete sterilization of changes in foreign exchange reserves as a special case ($h_1 = -1$, $h_2 = 0$). In recent years, however, the monetary authorities have shown less concern over the change in exchange reserves than over the "private currency flow", which is defined as the change in foreign exchange reserves less the increase in the government's foreign debt. Such a policy, which is characterized by a reaction function where $h_1 = h_2$, can be justified by the argument that (autonomous) changes in F^g must be interpreted as the result of purposeful behavior from the

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6 In the system operating until December 1985, there was a limited supply of borrowed reserves at a "discount rate" and an unlimited supply at a higher "penalty rate". An individual bank either borrowed (if at all) at the discount rate or the penalty rate, depending on the quantity borrowed.

monetary authorities; to sterilize <u>such</u> capital flows then makes no sense.

If the CB does not want to neutralize the effects of currency flows on the monetary base, but rather tries to reinforce such effects (e.g., in attempts to achieve "external balance") we expect h_1 to be positive. In the analyses below it will be assumed that $1 + h_1 > 0$ and that $1 + h_1 - h_2 > 0$, which will hold for reasonable policy designs.[7] Discretionary open market operations that are not motivated by currency flows or interest rate movements can be interpreted as exogenous changes in $\bar{T}^C$.

Foreigners are assumed to have an infinitely elastic supply of (and demand for) securities denominated in foreign currency at a given rate of interest r^*. We assume that foreigners neither demand nor supply securities or deposits denominated in domestic currency. These assumptions reflect the design of Swedish capital controls. In principle, capital controls also prohibit the public (i.e., private households and non-bank firms) from taking positions in foreign-currency securities for "speculative purposes". However, private foreign borrowing has been permitted and even encouraged as a means of financing Sweden's current account (or, rather, the government budget) deficits, and little seems to prevent the private net foreign debt from being changed in response to interest and exchange rate movements. Since the permissions for foreign borrowing are related to the individual firms' (expected) exports and imports, some measure(s) of foreign trade should probably be included in the public's asset demand functions. This may also be motivated by the existence of ordinary trade credits which

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7 If there is complete sterilization of movements in reserves, $h_1 = -1$ and $h_2 = 0$. In the case of complete sterilization of the private currency flow, $h_1 = h_2 = -1$. If, on the other hand, open market operations aim at "external balance" we might have $h_1 > 0$. If the balance is specified in terms of foreign exchange reserves (the private currency flow) $h_2 = 0$ ($h_2 = h_1$). Herring and Marston (1977) discuss how the sterilization coefficient is related to the weights given to internal and external balance.

may (at least in part) be little affected by short term movements in asset returns.[8]

If we let F^p denote the private sector's net foreign assets, it must be the case that

$$F^p = F^u + F^c + F^b, \tag{2.16}$$

and that

$$R = CAB - F^p - F^g, \tag{2.17}$$

where CAB is the (exogenous) value of cumulated current account surpluses (including capital gains and losses due to exchange rate changes).

From the balance sheets (2.3) - (2.6) and the definitions of F^p (2.16) and R (2.17), we can express the private sector's net financial wealth as:

$$W = B + CAB. \tag{2.18}$$

The accumulated government deficit B is assumed to be exogenously determined, along with the government's net holdings of foreign-currency securities F^g and its supply of domestic securities T.

In this model there are three assets with exogenous or predetermined returns - required reserves ("high powered money", which yield zero return), deposits (which yield r^D), and foreign-currency securities (which yield r^*). The only endogenously determined interest rate is that on domestic securities, r. The equilibrium condition for the domestic

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8 The need for financing of trade deficits and surpluses is the reason why transactions in the forward market are permitted. Although in principle restricted by trade volumes, these transactions can actively respond to changes in interest rates, spot and forward exchange rates, etc.

securities market can be written as

$$t^b(.) + t^p(.) + h(.) + \bar{T}^c + g(.) = T. \tag{2.19}$$

Alternatively, we may, as Englund, Hörngren and Viotti (1985), choose to define the equilibrium in terms of the reserves market:

$$CAB-f^b(.)-f^u(.)-f^c(.)-F^g+h(.)+\bar{T}^c+g(.) = ad(.). \tag{2.20}$$

The expression on the R.H.S. is the (banks') demand for reserves. The (CB's) supply of reserves on the L.H.S. is derived from the CB's balance sheet (2.4), and from the expression for R (2.17).[9]

Equilibrium also requires the market for forward foreign exchange to be in equilibrium. The net supply on this market (i.e., the net sales of forward foreign currency) is assumed to be governed by the following conditions:

$$Q^b = (1/S)f^b(.), \qquad \text{(banks)} \tag{2.21}$$

$$Q^p = (1/S)f^c(.) + q^p(\hat{S}^e, fp), \qquad \text{(public)} \tag{2.22}$$

$$Q^f = q^f(\hat{S}^e, fp), \qquad \text{(foreigners)} \tag{2.23}$$

where $q^p(.)$ and $q^f(.)$ are the supply functions of domestic and foreign "speculators and traders", i.e., agents who do not (necessarily) match their operations on the forward market with corresponding operations in the securities markets. It is assumed that q_1^p, $q_1^f < 0$, and that q_2^p, $q_2^f > 0$.[10]

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9 (2.20) can be derived by substitution of the balance sheets identities (2.3) plus (2.5) - (2.6) and the definition of wealth (2.18) into (2.19).

10 If domestic and foreign investors should be symmetrically modelled, it would be natural to allow the latter to invest in "covered" foreign-currency securities, i.e., to match (some of) their purchases of foreign securities with

Some discussion of (2.21) - (2.23) may be required. The net supplies are expressed in terms of foreign currency, which seems to be a natural normalization since we are talking about the market for forward foreign exchange (although it could just as well be described in terms of net demands for forward domestic currency). The banks' supply of forward foreign currency stems entirely from their demand for foreign-currency securities, which - due to capital controls - has to be completely covered. Note that it is the assumption of imperfect substitutability between domestic and covered foreign-currency securities that gives the banks some latitude for active portfolio management (cf. (2.12) and (2.13)). As to the supply of forward foreign exchange from the public, we see that there is a "speculative" supply over and above the supply which is derived from the demand for covered foreign-currency securities. The option for speculation in the forward market is a meaningful addition to the opportunity set only insofar as domestic and covered foreign-currency securities are not perfect substitutes. In the case of foreigners, things are different. Since they are assumed not (to be allowed) to have any holdings of domestic securities, the forward market is the only alternative for them if they want to speculate about changes in the exchange rate.

The CB is assumed to have an exogenously determined net supply of forward foreign exchange, $\bar{Q}$.[11] Hence, equilibrium in the forward market is fulfilled if

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corresponding sales of foreign currency on the forward market. This would imply that a securities demand function, $f^*(r^*, r^* + fp - \hat{S}^e)$ say, should be included in Q^f. It is immediately seen that this would affect the analysis only insofar as $f_1^* \neq - f_2^*$ and as exogenous changes in r^* are considered.

11 It may seem inconsistent to specify a reaction function for T^c while assuming that F^g and $\bar{Q}$ can be treated as exogenous variables. The qualitative results that follow do not, however, depend on these assumptions.

$$(1/S)f^b(.) + (1/S)f^c(.) + q^p(.) + q^f(.) + \bar{Q} = 0. \quad (2.24)$$

Assuming that the expected as well as the actual development of the exchange rate can be treated as exogenously determined, the portfolio balance model can be reduced to two equations - (2.19) or (2.20), plus (2.24) - that determine the interest rate on domestic securities r and the forward premium on foreign exchange fp.[12] The roles of exchange rate dynamics and expectations for asset market equilibrium are analyzed in Chapter 3.

In Figure 1, TT gives the combinations of r and fp that are consistent with equilibrium in the domestic securities market (or, equivalently, in the reserves market). TT has a positive slope, since an increase in the forward premium lowers the demand for domestic securities, and thus puts upward pressure on the domestic interest rate. (A formal analysis is given in the appendix.) In analogy, QQ gives the combinations of r and fp that are consistent with equilibrium in the forward market. An increase in r will lower the demand for uncovered and covered foreign securities. A decreased demand for covered securities is associated with a decreased supply of foreign currency on the forward market, which implies that the forward premium goes up along with r.

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[12] Although exchange rate expectations and levels are kept exogenous in our analysis, the portfolio balance framework is, of course, applicable also to the case of flexible rates; see, e.g., Genberg (1981) and Obstfeld (1983). In a dynamic analysis one would have to take account of the fact that supplies and demands on the forward market today give rise to demands and supplies on the spot market in the future, and of the endogeneity of wealth, and, in particular, expectations. See Driskill and McCafferty (1982) and Eaton and Turnovsky (1984).

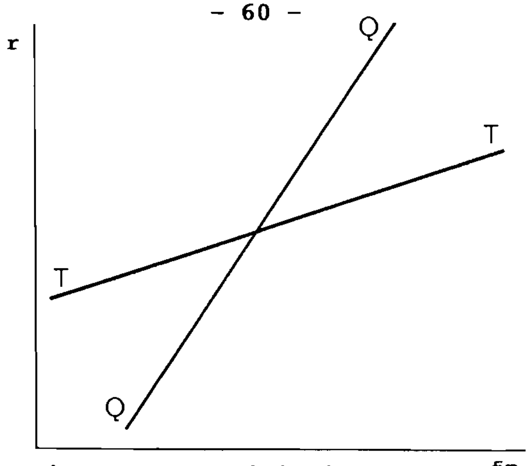

Figure 1: Equilibrium

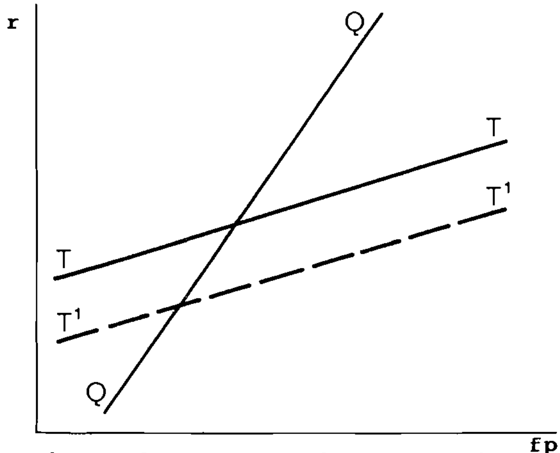

Figure 2: Open market operation

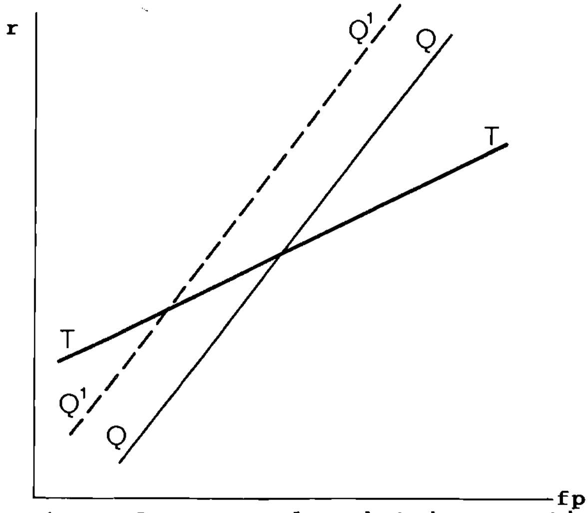

Figure 3: Forward market intervention

2.4 MONETARY POLICY AND CAPITAL FLOWS

In this section we will use the portfolio balance model to analyze the relation between monetary policy and capital flows, and, in particular, between capital mobility and monetary autonomy. Section 2.4.1 uses the model as it stands, which means that capital is imperfectly mobile in the sense that domestic securities and covered foreign-currency securities are treated as imperfect substitutes. The case of perfect capital mobility is studied in Section 2.4.2. Some implications for policy are discussed in Section 2.4.3.

2.4.1 Imperfect capital mobility

A discretionary open market operation in the form of an exogenous increase in the CB's holdings of domestic securities ($d\bar{T}^c > 0$) will shift TT downwards, as in Figure 2. As the CB's demand for domestic securities increases and the domestic interest rate is lowered, the private demand for foreign-currency securities increases and there is a net capital outflow. Part of the purchases of foreign securities are covered, and the associated increase in the supply of forward foreign currency puts downward pressure on the forward premium; the tendency towards excess demand in the domestic securities market is thus strengthened, and the decrease in the domestic interest rate is reinforced.

The same effect can be achieved by a properly sized decrease in the net supply of treasury bills and a corresponding decrease in the government's net holdings of foreign-currency securities, $dT = dF^g < 0$ (a so-called sterilized intervention). More precisely, it can be shown (cf. the appendix) that

$$\frac{dr}{dF^g} = -\left[1 + h_1 - h_2\right]\frac{dr}{d\bar{T}^c}. \qquad (2.25)$$

As long as the monetary authorities do not counteract their own operations by systematic sterilization (i.e., as long as $h_2 = h_1$), or if there is no systematic sterilization of capital flows whatsoever (i.e., if $h_1 = h_2 = 0$), sterilized intervention and conventional open market operations are equivalent in terms of interest rate effects. By inspection of (2.20) it is directly seen that (opposite) changes in $\bar{T}^c$ and F^g will have equivalent effects, as long as F^g is not an argument in h(.).

Alternatively, the monetary authorities may want to affect the domestic interest rate through operations in the forward foreign exchange market. A sale of forward foreign currency ($d\bar{Q} > 0$) shifts QQ upward, as in Figure 3. When the private and banking sectors buy foreign currency forward from the CB, these purchases are, in part, covered through decreased net holdings of foreign-currency securities. The associated capital inflow and decline in the domestic interest rate reinforces the negative effect on the forward premium.

Even if government foreign borrowing (decreases in F^g) and official sales of forward foreign currency (increases in $\bar{Q}$) are alternatives to conventional expansionary open market operations (increases in $\bar{T}^c$) in the sense that these operations all lower the interest rate on domestic securities, there are differences with respect to the effects on the foreign exchange reserves and on the private currency flow. Expansionary open market operations ($d\bar{T}^c > 0$) create net outflows on the private capital balance ($dF^p > 0$) and lower the foreign exchange reserves ($dR < 0$). In the case of sterilized intervention, the outflow of private capital is more than offset by government foreign borrowing ($dF^g < 0$), so that the level of foreign exchange reserves increases. Official sales on the forward market ($d\bar{Q} > 0$) also increase the foreign exchange reserves, but through a positive effect on the private capital balance ($dF^p < 0$).

One measure of the degree of monetary autonomy that has been used in empirical work by, e.g., Kouri and Porter (1974) and Herring and Marston (1977), is the offset coefficient. It is defined as the extent to which an initial increase in the supply of high powered money, e.g., an open market operation, exceeds the ultimate change. In terms of our model the offset coefficient can be defined as:

$$c \equiv \frac{d\bar{T}^c - adD}{d\bar{T}^c} = 1 - a\left[d_1 \frac{dr}{d\bar{T}^c} + d_2 \frac{dfp}{d\bar{T}^c}\right]. \tag{2.26}$$

It was argued in Section 2.2 that a reasonable operationalization of the concept monetary autonomy would be to identify it with the extent to which monetary policy affects the domestic interest rate (at a given exchange rate). Since $1-c$ is proportional to $dr/d\bar{T}^c$, an operationalization that relies on the offset coefficient is not inconsistent with the argument in Section 2.2. We will return to the offset coefficient below, when analyzing the consequences of perfect capital mobility and when discussing some empirical studies.

We also argued above that one measure of the degree of capital mobility is the degree of substitutability between domestic securities and covered foreign-currency securities. Let us assume that

$$f_2^c = f_2^b = -f_1^c = -f_1^b \equiv \phi. \tag{2.27}$$

It can then be shown (cf. the appendix) that

$$\frac{d(dr/d\bar{T}^c)}{d\phi} > 0. \tag{2.28}$$

In other words, a higher degree of substitutability between domestic and covered foreign-currency securities lowers the response of the domestic interest rate to open market operations (when $\bar{T}^c$ goes up, r goes down by less when ϕ is high than when ϕ is low). In this sense, a higher degree of capital mobility is associated with a lower degree of monetary autonomy.

It is not hard to get an intuitive understanding of why a high degree of substitution between domestic and covered foreign securities implies a low degree of monetary autonomy. The forward market in fact creates an endogenous supply of assets with a safe nominal return in domestic currency. (A purchase of a foreign security coupled with a sale of forward foreign currency yields the safe return $r^* + fp$.) If these assets are close substitutes to securities denominated in domestic currency, the return on the latter will be little affected by the actions of the monetary authorities.

In terms of Figure 1, TT gets steeper while QQ gets flatter as the degree of capital mobility increases. In the limiting case of perfect mobility, i.e., perfect substitutability between domestic and covered foreign-currency securities, both schedules converge to a slope of 1, which implies covered interest parity. This condition, however, only establishes a relation between r and fp. In order to determine how the level of r (and fp) is affected by monetary policy under perfect capital mobility, we have to reformulate our model for the case of perfect substitutability between domestic and covered foreign-currency securities.

2.4.2 Perfect capital mobility

Perfect substitutability between domestic and covered foreign-currency securities means that separate demand functions for these assets cannot be defined. For instance, the public's demand functions now refer to deposits, uncovered foreign-currency securities, and securities with a safe nominal return in domestic currency ($= r = r^* + fp$), i.e., domestic securities <u>or</u> covered foreign-currency securities. Under the condition of perfect capital mobility, asset demand functions may thus be respecified as follows:

$$D = \tilde{d}\left[r^* + fp,\ r^* + \hat{s}^e,\ r^D,\ s\right], \tag{2.29}$$

$$F^u = \tilde{f}^u\left[r^* + fp,\ r^* + \hat{s}^e,\ r^D,\ s\right], \tag{2.30}$$

$$\tilde{T}^p = \tilde{t}^p\left[r^* + fp,\ r^* + \hat{s}^e,\ r^D,\ s\right], \tag{2.31}$$

where "~" is used to distinguish asset demands under perfect capital mobility from those under imperfect mobility.

When domestic and covered foreign-currency securities are perfect substitutes, the banks play no important role in the portfolio balance model. Deposits are infinitely elastically supplied at the predetermined level of r^D; required reserves amount to aD; and the remainder, (1-a)D, is invested in nominally safe securities:

$$\tilde{T}^b - RB = (1-a)D. \tag{2.32}$$

The equilibrium of the portfolio balance model is now given by one condition in one endogenous variable (r or fp). It may be formulated as

$$\left[\tilde{T}^b - RB + \tilde{T}^p + T^c + g(.) - T\right] + Sq^p(.) + Sq^f(.) + S\bar{Q} = 0. \tag{2.33}$$

The term within brackets is the domestic excess demand for securities with a nominally safe return in domestic currency. This demand is satisfied through purchases of foreign-currency securities and corresponding sales of foreign currency on the forward foreign exchange market. This net supply on the forward market which derives from the demand for covered foreign-currency securities must, just as in the case of imperfect capital mobility, be matched by a corresponding net demand from foreign and domestic "speculators" (including the CB).

The private sector's total net holdings of foreign-currency securities, F^p, are given by the aggregate of uncovered holdings, F^u, and covered holdings, which in turn are given by the term within brackets in (2.33). It is obvious that the CB's open market operations and sales of forward foreign currency have direct effects on private capital flows. An autonomous decrease in the CB's holdings of domestic securities ($d\bar{T}^c < 0$) lowers the private demand for covered foreign-currency securities and creates a corresponding inflow of capital. Just as it makes no sense to sterilize currency flows in the form of government purchases or sales of foreign-currency securities (changes in F^g), it makes little sense to counteract covered purchases or sales of foreign securities which stem directly from changes in $\bar{T}^c$. For simplicity, let us assume that the CB, in the case of perfect capital mobility, chooses to sterilize changes in currency flows associated with the current account or <u>uncovered</u> purchases of foreign securities only, i.e., that the reaction function can be respecified as

$$T^c = \tilde{h}\left[CAB - F^u\right] + \bar{T}^c, \qquad (2.34)$$

where $\tilde{h}_1 > -1$.

Using the private sector's balance sheet,

$$\tilde{T}^p = W - F^u - D, \qquad (2.35)$$

the balance sheets for the government (2.3) and the banks (2.32), the definition of wealth (2.18), plus the behavioral functions (2.29) - (2.30) and (2.34), we may rewrite (2.33) as

$$CAB - \tilde{f}^u(.) - F^g + \tilde{h}(.) + \bar{T}^c + g(.) + Sq^p(.) +$$

$$+ Sq^f(.) + S\bar{Q} = a\tilde{d}(.). \qquad (2.36)$$

This equilibrium condition can be obtained by summation of the two equilibrium conditions for the general case of imperfect capital mobility, (2.20) and (2.24), with suitable revisions of asset demand and reaction functions. That the original equilibrium conditions may be aggregated is, of course, due to the fact that the aggregate of domestic and covered foreign securities can be viewed as the stock of one single composite asset.

From (2.36) and (2.34) it is easily seen that

$$\frac{dr}{d\bar{T}^c} = \frac{dfp}{d\bar{T}^c} = \left[a\tilde{d}_1+(1+\tilde{h}_1)\tilde{f}_1^u-Sq_2^p-Sq_2^f-g_1\right]^{-1} < 0, \qquad (2.37)$$

and that

$$\frac{dfp}{dF^g} = -\frac{dfp}{d\bar{T}^c} = -\frac{dfp}{Sd\bar{Q}}. \qquad (2.38)$$

Perfect capital mobility thus does <u>not</u> imply that there is no monetary autonomy (since $dr/d\bar{T}^c < 0$). It does imply, of course, that open market operations and interventions in spot and forward exchange markets have the same effects on the interest rate as on the forward premium (i.e., dr = dfp). Furthermore, these different operations will have <u>identical</u> effects on the interest rate, with reasonable assumptions about the CB's behavior (cf. (2.38)).

As to the effects from monetary policy on private capital flows, it should first of all be noted that private total net holdings of foreign-currency securities, F^p, are given by the aggregate of uncovered holdings, F^u, and covered holdings, which in turn - by (2.33) - must equal $-(Sq^p + Sq^f + S\bar{Q})$. That is,

$$F^p = \tilde{f}^u(.) - Sq^p(.) - Sq^f(.) - S\bar{Q}, \qquad (2.39)$$

and

$$\frac{dF^p}{d\bar{T}^c} = -\frac{dF^p}{dF^g} = \frac{\tilde{f}_1^u - Sq_2^p - Sq_2^f}{a\tilde{d}_1 + (1+\tilde{h}_1)\tilde{f}_1^u - Sq_2^p - Sq_2^f - g_1}. \qquad (2.40)$$

In the empirical literature, it is fairly common to estimate the offset coefficient from reduced form regression analysis of private capital flows. In the case of perfect capital mobility, the offset coefficient is given by

$$c \equiv \frac{d\bar{T}^c - adD}{d\bar{T}^c} = 1 - a\tilde{d}_1 \frac{dr}{d\bar{T}^c}, \qquad (2.41)$$

which implies that

$$\frac{dr}{d\bar{T}^c} = (a\tilde{d}_1)^{-1} (1 - c). \qquad (2.42)$$

The degree of monetary autonomy is thus closely related to (one minus) the offset coefficient. From (2.37) and (2.41) we have that

$$c = \frac{(1+\tilde{h}_1)\tilde{f}_1^u - Sq_2^p - Sq_2^f - g_1}{a\tilde{d}_1 + (1+h_1)\tilde{f}_1^u - Sq_2^p - Sq_2^f - g_1}, \qquad (2.43)$$

which implies that $dF^p/d\bar{T}^c = c$ if $\tilde{h}_1 = g_1 = 0$. Reduced form regression analysis of private capital flows can thus only be expected to reveal the true offset coefficient if the CB's actions are completely autonomous.

If domestic and foreign-currency securities are perfect substitutes on an <u>uncovered</u> basis, an open market operation will be completely offset by private capital flows ($c = 1$ since $\tilde{f}_1^u = -\infty$). Whether monetary autonomy is measured in terms of the interest rate effect, given by (2.37), or by the ultimate effect on the volume of high-powered money, given by one minus the offset coefficient, perfect substitutability on an uncovered basis implies that there is no monetary autonomy. Note, however, that the offset coefficient may be unity even if $\tilde{f}_1^u$ is finite, if the demand for money is interest-inelastic ($\tilde{d}_1 = 0$), or if the discount window is completely open ($g_1 = \infty$). It is thus not generally true that the higher the offset coefficient is, the less will the scope for monetary policy be. This is just a reflection of the fact that the offset coefficient is not a "deep parameter".

2.4.3 Policy implications

Before looking at the empirical literature, let us briefly discuss the conclusions for policy that can be drawn from the portfolio balance analysis in this chapter.

As to the role of capital mobility, we have seen that the higher the degree of substitutability between domestic and foreign securities, the lower is the degree of monetary autonomy. However, perfect substitutability between domestic and covered foreign securities does not imply that there is no autonomy, whereas perfect substitutability on an uncovered basis does. In the latter case, there is an infinitely elastic supply of securities (denominated in foreign currency) which are perfectly substitutable for domestic securities, and the return on the latter can therefore not be affected by the monetary authorities in a small open economy. In the case of perfect substitutability on a covered basis, however, this is not the case; as long as forward foreign currency is not infinitely elastically supplied, the monetary authorities can affect the forward premium and thus the nominally safe return in domestic currency.

In principle, sterilization of private capital flows may increase the scope for monetary policy. Government purchases or sales of foreign securities should, presumably, not be sterilized. This argument rests on the assumption that official foreign borrowing or lending is an ingredient in a purposeful stabilization policy that should not be counteracted by monetary authorities. An analogous argument can be made to the effect that, in the case of perfect capital mobility, covered purchases or sales of foreign-currency securities by private agents should not be sterilized, if they are directly caused by open market operations. One may, of course, argue that private capital flows which are induced by policy shocks should never be sterilized. In practice, it may be hard to determine the extent to which private capital flows should be sterilized. It is even hard to imagine why sterilization should be necessary. The monetary authorities can achieve independent interest-rate and foreign-exchange-reserves targets by suitable combinations of changes in $\bar{\bar{T}}^c$, F^g, and $\bar{Q}$, and the effects of other autonomous disturbances may be damped (or reinforced) by the supply of borrowed reserves.

If sterilization should nevertheless be seriously considered, it is important to note that sterilization of (uncovered) purchases or sales of foreign-currency securities only has a limited effect on capital flows. The effect on the interest rate/forward premium and on the private capital flows from any autonomous disturbance depends on the <u>net</u> effects on the demand for uncovered foreign-currency securities and the supply of forward foreign currency (cf. (2.37) and (2.40)). The foreigners' supply of forward foreign exchange may be interpreted as their (excess) demand for domestic securities, and the supply function $q^f(.)$ plays the same role in the equilibrating mechanism as would a securities demand function. This indicates that <u>the restriction on foreigners' holdings of domestic securities is of no consequence to the degree of monetary autonomy in the case of perfect capital mobility</u>.

Kouri (1976) notes that "in the absence of the 'default risk' or transaction costs the forward market does not expand the investment opportunity set" (p. 6). We have seen that the forward market may make capital controls ineffective. In particular, the forward market expands the investment opportunity set of foreign investors, who are prohibited from holding Swedish securities. This result is not inconsistent with Kouri's conclusion, since one may interpret the capital controls as imposing infinitely large transaction costs on international trade in a certain type of asset.[13]

The Swedish monetary authorities have more or less officially declared that they are concerned with private currency flows rather than total changes in foreign exchange reserves, and the supply of borrowed reserves, rather than sterilization, is used to stabilize target variables. Recently, operations in the forward market seem to have gained importance. These observations are easily interpreted in terms of the portfolio balance model. The restriction on foreign holdings of domestic securities, however, can only be justified insofar as domestic and covered foreign-currency securities are treated as imperfect substitutes. As we shall see below, available evidence indicates that capital is perfectly mobile, and hence, that the capital controls are of no consequence for the degree of monetary autonomy. The latter is determined by the degree of substitutability between domestic and uncovered foreign securities and - which amounts to the same thing under perfect capital mobility - by the elasticity of the supply of forward foreign currency. The conditions on the forward foreign exchange market are thus crucial for the degree of monetary autonomy and, in particular, for the effectiveness of capital controls.

Finally, let us comment on the proposition put forward by Franzén (1986) - see also SOU 1985:52, ch. 17 - and Johansson (1985), that foreign borrowing which is covered in the forward market does not affect the foreign exchange reserves. This proposition can be translated into the hypothesis that private

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[13] In analogy with Kouri's statement, the addition of a Eurocurrency market does not expand the investment opportunity set if there is a well-functioning forward market; cf. Herring and Marston (1977). The "Eurokron" market is described by Julin (1987).

capital flows consist entirely of changes in uncovered positions, i.e., that $dF^p = dF^u$. In general, however, any autonomous disturbance will give rise to capital flows that involve changes in both uncovered and covered positions. It can be verified from (2.39) that $dF^p = dF^u$ if the supply of forward foreign currency (from the public and foreigners) is completely inelastic, but this must be considered an extreme case. At least, I am aware of no empirical support of this hypothesis.

2.5 EMPIRICAL EVIDENCE

In order to get a deeper understanding of the scope for monetary policy, one would like to have empirical estimates of all structural equations in the portfolio balance model, i.e., of all the parameters of asset demand and reaction functions. Ideally, one would also like to have estimates of the structural equations of the real side of the economy. Needless to say, such information is not available.

Empirical studies of monetary autonomy may be grouped in three categories. First, there are estimates of single equations from portfolio balance models, such as the demand function(s) for foreign securities and the CB's reaction function(s). Second, there are studies of reduced forms aimed at estimating particular combinations of the underlying parameters, such as the offset coefficient. Third, there are what we may call atheoretical studies which examine the empirical evidence on parity conditions such as CIP and UIP. Taken together, these studies may provide some indirect evidence on the scope for monetary policy. There are no a priori reasons to view one approach as generally superior to the others, but they should be viewed as complementary. The usefulness of the various approaches also depends on the underlying structure of the economy, i.e., on the unknown properties which are the reason for the empirical studies in question. It is not, e.g., meaningful to try to estimate the structural equations of the portfolio balance model unless there is at least some degree of monetary autonomy; if domestic and foreign-currency securities are perfect substitutes it will not be possible to identify separate demand functions for those assets. The atheoretical parity tests may reveal whether capital mobility and/or asset substitutability is perfect or not, but do not give us any information on the degrees of mobility and substitutability if they are found to be less than perfect. Reduced form estimation of the offset coefficient allows for perfect substitutability as a special case. If the monetary authorities' actions are completely autonomous, the offset coefficient may be estimated from a reduced form regression of total private capital flows, and no separation of covered and uncovered transactions is necessary.

Kouri and Porter (1974) present some results from reduced form regression analyses of West Germany's capital account (quarterly data, 1960-1970). They assume that the CB's holdings of domestic securities, T^C, can be treated as an exogenous variable, i.e., that $h_1 = h_2 = 0$. One result is that it seems as if open market operations are largely neutralized by movements in short term capital flows - the offset coefficient is estimated to .72. Following Kouri and Porter, Grassman and Herin (1976) estimate the corresponding coefficient using quarterly Swedish data from 1966-1974 and arrive at a point estimate of .46. These results thus indicate that there may have been a higher degree of monetary autonomy in Sweden than in Germany during the period under consideration.

It is questionable, however, whether the Swedish and German central banks' operations during the 1960's and 1970's can safely be treated as exogenous. Obstfeld (1980b) estimates the structural equations of a portfolio balance model for West Germany on quarterly data from the 1960's, and finds evidence of almost complete sterilization. His estimate of the sterilization coefficient (h_1) is not significantly different from -1. Similar results are reported by Herring and Marston

(1977).[14] For comparison with the results obtained by Kouri and Porter (1974), Obstfeld (1982) also runs a reduced form regression on German capital flows, taking the endogeneity of T^c into account by employing the method of two-stage least squares. As shown in Section 2.4.2, however, the reduced form coefficient on T^c gives information about the offset coefficient only in the case of no sterilization. Obstfeld finds the coefficient to be insignificantly different from zero, and explains the difference between his result and that of Kouri-Porter to simultaneity bias in the latters' estimate; but Obstfeld himself apparently overlooks the effect that sterilization has on the definition of the offset coefficient.

Obstfeld (1983) reports that the conclusions about the German CB's reactions are not much affected if the period of a flexible exchange rate is examined. Using monthly data from 1975-1981 he still gets a sterilization coefficient not significantly different from -1. Simulations based on the portfolio balance model reveal, however, that the quantitative effects on the exchange rate from sterilized intervention may have been negligible. Genberg (1981) reviews several studies of German data from the 1970's and concludes that the evidence of the effectiveness of sterilization is very weak.

Genberg (1976) estimates a central bank reaction function on quarterly Swedish data from 1950-1968 and finds the sterilization coefficient to be slightly (but not significantly) less than -1 in absolute terms. Genberg nevertheless chooses to interpret the negative correlation between the domestic and foreign components of the monetary base as an indication that monetary policy has been completely offset by private capital flows. Lybeck, Häggström and Järnhäll (1979) fit both structural and reduced form equations to

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14 Herring and Marston and Obstfeld explicitly take account of the CB's operations in the forward foreign exchange market when estimating the reaction functions, but only the latter study considers the direct effects of these operations on the private capital balance (cf. (2.39) above).

quarterly Swedish capital flows for the period 1967-1974, and find some evidence of sterilization. As to the size of the estimated offset coefficient, the results are inconclusive.

Black (1983) uses monthly data from 1963-1979 to estimate the reaction functions of the CB's in ten different countries, including Sweden and West Germany. Sweden and Germany are both found to "give at least moderate attention to external variables" (p. 206), which is not consistent with complete sterilization. Germany appears to have put more emphasis on external variables during the period of floating than earlier, and to have put more weight on external balance than Sweden. Although the robustness of Black's results can be questioned (cf. the critical comments on Black's paper by Leiderman and Stockman), the conclusions are definitely in line with common prejudices, at least as far as Sweden and Germany are concerned.

A common result in empirical studies of private capital flows is the failure to establish any significant influence from interest rates - see, e.g., Kouri and Porter (1974), Cumby (1983), Hirdman, Nessén and Vredin (1986), and Hirdman (1987). This may be indicative of high degrees of monetary autonomy, and can in principle be explained as a result of low substitutability between domestic and foreign securities, or of an extremely successful monetary policy where the interest rate is managed so as to stabilize capital flows.[15] However, the result may also be due to measurement problems. Besides the problem of measuring (exchange rate) expectations, it is worth noting that failure to control for systematic changes in the CB's supply of forward foreign currency might create problems (cf. (2.39)). Note first that a regression analysis of $F^p - \bar{Q}$ against $r - r^*$ or fp will give an estimate of the total interest sensitivity of the demand for uncovered foreign--currency securities and the supply of forward foreign

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[15] Formally, if r is used to control F^p, F^p may appear to be exogenous w.r.t. r; see, e.g., Sims (1977).

currency. More importantly, if data on $\bar{Q}$ are not available - which often is the case, in practice - we face the traditional problem of omitted variables. The parameter estimates of the private securities demand and forward exchange supply functions will be inefficient and biased.[16] Judging from the study by Hirdman (1987), there seems to be little hope of achieving useful empirical estimates of the interest-sensitivity of capital flows without detailed information about the forward foreign exchange market.

Following the break-down of the international system of rigidly fixed exchange rates, there has been a shift in the focus of empirical research in the field of international monetary economics. In particular, it has been more popular to estimate (reduced form and atheoretical) exchange rate equations than (structural) asset demand equations. The two approaches should, nevertheless, be viewed as complementary. One may, e.g., view direct tests of parity conditions such as CIP and UIP as the first step in an empirical identification of a structural portfolio balance model.

Using monthly data from 1975-1984, McPhee (1984) and Englund, McPhee and Viotti (1985) present some evidence that the Swedish credit market has become more integrated with the world market. Specifically, deviations from CIP between one-month krona and Eurodollar interest rates have been much smaller since 1980 than earlier. At least since 1982, the deviations have been small enough to be explained by normal transaction costs. Similar results are presented by Frenkel and Levich (1981), who examine the deviations from CIP among treasury bills of different origin and among different Euromarket securities, including assets denominated in German marks. (Data are weekly, and cover the years 1973 - 1979.) These findings are consistent with the hypothesis of perfect capital mobility, but do not imply that there is no monetary autonomy, or that domestic

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[16] Equivalently, the estimates reflect the net effects of the behavior of private agents and the monetary authorities.

(Swedish and German) and foreign-currency securities are perfect substitutes also on an uncovered basis, i.e., that UIP holds.

The most common way to investigate whether UIP holds is to test whether forward exchange rates are unbiased predictors of future spot rates, under the maintained hypothesis of CIP.[17] Cumby and Obstfeld (1984) investigate dollar exchange rates using weekly data from 1976-1981. Although unbiasedness can be rejected in four out of five cases, it cannot be rejected for the U.S. dollar/German mark exchange rate. However, Fama (1984), who studies more dollar exchange rates for a longer period (1973-1982) rejects unbiasedness in all (nine) cases, including the dollar/mark relation. Oxelheim (1985) studies quarterly data on krona exchange rates for the period 1974-1984, and is not able to reject that the forward premia (on the krona in relation to the U.S. dollar or the German mark) are unbiased predictors of the depreciation of the krona.

On the basis of the information reviewed in this section, one may be tempted to conclude that even if the degree of monetary autonomy in Sweden was not lower than in Germany during the 1960's and early 1970's, recent UIP tests indicate that Sweden may now have a more limited autonomy (if any) than Germany. To the extent that one believes that German monetary policy, in contrast to the policies of a small economy like Sweden, can be expected to influence world market interest rates, this conclusion is of course strengthened. However, the estimated exchange rate equations have to be interpreted with caution. First, forward premia are usually not very informative when forecasting future exchange rate changes, irrespectively of whether they are found to be biased predictors or not. Exchange rate changes generally show a much higher variance than forward premia. This also implies that the estimated coefficients in the regression analyses are subject to great uncertainty, and

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[17] Note that (2.1) and (2.2) together imply that $\hat{s}^e = fp$. The literature on UIP is discussed more thoroughly in Chapter 3.

that they, therefore, may be sensitive even to minor changes in specification and/or estimation period. (Compare, e.g., the Cumby-Obstfeld (1984) and Fama (1984) papers referred to above.) Second, regression equations should be formulated and interpreted with reference to actual exchange rate policies. A reduced form equation or parity condition which may seem sensible to investigate using data from one exchange rate regime may not be relevant under another system. Specifically, we suspect that Sweden's exchange rate policy, which since 1977 is based on a particular official currency basket index (cf. Chapter 1), has implications to the effect that one should use different models when studying data from the pre- and post-1977 periods (and when studying Swedish and German data). We will examine the Swedish case more closely in Chapter 4, after having reviewed the theoretical and empirical arguments on international asset substitutability in Chapter 3.

2.6 SUMMARY

The purpose of this chapter has been to carry the discussion about capital mobility and monetary policy in Chapter 1 a bit further. It has been argued that capital mobility may be identified with the degree of substitutability between domestic securities and foreign securities which are covered in the forward foreign exchange market. Perfect capital mobility is thus taken to mean that the covered interest differential is zero, i.e., that CIP holds. It has also been argued that monetary autonomy may be taken to mean the possibility to affect the domestic interest rate through, e.g., open market operations, given a specific (realized and expected) value of the exchange rate.

In order to analyze the relation between capital mobility and monetary autonomy I have formulated a portfolio balance model that incorporates the forward foreign exchange market. While many simplifying assumptions have been made, the model still captures important institutional features of the Swedish credit market, such as capital controls and the monetary authorities' reaction functions. A principal finding is that increased capital mobility implies lower monetary autonomy, although perfect capital mobility does not imply that there is no autonomy. Perfect capital mobility means that domestic and covered foreign-currency securities are perfect substitutes, and that the demand for nominally safe securities in domestic currency may be satisfied through purchases of domestic securities <u>or</u> of foreign securities which are coupled with a sale of foreign currency on the forward market. The forward market thus creates an endogenous supply of securities with a safe return in domestic currency; consequently, this return may be little affected by the actions of the monetary authorities. Unless the supply of forward foreign currency is infinitely elastic, however, monetary policies will have <u>some</u> effect on the forward premium and the domestic interest rate.

In some earlier models, the supply of forward foreign currency has been treated as completely <u>inelastic</u>. I am aware of no empirical support of this hypothesis. However, empirical studies do suggest that domestic and covered foreign-currency securities are perfect substitutes, i.e., that CIP holds. This implies that a restriction against foreign holdings of domestic securities is ineffective. Foreigners' demand for domestic securities can be satisfied through purchases of foreign-currency securities, coupled with sales of forward foreign currency (purchases of forward Swedish currency).

There does not seem to exist any strong evidence on the actual degree of monetary autonomy. Regression analyses of structural asset demand functions typically suffer from a neglect of the forward foreign exchange market, and reduced form estimations of "offset coefficients" have not paid sufficient attention to the CB's reaction function(s).

If domestic securities are considered perfect substitutes to uncovered foreign-currency securities, i.e., if UIP holds, there is no monetary autonomy in a small open economy. Unlike CIP, UIP cannot be brought about through arbitrage activities, since uncovered borrowing and lending is risky. The theoretical and empirical evidence of the importance of risk for international interest rate differentials is the subject of Chapter 3.

Appendix

In this appendix, the portfolio balance model set out in Section 2.3 is analyzed formally.

Let A denote the determinant of the equation system given by (2.20) and (2.24). It is easily verified that

$$A = \left[g_1 - ad_1\right]\left[S^{-1}\right]\left[f_2^b + f_2^c + Sq_2^p + Sq_2^f\right] + ad_2\left[S^{-1}\right]\left[f_1^b + f_1^c\right] -$$
$$- \left[1 + h_1\right]\left[S^{-1}\right]\left[f_1^u(f_2^b + f_2^c) - f_2^u(f_1^b + f_1^c) + (f_1^b + f_1^u + f_1^c)(Sq_2^p + Sq_2^f)\right]. \tag{A1}$$

The assumption of gross substitutability ensures that $A > 0$, as long as $1 + h_1 > 0$.

The slope of TT in Figure 1 is given by

$$\left.\frac{dr}{dfp}\right|_{TT} = - \frac{ad_2 + (1 + h_1)(f_2^b + f_2^u + f_2^c)}{ad_1 - g_1 + (1 + h_1)(f_1^b + f_1^u + f_1^c)}, \tag{A2}$$

which is positive if $1 + h_1 > 0$, $f_2^b + f_2^c > - f_2^u$ and the absolute value of d_2 is small. (If the demand for money decreases very much when the forward premium goes up (i.e., if d_2 is large), the domestic interest rate may have to fall in order to clear the domestic securities - and reserves - market.) The slope of QQ is given by

$$\left.\frac{dr}{dfp}\right|_{QQ} = - \frac{S^{-1}(f_2^b + f_2^c) + q_2^p + q_2^f}{S^{-1}(f_1^b + f_1^c)} > 0. \tag{A3}$$

It can be seen that

$$\left.\frac{dr}{dfp}\right|_{TT} - \left.\frac{dr}{dfp}\right|_{QQ} = - \frac{SA}{[ad_1 - g_1 + (1+h_1)(f_1^b+f_1^u+f_1^c)](f_1^b+f_1^c)}, \quad \text{(A4)}$$

which is negative, so that TT is flatter than QQ, under the assumptions made above.

Differentiation of (2.20) and (2.24) gives the following results (under the assumptions made above, and assuming $1 + h_1 - h_2 > 0$):

$$\frac{dr}{d\bar{T}^c} = - (AS)^{-1}(f_2^b + f_2^c + Sq_2^p + Sq_2^f) < 0; \quad \text{(A5)}$$

$$\frac{dfp}{d\bar{T}^c} = (AS)^{-1}(f_1^b + f_1^c) < 0; \quad \text{(A6)}$$

$$\frac{dr}{dF^g} = (1 + h_1 - h_2)(AS)^{-1}(f_2^b + f_2^c + Sq_2^p + Sq_2^f) > 0; \quad \text{(A7)}$$

$$\frac{dfp}{dF^g} = - (1 + h_1 - h_2)(AS)^{-1}(f_1^b + f_1^c) > 0; \quad \text{(A8)}$$

$$\frac{dr}{d\bar{Q}} = - A^{-1}[(1 + h_1)(f_2^u + f_2^c + f_2^b) + ad_2] < 0; \quad \text{(A9)}$$

$$\frac{dfp}{d\bar{Q}} = A^{-1}[(1 + h_1)(f_1^b + f_1^u + f_1^c) - g_1 + ad_1] < 0. \quad \text{(A10)}$$

Defining ϕ as in (2.27),

$$\frac{d(dr/d\bar{T}^c)}{d\phi} = - 2(AS)^{-1} + A^{-2}S^{-1}(2\phi + Sq_2^p + Sq_2^f)\frac{dA}{d\phi} =$$

$$= 2\, A^{-2}S^{-1}[(2\phi + Sq_2^p + Sq_2^f)2^{-1}(dA/d\phi) - A] =$$

$$= 2(AS)^{-2}(Sq_2^p+Sq_2^f)[-ad_2-(1+h_1)(f_2^u-Sq_2^p-Sq_2^f)] > 0.$$

(A11)

It can also be shown that

$$\frac{d}{d\phi}\left[\frac{dr}{dfp}\bigg|_{TT}\right] = -\frac{2(1+h_1)[a(d_1+d_2)-g_1+(1+h_1)(f_1^u+f_2^u)]}{[ad_1-g_1-(1+h_1)(2\phi-f_1^u)]^2} > 0, \quad \text{(A12)}$$

and that

$$\frac{d}{d\phi}\left[\frac{dr}{dfp}\bigg|_{QQ}\right] = -\frac{Sq_2^p + Sq_2^f}{2\phi^2} < 0, \quad \text{(A13)}$$

i.e., that TT gets steeper while QQ gets flatter as ϕ gets larger. It is easily seen from (A2) - (A3) that as $\phi \to \infty$,

$$\frac{dr}{dfp}\bigg|_{TT} \to 1 \quad \text{and} \quad \frac{dr}{dfp}\bigg|_{QQ} \to 1.$$

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3. The Foreign Exchange Risk Premium: A Review of Theory and Evidence*

3.1 INTRODUCTION

This chapter is focused on a concept known as the foreign exchange risk premium, which is a direct measure of the degree of substitutability between domestic and uncovered foreign-currency securities. The maintained hypothesis is that the degree of substitutability between domestic and covered foreign-currency securities is very high, so that capital mobility can be viewed as perfect. Under this assumption the foreign exchange risk premium, p, may be defined in two equivalent ways; it can either be expressed as the deviation from uncovered interest parity (UIP),

$$r = r^{*} + \hat{S}^{e} + p, \qquad (3.1)$$

or as the "bias" in the forward premium as a predictor of the rate of change in the spot exchange rate,

$$fp = \hat{S}^{e} + p, \qquad (3.2)$$

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* This chapter was written together with Lars Hörngren.

where r (r^*) is the nominally safe interest rate on domestic (foreign) securities; $\hat{s}^e$ is the expected rate of depreciation of the domestic currency; and fp is the forward premium (in percent) on foreign exchange. The definitions of p implied by (3.1) and (3.2) are obviously equivalent under the condition of covered interest parity (CIP),

$$r = r^* + fp, \qquad (3.3)$$

which is our operationalization of the concept of perfect capital mobility.

It was argued in Chapter 2 that UIP has to be violated in order for there to be some "monetary autonomy" in a small open economy. According to (3.1) a non-zero risk premium is thus a necessary condition for monetary autonomy. However, it should be noted that although the term p in (3.1) and (3.2) is referred to as a risk premium, there may be other reasons than risk behind deviations from UIP (and from unbiasedness). If the (true) risk premium is zero, obstacles to mobility or general market inefficiencies are necessary for autonomy.

One might conjecture that current exchange rate policies, which do not keep exchange rates permanently and credibly fixed, imply that assets denominated in different currencies will not in general be treated as perfect substitutes by investors who are concerned with risk. The actual degree of monetary autonomy, as defined in Chapter 2, would then be determined by the sensitivity of the risk premium to changes in monetary policy. The possibility for an independent interest rate policy thus hinges on some knowledge of the determinants of the risk premium and how they can be influenced by systematic policy actions.

Portfolio balance models such as that of Chapter 2 rely on assumptions of imperfect asset substitutability, and the reliability of their predictions about the effects of monetary policy depends on the validity of that assumption. Since imperfect asset substitutability has been assumed a priori, static portfolio balance models are not informative as to the nature of the foreign exchange risk premium. The postulated asset demand functions are not explicitly derived from maximizing behavior of investors, and the static framework also precludes a rigorous analysis of exchange rate dynamics and the consequences thereof. In particular, interest rate (risk premia) sensitivity to changes in monetary policy cannot be related to individual attitudes towards risk or to the properties of exchange rate processes.

The purpose of this chapter is to review the literature on international asset pricing. The review consists of two parts, discussing the theoretical (Section 3.2) and empirical (Section 3.3) literature, respectively. We discuss what implications the reviewed studies have for the conclusions about the behavior of the foreign exchange risk premium and, ultimately, for the scope for monetary policy. The connection between the theoretical models and the empirical studies, and the focus on the foreign exchange risk premium are what distinguishes our review from earlier (more comprehensive) reviews of international asset pricing, such as Branson and Henderson (1985).[1]

Broadly speaking, theoretical developments that go beyond the static portfolio balance model involve two steps. First, asset demand functions may be derived from intertemporal utility maximization, based on rational expectations, under specific assumptions about the nature of exogenous stochastic processes characterizing asset returns and exchange rates. This approach is taken, e.g., in Kouri's (1977) application of Merton's (1971) model to the determination of interest rates and forward

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1 Adler and Dumas (1983) survey the theoretical and empirical literature on international asset pricing, but are more concerned with the implications for corporate finance than macroeconomic policy. Boothe and Longworth (1986) also survey related empirical work.

premia. Second, asset prices and exchange rates may be derived as functions of parameters of utility functions, production technology, money supply, etc. Such a general equilibrium framework is characteristic of Lucas' (1978, 1982) models, and has been applied to an analysis of the forward premium by, e.g., Hodrick and Srivastava (1984).[2]

Although the demand or supply for forward foreign currency is not explicitly treated in the models to be reviewed, there is a strong connection between this and the preceding chapter. In Chapter 2 we made use of (derivatives of) demand functions for uncovered foreign-currency securities <u>and</u> supply functions for forward foreign currency. We also noted, however, that in the case of perfect capital mobility (CIP), either function reflects a demand for open (uncovered) positions. To understand the nature of the foreign exchange risk premium it suffices, therefore, to look at the supply on the forward market <u>or</u> the demand for uncovered foreign-currency securities, and the models we have selected to review are focused on the latter.[3]

3.2 THEORETICAL MODELS OF THE FOREIGN EXCHANGE RISK PREMIUM

The literature on international asset pricing has been growing rapidly in recent years. The purpose here is not to provide a complete and general survey of this vast field. The focus is limited by our interest in the determination of the foreign exchange risk premium and the implications that asset pricing

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2 Stulz (1984) combines elements of the traditions associated with Merton and Lucas in a model of the foreign exchange risk premium. Driskill and McCafferty (1982) analyze a rational-expectations model where spot and forward exchange rates are endogenously determined, but where asset demand functions are not explicitly derived from optimizing behavior.

3 In terms of the model of Chapter 2, we look into the determinants of the $\tilde{f}^u(.)$ function, while the $q^p(.)$ function is neglected. The converse strategy is followed by Eaton and Turnovsky (1984) who assume that all "speculation" (i.e., open positions) takes place in the forward market.

models have for the question of international interest rate dependence.

The review will proceed from the specific to the general, starting with a model with just one consumption good. We will then study how the risk premium is affected as the simple framework is generalized.

3.2.1 A simple continuous time asset pricing model

To establish "first principles" regarding the determination of the foreign exchange risk premium we will start by considering a modified version of the model presented by Kouri (1977). We have simplified his model by ignoring equity and not giving any explicit role to money. In addition, the stochastic structure is somewhat different.

It is assumed that the world is made up of n+1 countries. There are bonds denominated in each of the local currencies, i.e., there are n+1 assets. These bonds are nominally safe in the sense that they give a predetermined (instantaneous) return in the currency in which they are denominated, i.e.,

$$\frac{dF_i}{F_i} = r_i \, dt, \qquad i = 1,\ldots,n+1, \tag{3.4}$$

where F_i is the nominal (currency i) value of a bond denominated in currency i.

Although the nominal return is safe, the real return of course depends on the rate of inflation and the development of the exchange rates. We therefore have to specify the dynamics of the price levels in the n+1 countries and of the n exchange rates. It is assumed that the rates of inflation in the first n countries follow Itô processes, i.e.,

$$\frac{dP_i}{P_i} = \pi_i \, dt + \sigma_i \, dz_i, \qquad i = 1,\ldots,n, \tag{3.5}$$

where π_i is the (instantaneous) expected rate of inflation, σ_i^2 is the (instantaneous) variance of the rate of inflation and dz_i is a so called Wiener process.[4] For simplicity, it is assumed that the rate of inflation in the (n+1) country is deterministic, i.e.,

$$\frac{dP_{n+1}}{P_{n+1}} = \pi_{n+1} \, dt. \tag{3.6}$$

The n+1 countries produce the same single traded good, and the law of one price is assumed to hold. This implies that exchange rates adjust instantaneously to offset differences in the rates of inflation between countries, i.e.,

$$S_i = \frac{P_i}{P_{n+1}}, \qquad i = 1,\ldots,n, \tag{3.7}$$

where S_i is the price of currency i in terms of the (n+1)st currency, which will be used as reference currency throughout this section. Note that the assumptions made imply that there is one asset, the (n+1)st bond, with a safe <u>real</u> return.

Applying Itô's Lemma, it is straightforward to show that (3.7) implies that the rate of depreciation of the ith currency is given by

$$\frac{dS_i}{S_i} = \left[\pi_i - \pi_{n+1}\right] dt + \sigma_i \, dz_i. \tag{3.8}$$

Having specified price and exchange rate dynamics, we can now return to the problem of determining the real returns on bonds.

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4 For details about Itô processes and other elements of stochastic calculus, see, e.g., Merton (1971) and Malliaris and Brock (1982).

Let $\bar{F}$ denote the real value (in terms of the single good) of a security denominated in currency i, i.e.,

$$\bar{F}_i = \frac{F_i}{P_i}. \tag{3.9}$$

We can differentiate (3.9), using Itô's Lemma, which gives

$$\frac{d\bar{F}_i}{\bar{F}_i} = \left[r_i - \pi_i + \sigma_i^2\right]dt - \sigma_i\, dz_i, \tag{3.10}$$

$$i = 1,\ldots,n.$$

Since $\sigma_{n+1}^2 = 0$ by assumption,

$$\frac{d\bar{F}_{n+1}}{\bar{F}_{n+1}} = \left[r_{n+1} - \pi_{n+1}\right]dt. \tag{3.11}$$

In this setup, we introduce an investor who chooses paths of consumption and asset holdings over an infinite horizon so as to maximize expected utility. At each point in time, he is subject to a wealth constraint

$$W = \sum_{i=1}^{n+1} \bar{F}_i. \tag{3.12}$$

As asset returns are assumed to be his only source of income, the stock of wealth changes (stochastically) over time according to

$$dW = \sum_{i=1}^{n+1} d\bar{F}_i - C\, dt, \tag{3.13}$$

where C is the (instantaneous) rate of consumption. We can rewrite (3.13) as

$$dW = W\left[\sum_{i=1}^{n} w_i \frac{d\bar{F}_i}{\bar{F}_i} + \left[1 - \sum_{i=1}^{n} w_i\right]\frac{d\bar{F}_{n+1}}{\bar{F}_{n+1}}\right] - C\,dt, \qquad (3.14)$$

where $w_i = \frac{\bar{F}_i}{W}$.

Substituting from (3.10) and (3.11), we get

$$dW = W\left[\sum_{i=1}^{n} w_i\left[r_i - r_{n+1} - \left[\pi_i - \pi_{n+1}\right] + \sigma_i^2\right] + r_{n+1} - \pi_{n+1}\right]dt -$$

$$- C\,dt - W\sum_{i=1}^{n} w_i\,\sigma_i\,dz_i. \qquad (3.15)$$

We can now state the investor's optimization problem formally:

$$\max E_t \int_t^{\infty} U(C_\tau, \tau)d\tau, \qquad (3.16)$$

subject to the wealth constraint (3.15). E_t is an expectation operator conditional on current (period t) information. The instantaneous utility function $U(C_\tau, \tau)$ is assumed to be strictly concave.

This problem is solved by stochastic dynamic programming.[5] First, define the optimal value function:

$$J(W, t) \equiv \max E_t\left[\int_t^{\infty} U(C_\tau, \tau)d\tau\right]. \qquad (3.17)$$

Second, derive the optimal portfolio composition and rate of

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[5] The reader is referred to Merton (1969, 1971, 1973) for more rigorous presentations of this technique.

consumption by solving the Hamilton-Jacobi-Bellman equation:

$$\max_{\{C,w_i\}} \Bigg[U(C_t,t) + J_t + J_W W\Big[\sum_{i=1}^{n} w_i\Big(r_i - r_{n+1} - (\pi_i - \pi_{n+1}) + \sigma_i^2\Big] + r_{n+1} - \pi_{n+1}\Big] - J_W C + \frac{1}{2} J_{WW} W^2 \sum_{i=1}^{n}\sum_{j=1}^{n} w_i w_j \sigma_{ij}\Bigg] = 0, \qquad (3.18)$$

where σ_{ij} is the covariance between inflation in countries i and j.

The first order conditions are

$$U_C(C_t,t) = J_W, \qquad (3.19)$$

$$J_W W\left[r_i - r_{n+1} - \left[\pi_i - \pi_{n+1}\right] + \sigma_i^2\right] + J_{WW} W^2 \sum_{j=1}^{n} w_j \sigma_{ij} = 0, \quad i = 1,\ldots,n. \qquad (3.20)$$

The interpretation of (3.19) is straightforward: equate the marginal utility of consumption to the marginal value of one more "unit" of wealth.

Conditions (3.20) are more interesting as they give the optimal portfolio strategy. We can rewrite the n conditions in (3.20) using matrix notation as

$$J_W W\left[r - \pi + \sigma^2 - \iota\left[r_{n+1} - \pi_{n+1}\right]\right] + J_{WW} W^2 \Omega w = 0, \qquad (3.21)$$

where ι is an (n x 1) vector of ones and $\Omega = [\sigma_{ij}]$ is the (n × n) variance-covariance matrix of inflation rates. The optimal portfolio strategy is thus

$$w = - \frac{J_W}{J_{WW}\, W}\, \Omega^{-1}\left[r - \pi + \sigma^2 - \iota\left[r_{n+1} - \pi_{n+1}\right]\right]. \qquad (3.22)$$

When interpreting (3.22) we may first note that $\phi \equiv -(J_W/J_{WW}W)$ is a measure of relative risk tolerance.[6] Hence, the portfolio shares in the n risky assets are (as expected) increasing functions of ϕ. In addition, asset demands depend on the expected real excess returns over the real return on the risk free asset and on the variance-covariance structure of the inflation rates. An increase in the expected return on any given asset always increases the demand for that asset, but the signs of the cross effects depend on the covariance structure in a complicated way (cf. Branson and Henderson (1985)).

Having derived the individual asset demand functions, we can proceed to characterize the equilibrium asset returns by deriving the aggregate asset demands and specifying the outstanding stocks of assets.

Assume that there are h individual investors with homogeneous expectations but (possibly) different initial endowments. By summing across individuals, we can write the (n x 1) vector of aggregate asset demand functions (as fractions of aggregate (world) wealth) as

$$x = T\cdot\Omega^{-1}\left[r - \pi + \sigma^2 - \iota\left[r_{n+1} - \pi_{n+1}\right]\right], \qquad (3.23)$$

where $T = \dfrac{\sum_{i=1}^{h} \phi_i\, W_i}{\sum_{i=1}^{h} W_i}$,

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6 In the present set-up, $J_W/J_{WW} = U_C/U_{CC}C_W$, so ϕ is obviously related to the Arrow-Pratt measure of risk aversion.

and the subscript i relates to the i:th individual. The scalar T is thus a wealth weighted measure of (world) risk tolerance.

We can use (3.23) to determine market equilibrium as the rates of return that have to obtain for a given stock of assets to be willingly held:

$$r - \iota r_{n+1} - \left[\pi - \iota \pi_{n+1}\right] + \sigma^2 = T^{-1} \Omega x. \qquad (3.24)$$

Recalling from (3.8) that

$$\epsilon_i \equiv (\pi_i - \pi_{n+1})$$

is the expected rate of depreciation of the i:th currency, we can rewrite (3.24) as

$$r - \iota r_{n+1} + \sigma^2 = \epsilon + T^{-1} \Omega x. \qquad (3.25)$$

Hence, we can conclude that the nominal interest rate differential is determined by the expected rate of depreciation and a risk premium. The latter depends on the (world) degree of risk aversion (T^{-1}), the variance-covariance structure (Ω), and the composition of the outstanding (world) portfolio (x).

Note that (3.25) implies that UIP will be violated even in the case of risk neutrality ($T = \infty$), due to the presence of σ^2 on the L.H.S. This is a special case of Jensen's inequality, and can be circumvented in this simple model by a suitable renormalization.[7] In a more general case, where, e.g., P_{n+1} is stochastic and no asset with a safe real return exists, the problem is more fundamental ; see McCulloch (1975), Frenkel and Razin (1980), Engel (1984), and Obstfeld (1986).

Equation (3.25) enables us to state more precisely the conditions for UIP to hold. UIP obtains (approximately) if investors are risk neutral ($T^{-1} = 0$) or (exactly) if there is no uncertainty concerning the rates of inflation ($\Omega=0$, $\sigma^2=0$). If neither of these conditions holds, assets denominated in different currencies will be regarded as imperfect substitutes, and forward exchange rates will be systematically biased predictors of future spot exchange rates.

In addition, this model implies that as long as investors are risk averse, relative asset returns will be affected by changes in asset supplies. There is thus a role for conventional monetary policy since an open market sale increasing the stock of a given asset will change the required premium and, hence, the interest rate differential. In this sense, the current model provides some micro foundations for standard macro portfolio balance models of the type analyzed in Chapter 2. This result is exploited for purposes of policy analysis by Kouri (1977), but his procedure is not without problems, as we shall see in the next subsection. (The question is whether monetary policy leaves Ω unaffected.)

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7 Let $M_i \equiv 1/S_i = P_{n+1}/P_i$. The expected rate of change of the exchange rate M_i is equal to

$$\mu_i = \pi_{n+1} - \pi_i + \sigma_i^2.$$

Hence,

$$\iota r_{n+1} - r = \mu - T^{-1}\Omega x,$$

which implies that UIP holds in the case of risk neutrality. This dependence on arbitrary choices of units is known as Siegel's paradox; cf. Siegel (1972).

Equilibrium rates of return in this model may also be expressed in terms more obviously related to the traditional Capital Asset Pricing Model (CAPM), although in an open economy version.

Let μ_x denote the expected real rate of return on the world market portfolio, and σ_x^2 its variance, i.e.,

$$\mu_x = x'\left[r-\pi-\iota\left[r_{n+1}-\pi_{n+1}\right]+\sigma^2\right] + r_{n+1} - \pi_{n+1}, \qquad (3.26)$$

and, by definition,

$$\sigma_x^2 = x'\Omega x. \qquad (3.27)$$

Substituting from (3.24) and (3.26) gives

$$\sigma_x^2 = x'\Omega x = T\, x'\left[r - \pi - \iota\left[r_{n+1} - \pi_{n+1}\right] + \sigma^2\right] =$$

$$= T\left[\mu_x - \left[r_{n+1} - \pi_{n+1}\right]\right]. \qquad (3.28)$$

The covariance between the return on asset i and the market portfolio can also be inferred from the fundamental pricing equation (3.24). Expanding the i:th row of (3.24), we have

$$\sigma_{xi} \equiv \sum_{j=1}^{n} x_j\, \sigma_{ij} = T\left[r_i - \pi_i - \left[r_{n+1} - \pi_{n+1}\right] + \sigma_i^2\right]. \quad (3.29)$$

Defining the analog in this model to the standard CAPM "beta",

$$\beta_i = \frac{\sigma_{xi}}{\sigma_x^2}, \qquad (3.30)$$

and substituting from above, we have

$$r_i - \pi_i - \left[r_{n+1}-\pi_{n+1}\right] + \sigma_i^2 = \beta_i\left[\mu_x - \left[r_{n+1}-\pi_{n+1}\right]\right]. \quad (3.31)$$

This expression shows that the risk premium (or discount) on an asset denominated in currency i is higher the higher the covariance between its return and the return on the market portfolio. As in this model all uncertainty derives from the rates of inflation, this implies that a low correlation between the inflation in country i and "world" inflation makes the i:th bond a good hedge and, thus, the required risk premium is correspondingly lower.

3.2.2 Extensions of the simple model

The model analyzed in the previous subsection is essentially a modified version of Kouri (1977). In his model, the investor can choose among nominally riskless assets, equity, and money. A demand for money is secured by assuming that the investor's money holdings is an argument in the utility function. The effect of including equity in the model depends on whether the stochastic processes of equity returns and inflation rates are correlated. Risk premia will be affected not only by the variance-covariance structure of inflation - as in the model of the previous subsection - but also by the covariance between inflation rates and equity returns. In this section, we will discuss this and some of the other extensions that have been presented in the literature and how they affect the properties of the risk premium.

Frankel (1982) considers the case where investors consume goods from different countries. Each good is produced in a single country and the law of one price holds, i.e., the currency i price of a good from country j is equal to the nominal price charged in country j multiplied by the currency-i/currency-j exchange rate. Unlike Kouri (1977), Frankel assumes that the goods of different origin are imperfect substitutes in consumption. The optimal composition of consumption is, however, not modelled, but the budget shares allocated to each good, denoted by α_j, are exogenous and constant. The result of introducing several goods is to make the portfolio decision depend on the consumption pattern. No single security can provide a riskless real rate of return. Instead a riskless portfolio is obtained by equating the portfolio shares to the consumption shares, i.e., $w_j = \alpha_j$. For an investor with some degree of risk tolerance, it is not optimal to invest only in this safe portfolio, but w_j also depends on the stochastic structure of exchange rates. The inclusion of many goods into the model makes risk premia dependent on the consumption pattern, but since the latter is non-stochastic, the mechanisms that give rise to risk premia are the same as those discussed in the previous section.

Kouri (1977) and Fama and Farber (1979) prefer to talk about the risk premium as arising from "inflation risk" rather than "exchange rate risk". This is not a very meaningful distinction, however, as they model economies where the law of one price (as well as purchasing power parity) holds. In this type of model exchange rates and prices do not change independently, and whether the risk involved should be labelled exchange risk or inflation risk is purely a matter of semantics.

Branson and Henderson (1985) allow both goods prices (or price levels) and exchange rates to be stochastic and given by exogenous, separate (but possibly correlated) Itô processes. Consequently, there are two different types of uncertainty, and the behavior of the nominal exchange rate does not completely determine that of the real exchange rate. This implies that the covariances between inflation and depreciation rates also affect portfolio choice, and, hence, the risk premium. In particular, a (foreign) asset that has a high exchange rate risk, i.e., that is denominated in a currency with a high variance, may nevertheless be valuable for a risk averse investor if it has a low inflation risk in the sense that the currency in question tends to appreciate when the inflation rates go up.[8]

The models of Frankel (1982) and Branson and Henderson (1985) are cast in the static mean-variance optimization framework, where the investor is assumed to maximize a function of the mean and the variance of end-of-period real wealth. However, mean-variance optimization, per se, is not crucial in this context. Merton (1973) demonstrates that given that the investment (and consumption) opportunities are constant across time (state independent), mean-variance and multi-period expected utility models give rise to the same type of asset pricing relations, and to conventional CAPM formulations. If, on the other hand, the assumption that asset prices follow Itô processes is abandoned, mean-variance optimization is not, in general, equivalent to multi-period utility maximization (cf. Merton (1971)).

To make the equivalence break down it is sufficient to introduce a stochastic (instantaneously) risk free interest rate in a multi-period model. This exposes the investor to a type of risk that is absent in the models discussed so far, which can be interpreted as term structure risk. For example, an increase in the risk free (one-period) interest rate leads to capital losses on fixed income securities, such as multi-period bonds.

Assume, for example, that there is a nominally risk free short term security with return r, and that there is a set of longer term securities yielding r_i ($i = 1,\ldots,n$). The latter returns are nominally safe if calculated over a certain interval t_o - t_i, but the instantaneous returns are stochastic and dependent on stochastic movements in r. The n+1 securities may be associated with different countries, as in Section 3.2.1, or may (for now) be viewed as different securities in a single

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8 Adler and Dumas (1983) discuss in greater detail the aggregation problems that emerge when there are many goods and the consequences for the asset pricing model.

(closed) economy. Let us, following Stulz (1982), consider the case of an extremely risk averse investor, who chooses his portfolio so that the maturity structure coincides exactly with some preferred (non-stochastic) consumption pattern. The investor's real wealth at any instant, evaluated at current goods and asset prices, will be stochastic and dependent on r. However, this variance of real wealth is of no consequence to his lifetime utility. This example serves to illustrate that end-of-period real wealth is imperfectly correlated with future consumption possibilities if the investment opportunity set is stochastic. As pointed out by Stulz (1982), the riskiness of an asset should be measured by its contribution to the variance of the optimal value J rather than to wealth.

The consequences of introducing a stochastic risk free rate are analyzed by Merton (1973). He shows that the required excess return on a given asset no longer can be expressed only in terms of its relation to the market portfolio as in (3.31), but must also be related to how it covaries with a portfolio that hedges against changes in the risk free rate. The investor will choose his optimal portfolio by obtaining a mix of three "mutual funds", namely, (i) the risk free asset, (ii) the market portfolio, and (iii) the portfolio that hedges against interest rate variability. This result is referred to as three-fund separation. In this case, there is only one state dependent variable that represents shifts in the investment opportunity set, but this result is easily generalized. For each additional state variable that is introduced a new source of risk is added, and an additional mutual fund, chosen so as to have the highest possible negative correlation with the state variable in question, will be included in the investor's portfolio. This leads to a "multi-beta" asset pricing model, where the excess return on any asset is related not only to its covariation with the market portfolio, but also to how it behaves relative to the N portfolios that hedge against changes in the N state variables that affect the investment opportunity set.

Breeden (1979) shows that Merton's multi-beta model can be converted into an equivalent single-beta model by exploiting the fact that in optimum the marginal utility of wealth equals the marginal utility of consumption (cf. (3.19)). This makes it possible to express the asset pricing relation in terms of just one parameter, namely, a "beta" that measures the covariance between the return on the asset and the change in the rate of consumption. Formally, assuming that there is just one good,

$$\mu_i - r = \beta_{iC} \left[\frac{\mu_M - r}{\beta_{MC}}\right], \qquad (3.32)$$

where

$$\beta_{iC} = \frac{\mathrm{cov}(\mu_i,\ d\ \ln C)}{\mathrm{var}(d\ \ln C)},$$

μ_i is the expected rate of return on security i; r is the rate of return on the riskless asset; C is the rate of consumption; μ_M measures the expected return on any portfolio (i.e., not necessarily the market portfolio); and β_{MC} is defined analogously to β_{iC}.

Breeden's model has a highly intuitive interpretation. From (3.32) we see that a risky asset in this framework is one that has a rate of return that is highly correlated with (the rate of) consumption. Under standard assumptions, the marginal utility of consumption is low in states where the level (or rate) of consumption is high. The mirror image of high consumption is that investment opportunities are unfavorable, or as expressed by Breeden (1979): "Always, when the value of an additional dollar payoff in a state is high, consumption is low in that state, and when the value of an additional investment is low, optimal consumption is high" (p. 278). Therefore investors/consumers are willing to pay a premium (require a lower rate of return) for an asset that has high payoffs in the low consumption (favorable investment) states. It should be noted that Breeden's analysis is not an alternative to Merton's in the sense that it offers some other explanation as to the fundamental determinants of relative asset returns. Consumption-CAPM does, however, have other implications for empirical work than single-beta and multi-beta CAPM's.

The basic intuition of the closed economy intertemporal asset pricing models of Merton (1973) and Breeden (1979) carries over to Stulz' (1981) extension to international asset pricing. Stulz considers a two-country multi-commodity world, where both investment and consumption opportunities differ between countries. The differences in opportunity sets are reflected in differences in the price indices which agents use to calculate expected real returns in different states, i.e., purchasing power parity is violated (e.g., due to the presence of nontraded goods). Specifically, the means, variances, and covariances of a set of assets depend on whether the investor resides in the "home" country or in the "foreign" country. This implies that there are non-trivial aggregation problems involved in deriving the equilibrium asset pricing relations.

Different types of aggregation problems emerge for different reasons. First, the existence of many goods raises the problem of defining some price index that can be used to calculate (expected) excess <u>real</u> returns and covariances between returns and the <u>real</u> rate of consumption. Breeden (1979) treats this problem thoroughly, and shows that two different price indices will generally, when preferences are non-homothetic, be required; one (based on marginal budget shares) for the calculation of excess returns, and another (based on average budget shares) for the calculation of the (real) consumption-betas. Second, there is the problem of aggregating asset demands of individuals who use different price indices when calculating their optimal portfolios. Third, the concept of risk aversion is not unambiguous in a multi-good model (cf.

LeRoy (1982)).

Ignoring the aggregation problems, we may specify the following general asset pricing equation (cf. Breeden (1979), pp. 287-288 and Stulz (1981), p. 396):

$$\mu_i - r - \sigma_{i,\pi} = \left[T^W/C\right]^{-1} \left[\sigma_{i,C} - \sigma_{i,\pi}\right], \qquad (3.33)$$

where T^W and C are measures of world risk tolerance and world consumption expenditures, respectively; $\sigma_{i,\pi}$ and $\sigma_{i,C}$ are the covariances of the return on asset i with the world rates of inflation and consumption, respectively. (Asset returns, inflation, and consumption have to be measured in a common currency, e.g., the U.S. dollar.)

Given the asset pricing equation in (3.33) it is straightforward to derive an expression for the foreign exchange risk premium. Let r_i be the return on a nominally riskless bond denominated in domestic currency, and let r be the return on a foreign bond denominated in, say, dollar. From the analysis in Section 3.2.1, we know that we can rewrite (3.33) as

$$r_i - \epsilon + \sigma^2 - r - \sigma_{i,\pi} = \left[T^W/C\right]^{-1}\left[\sigma_{i,C} - \sigma_{i,\pi}\right] \qquad (3.34)$$

where $\sigma^2(\epsilon)$ is the variance (mean) of the change in the spot exchange rate (units of domestic currency per dollar). If $\sigma_{i,C} > 0$, the dollar return on the domestic bond is positively correlated with consumption, which implies that the domestic currency appreciates in high-consumption states. This makes domestic bonds relatively risky, and their required return is correspondingly higher in relation to dollar bonds.

Consider a seller of forward domestic currency. His expected gain, in terms of dollar, equals the difference between the expected future spot rate and the forward rate, F. (Given F, a seller of domestic currency clearly profits from a depreciation.) If the covariance between the spot rate and consumption is high, so that the domestic currency depreciates in high-consumption states (i.e., if $\sigma_{i,C}$ is low), the return tends to be high when the additional income gives relatively little in terms of added utility. This implies that a short forward position is not a good hedge against consumption risk, and that the forward rate will be low for any given expected future level of the spot rate. In other words, the forward premium ($r_1 - r \approx \ln F - \ln S$) is negatively related to the covariance between S and C, and positively related to $\sigma_{i,C}$, which is consistent with (3.34).

Comparing (3.34) to the expression for the risk premium derived in the simple model (cf. (3.25)), we note the presence of $\sigma_{i,\pi}$. As discussed above in connection with Branson and Henderson (1985), when goods prices and exchange rates both are stochastic, the risk of a given asset depends also on its covariance with goods prices. For example, an asset that has a high return in high inflation states will be considered less risky.

Stulz (1981) emphasizes that in his model "a change in the supply of government bonds does not necessarily affect the risk premium incorporated in the forward exchange rate" (p. 400). While it is true that asset stocks are absent in (3.34), there is nothing in the model that precludes open market operations from influencing asset prices and risk premia. It seems inevitable that the stock of government bonds is one of the state variables in a model of this type.[9] However, the connection between asset supplies and risk premia will be considerably more complicated than in (3.25) where, at least formally, one can conceive of an open market operation as a

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9 This is indicated more clearly by Merton (1973) and Breeden (1979).

(comparative static) change in the vector of asset shares, x.[10] In the Merton-Breeden-Stulz models the processes generating asset returns are functions of the underlying state variables, implying that both expected rates of return and their variability are dependent on the state that is realized. This is a general feature of rational-expectations general equilibrium models. The Merton-Breeden-Stulz models do not, however, deal explicitly with the supply side of the economy, and thus cannot be viewed as complete general equilibrium models. (Although their partial analyses, as stressed by Breeden (1979), may be fully consistent with general equilibrium.) Analysis of the effects of open market operations requires a more detailed specification of, in particular, the supply side of the model, and of the stochastic processes of the underlying state variables.

One step in this direction is taken by Stulz (1984). He develops a consumption CAPM model where the exchange rate is endogenously determined. In order to handle this extension, he assumes that there is only one good, which of course reintroduces purchasing power parity. Stulz shows that the exchange rate depends positively on the domestic money stock and interest rate and negatively on the corresponding foreign variables. He therefore interprets his model as a monetary approach model derived in an optimizing framework. Contrary to his earlier model, but in line with Kouri (1977), Stulz (1984) gives an explicit role to money by assuming that money is an argument in the investor's utility function.

Just as in Stulz (1981), the forward premium is a decreasing function of the covariance between the exchange rate and consumption. The endogeneity of the spot rate means that it is possible to go one step further and express this covariance in terms of the more fundamental variables, in particular, the money supply processes. For example, an increase in the covariance between the domestic money supply and consumption

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[10] Kouri (1977) performs some experiments of this type.

lowers $\sigma_{i,C}$ and, hence, lowers the forward premium by making a short forward position less risky for the reasons discussed in the example above.

Stulz' (1984) model is still not a complete general equilibrium model, since the goods market is not analyzed explicitly. The determination of the foreign exchange risk premium in a full general equilibrium setting is analyzed by Hodrick and Srivastava (1984, 1986). They use Lucas' (1982) dynamic (discrete time) general equilibrium model of international asset pricing, where exogenous stochastic processes determine the paths for output and money supplies. Goods and asset prices are thus endogenous functions of these "fundamental" stochastic variables. Money is introduced in this model by imposing a cash-in-advance constraint, i.e., by requiring that a means-of-exchange is used in all goods transactions.[11]

The world consists of two countries with agents that have identical preferences but are endowed with two different consumption goods in period t. Agents in the home country are endowed with x_t units of good x and nothing of good y, whereas in the foreign country agents receive y_t units of good y. These endowments follow known, stochastic Markov processes.

The nominal uncertainty in the model derives from changes in the money supplies in the two countries. They are also assumed to follow known exogenous Markov processes, where the growth rates may also depend on the real state of the world, i.e., the

[11] The assumptions concerning the sequence of transactions in each period are important for the properties of models of this type. In Lucas (1982), no uncertainty remains when the financial markets open which means that the cash constraint is always exactly binding. Svensson (1985) modifies the Lucas model by assuming that agents have to decide on their money holdings before the state of the world is revealed which leads to a more general money demand function. Olofsson (1985) uses Svensson's version of the model to study the foreign exchange risk premium. As the results with regard to the premium are highly similar, we will only discuss the Lucas model as presented by Hodrick and Srivastava (1984).

realization of the output process.

The representative agent in each country maximizes a standard expected utility function

$$E_t \left\{ \sum_{t=0}^{\infty} \beta^t U\left[x_{it}, y_{it}\right] \right\}, \qquad 0 < \beta < 1 \tag{3.35}$$

where x_{it} and y_{it} are the quantities consumed by agent i, and β is a constant discount factor.

It is assumed that the home good x can be bought only with home currency and since no uncertainty remains when goods and asset markets open, the nominal price of good x is simply

$$p_{xt} = \frac{M_t}{x_t}, \tag{3.36}$$

where M_t is the supply of domestic money. Similarly, if N_t is the supply of foreign money, the nominal price of good y is

$$p_{yt} = \frac{N_t}{y_t}. \tag{3.37}$$

Under these assumptions, the spot exchange rate can be determined by the arbitrage condition

$$S_t = \frac{p_{x,t}}{p_{y,t}} \cdot q_t = \frac{M_t\ y_t}{N_t\ x_t} \cdot q_t, \tag{3.38}$$

where q_t is the relative price of good y in terms of good x.

Equation (3.38) thus implies (as expected) that an increase in the domestic money supply M_t raises S_t, i.e., leads to a depreciation of the home currency.

Next, we must determine the forward exchange rate. Denoting the home and foreign one-period interests rates by $r_{x,t}$ and $r_{y,t}$, respectively, covered interest parity implies

$$1 + r_{x,t} = (1 + r_{y,t}) \frac{F_t}{S_t}. \tag{3.39}$$

By definition, the gross return on an asset paying one unit of home currency at t+1 is the inverse of the price at time t of that asset, or $1/b_{x,t}$. Hence, (3.39) becomes

$$F_t = S_t \cdot \frac{b_{y,t}}{b_{x,t}}. \tag{3.40}$$

However, the asset prices are endogenously determined. In general, the equilibrium price of any asset in this framework is "such that the marginal utility foregone by purchasing the asset is equal to the conditional expectation of the marginal utility of the return from holding the asset" (Hodrick and Srivastava (1984, p. 8)).

Let us consider a discount bond paying one unit of home currency at t+1. The expected (discounted) marginal utility of one unit of M is given by the amount of good x it is expected to buy, evaluated by the agents at the marginal utility of good x at t+1 (since M cannot be used to buy good y), or, formally,

$$E_t\left[\beta\ U_{x,t+1} \cdot \frac{1}{p_{x,t+1}}\right].$$

In order to get this expected payoff, the agent has to pay $b_{x,t}$ which in terms of current marginal utility foregone is worth

$$b_{x,t}\ U_{x,t} \cdot \frac{1}{p_{x,t}}.$$

Equality between these two expressions implies that the asset price must be

$$b_{x,t} = E_t \left[\frac{\beta U_{x,t+1}}{P_{x,t+1}} \bigg/ \frac{U_{x,t}}{P_{x,t}}\right] \equiv E_t\left[Q^M_{t+1}\right]. \qquad (3.41)$$

The price of a one-period security in home currency is thus equal to the conditional expectation of the intertemporal marginal rate of substitution of the home currency which Hodrick and Srivastava (1984) denote $E_t(Q^M_{t+1})$, for brevity. Q^M_{t+1} can be interpreted as a measure in utility terms of the change in the purchasing power of the home currency.

Obviously, a similar expression holds for the foreign currency denominated asset and (3.40) can be rewritten as

$$F_t = S_t \cdot \frac{E_t(Q^N_{t+1})}{E_t(Q^M_{t+1})} . \qquad (3.42)$$

While demonstrating that the forward premium is determined by both real and monetary uncertainty interacting with the preferences of the representative agents, (3.42) has no readily intuitive interpretation. To get an explicit solution for the risk premium one has to specify the structure of preferences as well as of the exogenous stochastic processes.

Domowitz and Hakkio (1985) provide an example where the forward premium depends on the expected rate of depreciation of the spot exchange rate plus a term which is proportional to the variances of the money stocks but independent of consumer preferences. They choose to label the second term a <u>risk</u> premium, a definition that is questionable given that this term is due solely to Jensen's inequality and has nothing to do with the investor's degree of risk aversion. Analogous expressions thus appear also in the partial models discussed above even under assumptions of risk neutrality (see, e.g., equation (3.25)).

To our knowledge, the paper by Domowitz and Hakkio (1985) is the only attempt to parameterize Lucas' (1982) model (while maintaining the two-good structure) in a study of the foreign exchange risk premium. The general equilibrium model offers insights into the nature of the risk premium, but the theoretical framework is in some respects too general and in others too specific to offer any guidance for empirical research, let alone policy analysis.

3.2.3 Implications

One way to look at our review is to interpret it as an investigation of the micro foundations of the traditional portfolio balance models. A simple example shows that the static portfolio-balance model and intertemporal utility-maximization approaches need not be inconsistent. Consider an open market operation by the domestic central bank which involves a sale of domestic securities. The portfolio balance model suggests that the domestic interest rate goes up, which - at given exchange rate expectations and foreign interest rates - implies that the foreign exchange risk premium also rises. Since private investors must reduce their holdings of (increase their debt in) foreign-currency denominated assets, they become more exposed in case the domestic currency should depreciate. To accept this situation, they require a (higher) premium on domestic relative to foreign assets.

However, an important result in intertemporal asset pricing models is that risk premia are complicated functions of the covariance structure of the fundamental stochastic processes. The riskiness of a position in domestic or foreign currency depends on the variances and covariances of, e.g., inflation and exchange rates, or - more generally - of asset prices and consumption. The effects of an open market operation thus depend on whether it changes private agents' perceptions about the stochastic structure of the economy. The simple and highly intuitive direct effect from open market operations on the risk premium may be weakened or strengthened by any indirect effects on expectations. The central bank's asset holdings may be considered state variables which change stochastically over time, and affect the dynamic processes of asset prices and exchange rates in general equilibrium. Rational agents can therefore be expected to revise their expectations in response to policy actions. This qualification to the results derived in static and/or partial portfolio balance models strongly parallels the well-known critique of the use of reduced-form Phillips curves for policy analysis.

The asset pricing models furthermore suggest that certain restrictions on the parameters of asset demand functions should (or should not) be imposed. In particular, the demand for nominally safe domestic and foreign-currency securities should depend on the expected <u>difference</u> between the returns on these two types of assets and not on the levels of returns. On the other hand, the assumption of gross substitutability, which is often imposed in portfolio balance models, has no strong theoretical justification. When asset demands are explicitly derived from purposeful behavior one is also forced to be explicit about if, why, and how national currencies are valued. For a more detailed discussion of these issues, see Branson and Henderson (1985).

In the introduction to this chapter we stated that a non-zero risk premium is necessary for monetary autonomy. Theoretical analyses suggest that risk premia will be non-zero if there is some variance in exchange rates, and if investors are not risk neutral. If risk neutrality can be ruled out on a priori grounds, exchange rate variability thus becomes a sufficient condition for monetary autonomy. At the same time, monetary autonomy has been defined as the possibility to affect the domestic interest rate <u>given</u> a specific level of the exchange rate. In other words, even if monetary authorities would prefer to keep exchange rates basically fixed, and consider this to be an important ingredient in (or a constraint on) an independent monetary policy, they have to create some uncertainty about the future level of the exchange rate in order for monetary policies to be effective.

Not only does the optimal exchange rate policy depend on the degree of international asset substitutability, as argued by, e.g., Henderson (1984), but asset substitutability is also a function of the design of exchange rate policy. One question that immediately arises is whether the benefits of autonomy exceed the costs of the induced uncertainty. Although normative issues are not discussed in this chapter, the distinction between what possibly can be done (by creating uncertainty) and what should be done (i.e., what the optimal degree of uncertainty is) is important.

Although the theoretical models reviewed obviously leave some important questions unanswered, they offer some guidelines for empirical research. In the models based on the conventional CAPM formulation, there is a direct connection between asset stocks and the size of the risk premium, and this connection should be possible to verify (or reject) in empirical studies. In more general formulations of asset pricing models, such as the consumption-CAPM, the size of the risk premium is more directly related to real consumption than to asset stocks.

3.3 EMPIRICAL WORK

The theoretical analyses of, e.g., Merton (1971, 1973), Lucas (1978), and Breeden (1979) have inspired many researchers to study the actual co-movements of asset returns and consumption. For example, Grossman and Shiller (1981) argue that the variability of U.S. stock prices is not consistent with risk neutrality, given the variability of U.S. consumption. Also referring to U.S. data, Grossman, Melino, and Shiller (1985) report that stock yields have higher average real return and higher covariance with consumption than other financial assets.

At an informal level, therefore, data on asset returns seem to be consistent with optimizing (consumption-smoothing) behavior by risk averse investors, and with theoretical asset pricing models. However, when Hansen and Singleton (1983) attempt to estimate the (constant) relative risk aversion of a representative (American) investor, they arrive at plausible but very imprecise point estimates. The overidentifying restrictions derived from specific assumptions about properties of preferences and stochastic processes are rejected. Similar results are reported by Grossman, Melino, and Shiller (1985).[12]

Given these results obtained in closed economy settings, it is perhaps not surprising that the overwhelming part of empirical studies on foreign exchange risk premia have followed a non-structural, or atheoretical, approach. That is, there are numerous studies investigating the existence of risk premia, while there are relatively few attempts to explain these premia in terms of empirical regularities in fundamental variables. We will review the results from some atheoretical tests in Section 3.3.1, while some tests based on structural asset pricing models are summarized in Section 3.3.2. A comprehensive survey of the empirical literature is offered by Boothe and Longworth (1986).

3.3.1 Atheoretical tests

The most common way to test for the existence of a risk premium is to examine whether forward exchange rates are unbiased predictors of future spot exchange rates. Under the maintained hypothesis of CIP, this unbiasedness test is equivalent to a test for UIP (cf. (3.1)-(3.3)). The null hypothesis of no risk premium corresponds to the hypothesis that $[\alpha_1, \beta_1] = [0, 1]$ in

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[12] Hansen and Singleton (1982) propose an instrumental variables technique which is shown to yield smaller standard errors than the maximum likelihood procedure applied by Hansen and Singleton (1983). Mankiw, Rotemberg, and Summers (1985) apply this technique in a study of U.S. data, but the overidentifying restrictions implied by intertemporal utility maximization are rejected.

the regression model

$$s_{t+1} - s_t = \alpha_1 + \beta_1\left[f_t - s_t\right] + \epsilon_{t+1}, \tag{3.43}$$

where s and f are the logarithms of the spot and forward rates, respectively. Under the joint hypothesis of no risk premium and rational expectations, ϵ_{t+1} is the innovation in (i.e., the unforecastable part of) the exchange rate, and $[\alpha_1, \beta_1]$ can be estimated by OLS.[13] In most cases, studies based on (3.43) have rejected unbiasedness; see, e.g., Cumby and Obstfeld (1984) and Fama (1984) for test results and further references.

It is interesting to go beyond this finding and inquire into the properties of the implied risk premium. Fama (1984) notes that the deviation of β_1 from unity is "a direct measure of the variation in the premium in the forward rate" (p. 321). Using (3.2) we can write the forward premium, $f_t - s_t$, as the sum of two components, namely, the expected rate of depreciation and the risk premium:

$$f_t - s_t = E\left[s_{t+1} - s_t\right] + p_t. \tag{3.44}$$

This implies that, under rational expectations, the regression coefficient β_1 can be expressed as

$$\beta_1 = \frac{\mathrm{cov}(s_{t+1}-s_t, f_t-s_t)}{\sigma^2(f_t-s_t)} =$$

$$= \frac{\sigma^2[E(s_{t+1}-s_t)] + \mathrm{cov}[p_t, E(s_{t+1}-s_t)]}{\sigma^2(p_t) + \sigma^2[E(s_{t+1}-s_t)] + 2\,\mathrm{cov}[p_t, E(s_{t+1}-s_t)]}. \tag{3.45}$$

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13 The use of logarithms is usually motivated as a way to circumvent the problems created by Jensen's inequality. The specification in terms of differences is used to avoid statistical problems caused by possibly non-stationary data. See Hansen and Hodrick (1980), Engel (1984), Meese and Singleton (1982), and Cumby and Obstfeld (1984) for discussions of these issues.

If there is zero covariance between the risk premium and the expected rate of depreciation, β_1 measures the proportion of the variance that can be attributed to $\sigma^2[E(s_{t+1} - s_t)]$. Hence, $1 - \beta_1$ is the fraction that is due to the variance in the risk premium.

However, it cannot be ruled out that the risk premium and the expected rate of depreciation are correlated and in Fama's study there is actually evidence of such a correlation. Using spot and forward dollar exchange rates for nine currencies, Fama consistently gets negative values for β_1. From (3.45) this is seen to imply that

$$cov[p_t, E(s_{t+1} - s_t)] < 0 \qquad (3.46)$$

and

$$\sigma^2[E(s_{t+1} - s_t)] < |cov[p_t, E(s_{t+1} - s_t)]|. \qquad (3.47)$$

Moreover, $\beta_1 < 0$ implies that

$$1 - \beta_1 = \frac{\sigma^2(p_t) + cov[p_t, E(s_{t+1}-s_t)]}{\sigma^2(f_t - s_t)} > 1, \qquad (3.48)$$

and, the denominator being positive, we see that

$$\sigma^2(p_t) > |cov[p_t, E(s_{t+1} - s_t)]|. \qquad (3.49)$$

Hence, it must hold that

$$\sigma^2(p_t) > \sigma^2[E(s_{t+1} - s_t)], \qquad (3.50)$$

i.e., the variance in the risk premium exceeds the variance in the expected rate of depreciation. Fama's (1984) results thus indicate that time varying risk premia exist and he can also say something about their properties. Risk premia seem to have higher variance than, and to be negatively correlated with, changes in exchange rates.[14]

Let us briefly discuss some econometric problems involved when interpreting regression equations like (3.43). Suppose that the null hypothesis $[\alpha_1, \beta_1] = [0, 1]$ cannot be rejected, or that at least β_1 is not significantly different from unity. As stressed by Gregory and McCurdy (1984, 1986), one should nevertheless not be led to conclude that there is no evidence of a time-varying risk premium, unless the regression equation shows no signs of parameter instability, autocorrelated residuals, etc.[15] Only when the regression does not lead to a rejection of the null <u>and</u> passes the diagnostic tests the result is fully consistent with unbiasedness. Such findings have been reported by Gregory and McCurdy (1984, 1986) in the cases of the U.S./Canadian dollar rate (1976-1980), and the U.S. dollar in relation to the Italian lira (1978-1981), the Japanese yen (1978-1981), and the German mark (1974-1977).

Suppose, on the other hand, that the null hypothesis of unbiasedness is rejected (as in, e.g., Fama's (1984) paper). Diagnostic tests are still called for, insofar as one wishes to give the regression coefficient(s) a specific interpretation. As pointed out by Hodrick and Srivastava (1986), the coefficients estimated by Fama (1984) may be biased under the alternative hypothesis of a time-varying risk premium, due to residual autocorrelation. They conjecture, however, that the

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14 Hodrick and Srivastava (1986) show that these empirical findings are consistent with intertemporal general equilibrium theory.

15 Note that the unbiasedness hypothesis does not imply that residuals should be homoskedastic (even if non-overlapping data are used); but if they are not, standard errors will not be consistently estimated by OLS. For applications of techniques which yield consistent estimators even in the presence of heteroskedasticity, see Cumby and Obstfeld (1984) and Hodrick and Srivastava (1984).

bias is small, since any autocorrelation in the risk premium is likely to be dominated by the variance of exchange rate innovations. Hodrick and Srivastava present and make use of techniques which allow for autocorrelated residuals, and their results confirm Fama's earlier findings.

The regression model (3.43) is a natural formulation of a test for unbiasedness and it gives some interesting insights into the behavior of risk premia. However, in order to obtain absolute measures of the implied premia, other techniques must be applied. Wolff (1987) presents one such approach, which he describes as complementary to the regular regression model. He uses a signal-extraction technique known as the Kalman filter to identify the time-series properties of the spot exchange rate, which enables him to derive a direct estimate of the expectations and risk premium components of the forward premium. Wolff finds that the premium in the dollar/pound exchange rate can be modelled as an AR(1) process, whereas the dollar/mark and dollar/yen premia follow MA(1) processes. Just like Fama (1984), he concludes that the variations in the premia are significant. They account for more than half of the variance in the deviations between forward and realized spot rates. The estimated premia also show considerable variability over time. Moreover, the risk premium on a given currency can vary between positive and negative over time.

Wolff's (1987) study must be labelled atheoretical as there is no attempt to explain the particular time-series patterns that emerge. However, it gives support to the conclusion from Fama's (1984) regression tests that time-varying risk premia are an important element in the forecast errors that are made when forward rates are used to predict future spot rates.

Korajczyk (1985) can be said to take the finding that there are deviations from unbiasedness as his starting point. He points out that intertemporal general equilibrium asset pricing models imply that "the risk premia in forward prices should be identical to the risk premia differential in the real returns on default-free nominal bonds denominated in the respective currencies" (p. 347). Korajczyk thus tests the hypothesis that the deviations from unbiasedness can be accounted for by estimated differences in expected real returns. It is well known that UIP and PPP (purchasing power parity) jointly imply real interest rate parity (see, e.g., Cumby and Obstfeld (1984)). References to formal asset pricing models are not necessary to motivate this relation. Under the maintained hypotheses of CIP and relative ex ante PPP, Korajczyk (1985) attributes risk premia to deviations from real interest rate parity.

Using a 3SLS procedure where the first step is used to estimate the unobservable expected real interest rate differential from a set of instrumental variables, Korajczyk cannot reject the null hypothesis that risk premia are the cause of deviations from unbiasedness. This result means that the data are consistent with CIP, PPP, and the implicit model of real interest rate differentials, but the tests do not really give any evidence on the common determinants of the co-movements in risk premia and interest rate differentials. In this sense, Korajczyk's study must also be classified as atheoretical. His results are consistent with the hypothesis that risk premia exist, but in order to study their determinants structural asset pricing models must be specified and tested.[16]

3.3.2 Tests of structural asset pricing models

Probably the most direct test of an asset pricing model is made by Frankel (1982). He develops an expression for the risk premium using an international portfolio balance model derived from mean-variance optimization. The representative investor is assumed to maximize a function of the mean and the variance of

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[16] An important contribution in Korajczyk's (1985) work is the calculation of sample distributions for test statistics which do not rely on normality assumptions.

his end-of-period real wealth (evaluated in U.S. dollars). With the dollar as the reference currency, the investor chooses a vector x_t of portfolio shares allocated to n other assets denominated in different currencies. The only uncertainty in the model relates to exchange rate changes. However, the investor is assumed to pay for goods from a given country with the currency of that country, which means that the real value of his portfolio depends also on the composition of his consumption basket, summarized by the vector α of consumption shares allocated to goods produced in the n foreign countries. The consumption pattern is exogenous and assumed to be constant over time.

Under the circumstances given in Frankel's model, end-of-period wealth is a "sufficient statistic" for future consumption possibilities (cf. Stulz (1982)). Except for the presence of several goods, which are consumed in fixed proportions, the static mean-variance model is basically equivalent to the simple intertemporal model discussed in Section 3.2.1. Solving the optimization problem gives the following asset demand equations:

$$x_t = \alpha + (\rho\Omega)^{-1}\left[r_t - \iota r_t^{\$} - E\left[s_{t+1} - s_t\right]\right]. \qquad (3.51)$$

Here x_t is a $(n\times1)$ vector of portfolio shares; s_t is a $(n\times1)$ vector of (logs of) dollar exchange rates (DM/\$, etc.); r_t is a $(n\times1)$ vector of nominal non-dollar interest rates, while the dollar interest rate is denoted $r_t^{\$}$; Ω is the variance-covariance matrix of exchange rate changes; ι is a vector of n ones; and ρ is the coefficient of relative risk aversion. ρ is assumed to be constant, which implies that the underlying utility function is assumed to be isoelastic. α, the $(n\times1)$ vector of consumption shares, also represents the minimum-variance portfolio that an extremely risk averse investor would hold. The second term in (3.51) can be referred to as the "speculative portfolio". Assuming asset supplies to be exogenously fixed, (3.51) can be interpreted as an equilibrium condition which we can invert to get an expression for the deviation from UIP:

$$r_t - \iota r_t^{\$} - E\left[s_{t+1} - s_t\right] = \rho\Omega\left[x_t - \alpha\right]. \tag{3.52}$$

To adapt the model to econometric estimation Frankel invokes rational expectations, i.e.,

$$E(s_{t+1}) = s_{t+1} + \epsilon_{t+1}, \tag{3.53}$$

where ϵ_{t+1} is the error in the exchange rate forecast. Under rational expectations, it is independent of all information available at time t. Combining (3.52) and (3.53) gives the regression model

$$r_t - \iota r_t^{\$} - \left[s_{t+1} - s_t\right] = \rho\Omega\left[x_t - \alpha\right] + \epsilon_{t+1} \tag{3.54}$$

Frankel emphasizes that "Ω is precisely the variance-covariance matrix of the error term, and the system should be estimated subject to this constraint" (p. 260). Applying maximum likelihood techniques, he estimates the crucial parameter ρ simultaneously with Ω.

This test requires data on interest rates and exchange rates for the L.H.S. variables and observations on x_t and α. Recalling that these are the vector of asset shares in the world market portfolio and the vector of consumption shares, respectively, it is obvious that Frankel encounters considerable measurement problems.

When (3.54) is estimated using a maximum likelihood procedure, it turns out that the likelihood function is extremely flat, but that its maximum is at ρ=0. The hypothesis of risk neutrality can therefore not be rejected. However, the evidence is not very strong and the test gives no basis for asserting the null hypothesis $\rho=0$ as Frankel, e.g., cannot reject $\rho=1$ or $\rho=2$ either. The power of the test is therefore quite low, a feature which Frankel's analysis shares with the closed-economy applications referred to above.

It should be noted that Frankel (1982) assumes CIP to hold and uses forward premia instead of interest rate differentials when computing the dependent variable. The regression equation is thus respecified as

$$f_t - s_{t+1} = \rho\Omega\left[x_t - \alpha\right] + \epsilon_{t+1}, \tag{3.55}$$

where f_t is a vector of forward dollar exchange rates.

This approach is also followed by Park (1984), who presents a two-country version of Frankel's test. In a world of only two currencies, (3.55) is reduced to

$$f_t - s_{t+1} = \rho\sigma^2\left[x_t - \alpha\right] + \epsilon_{t+1}, \tag{3.56}$$

where (f, s, x, α) are now scalars, σ^2 is the variance of the exchange rate, and $\sigma^2 = \sigma_\epsilon^2$. Park (1984) allows for variable consumption shares, and specifies his model as

$$s_{t+1} = c_o + c_1 f_t + c_2\left[x_t - \alpha_t\right] + \eta_{t+1}, \tag{3.57}$$

and tests the null hypothesis $c_2 = 0$ against $c_2 < 0$. There are several differences between this test and Frankel's. First, Park imposes less structure on his model by not acknowledging the theoretical constraint that $c_2 = -\rho\sigma^2$. Second, Park allows $[c_o, c_1]$ to differ from [0, 1]. An interesting question then is: what conclusion should be drawn if it turns out that one can reject neither that $c_2 = 0$ (which is consistent with UIP) nor that $c_1 \neq 1$ (which is an indication of biasedness in the forward exchange rate)?

Given an estimate of c_o not significantly different from zero, the conclusions from different estimates of $[c_1, c_2]$ are summarized in the table below.

	$c_1 = 1$ Not rejected	$c_1 = 1$ Rejected
$c_2 = 0$ Not rejected	. Consistent with UIP	. Not consistent with UIP . Wrong model of the risk premium
$c_2 < 0$ Not rejected	. Not consistent with UIP . Correct model of the risk premium	. Not consistent with UIP . Insufficient model of the risk premium

The only result that is consistent with UIP is if it cannot be rejected that $[c_1, c_2] = [1, 0]$. While Frankel (1982) is unable to reject that $c_2 = 0$, he cannot say anything about the value of c_1. Therefore it cannot be ruled out that his failure to reject UIP is due to use of an incorrect model of the risk premium.

Park (1984) reaches a conclusion different from that of Frankel. Using U.S. dollar/D-mark rates, Park obtains estimates of c_2 that are negative, which is consistent with positive risk aversion. In quarterly exchange rates, the adjusted market portfolio $(x_t-\alpha_t)$ explains 10-20 percent of the total variance. The proportion is somewhat smaller for monthly data. Park concludes that "[t]he tests provide firm evidence for a risk premium in the foreign exchange market" (p. 175). Park makes no joint test of $[c_1, c_2]$, however. In fact, in quarterly data c_1 is significantly less than unity. It can therefore be questioned whether Park offers a sufficient explanation of the risk premium.

It is illuminating to relate Park's model to the time-series test used by, e.g., Fama (1984). Park estimates a model where the dependent variable might be non-stationary and his hypothesis tests should therefore be interpreted with caution. A more appropriate formulation than (3.57) is therefore

$$s_{t+1} - s_t = c_o + c_1\left[f_t - s_t\right] + c_2\left[x_t - \alpha_t\right] + \eta_{t+1}, \quad (3.58)$$

which is equivalent to (3.57) under the null hypothesis of UIP, $[c_o, c_1, c_2] = [0, 1, 0]$.

Comparing (3.58) to Fama's regression model, repeated here for convenience,

$$s_{t+1} - s_t = \alpha_1 + \beta_1\left[f_t - s_t\right] + \epsilon_{t+1}, \quad (3.43)$$

we see immediately that the essence of Park's test is therefore to try to decompose Fama's residual term into a systematic risk premium and a random component. Analogously, Frankel (1982), by assuming $c_1=1$, tries to find a systematic component in the deviations between the realized spot rate and the forward rate.

Frankel and Park rely on a mean-variance asset pricing model where the risk premium is shown to depend on variables that are, at least in principle, observable. Domowitz and Hakkio (1985) base their theoretical and empirical analysis on Hodrick and Srivastava's (1984) extension of Lucas' (1982) intertemporal general equilibrium model. As discussed in Section 3.2.2, they construct an example where the bias in the forward rate as a predictor of the future spot rate is proportional to the difference between the variances in the money supply processes in the two countries.[17] However, instead

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[17] The question whether this can be appropriately defined as a risk premium in their particular example was discussed in Section 3.2.2.

of relating the risk premium to the conditional variances in a set of exogenous variables, they assume that it depends directly on the forecast errors in previous periods. In our notation, the regression estimated by Domowitz and Hakkio can be written as

$$s_{t+1} - s_t = \beta_o + \beta_1\left[f_t - s_t\right] + \theta h^2_{t+1} + \epsilon_{t+1}, \qquad (3.59)$$

where h^2_{t+1}, the time-varying component of the risk premium, is a function of lagged forecast errors, ϵ^2_t. In essence, this is thus the test for unbiasedness (3.43) augmented by a proxy for the risk premium.

The empirical results from estimating (3.59) using maximum likelihood techniques are mixed. Domowitz and Hakkio study five dollar exchange rates and in no case can the hypothesis $\theta = 0$ be rejected. In a joint test of $\beta_o = \theta = 0$ and $\beta_1 = 1$, the null hypothesis is rejected for two out of five currencies. There is thus some evidence of a bias, but the specific assumption that the risk premium (or the bias) is systematically related to lagged forecast errors does not gain much support.

Hodrick and Srivastava (1984) derive testable cross-equation constraints from a conventional capital asset pricing model. Their starting point is the following relation,

$$E\left[\frac{S^i_{t+1} - F^i_t}{S^i_t}\right] = \beta^i_t \cdot y_t, \qquad i=1....,n. \qquad (3.60)$$

$(S^i_{t+1} - F^i_t)/S^i_t$ is the excess of the relative return of an uncovered position in currency i over that of a covered position, y_t is the expected difference between the return of a benchmark asset and a nominal risk-free return, and β^i_t is the standard CAPM-β, i.e., the covariance between $(S^i_{t+1} - F^i_t)/S^i_t$

and the return on the benchmark asset, divided by the variance of the latter. It is assumed that the β^i's are constant.

As demonstrated in Section 3.2.1, such a CAPM relation can be derived in a simple intertemporal model where asset returns, exchange rates, etc. follow state-independent stochastic Itô processes. It also follows from a static mean-variance approach (cf. Branson and Henderson (1985)). Hodrick and Srivastava (1984) choose to interpret (3.60) as "perfectly consistent" with Lucas (1982) general equilibrium model. This is a somewhat misleading interpretation, since the simple CAPM relations break down when one goes to more general, equilibrium treatments (where, e.g., asset returns and exchange rate processes are state-dependent). The difference between the study by Hodrick and Srivastava (1984) and those based on structural equations derived from mean-variance optimization therefore lies more in the empirical work than in the theoretical underpinnings.

Instead of defining a benchmark asset (or portfolio) and compute its rate of return relative to the riskfree rate in order to obtain a direct measure of y_t, which would be analogous to Frankel's (1982) approach, Hodrick and Srivastava treat y_t as an unobservable variable. Being unknown to the econometrician, y_t must be replaced by the best linear predictor based on a subset of available information, using instrumental variables. Specifically, Hodrick and Srivastava assume that

$$y_t = \gamma_o + \sum_i \gamma_1^i \left[\frac{F_t^i - S_t^i}{S_t^i}\right] + \eta_t, \qquad (3.61)$$

i.e., the forward premia on all the currencies in the sample are used as instruments. Using (3.61), the following system of n regression equations is obtained:

$$\frac{S^j_{t+1} - F^j_t}{S^j_t} = \beta^j\gamma_o + \beta^j \sum_i \gamma^i_1 \left[\frac{F^i_t - S^i_t}{S^i_t}\right] + \nu^j_{t+1}, \quad j=1,..,n, \quad (3.62)$$

$$\nu^j_{t+1} = \beta^j\eta_t + \phi^j_{t+1}, \quad (3.63\ a)$$

$$\phi^j_{t+1} = E\left[\frac{S^j_{t+1} - F^j_t}{S^j_t}\right] - \frac{S^j_{t+1} - F^j_t}{S^j_t} . \quad (3.63\ b)$$

The cross-equation constraints in (3.62) enable them to recover separate estimates of the β's and γ's.

Hodrick and Srivastava (1984) get significant estimates of the β^i's, and for two out of five currencies (the Swiss Franc and the Japanese Yen vs. the U.S. dollar) they can reject the hypothesis that the composite parameters $\hat{\theta}_{ij} = \hat{\beta}^j\hat{\gamma}^i_1$ are all zero, which would seem to give some support to their particular CAPM model of a time-varying risk premium. However, the cross-equations constraints imposed by the model are rejected at the five percent level. Hodrick and Srivastava (1984) conclude: "If the source of the rejection of the unbiasedness hypothesis is a time-varying risk premium, it appears that the assumptions of the [Hansen and Hodrick (1983)] model are too strong. Either the β's ... are not constant, or some other model of risk and return is necessary to describe the risk premium" (p. 15). Recall that the intertemporal asset pricing models do not offer any grounds for assuming that the β's are constant. As noted by Hodrick and Srivastava, this hypothesis is strictly empirical, and it turns out to be rejected.

Note the formal similarity between (3.62) and the test equation used by Fama (1984). The dependent variables in (3.43) and (3.62) are different, but this is purely a matter of convenience. Under unbiasedness (β_1 = 1 in (3.43)) we would expect $\hat{\theta}_{ii}$ = 0. Examining the results from Hodrick and

Srivastava's (1984) estimates of the unconstrained model, we find that the $\hat{\theta}_{ii}$'s are negative in four out of five cases and significantly so in three. The pattern is thus the same as in Fama (1984) although less uniform.

Mark (1985) also takes the intertemporal asset pricing model as his point of departure. The theoretical framework is a parameterized one-good version of the Lucas (1982) model. Using a utility function exhibiting constant relative risk aversion, denoted by γ, he shows that optimal investor behavior implies

$$E\left[c_{t+1}^{\gamma}\ \pi_{t+1}\left(s_{t+1}^{j} - f_{t}^{j}\right)|I_t\right] = 0, \quad \forall j, \tag{3.64}$$

where c_{t+1} is the rate of consumption, π_{t+1} the rate of inflation (in the domestic country), and I_t denotes the information set at time t. Applying the generalized instrumental variables technique suggested by Hansen and Singleton (1982), Mark uses condition (3.64) to estimate γ, the degree of risk aversion of the representative investor.

Using U.S. consumption data and four dollar exchange rates, Mark (1985) obtains very imprecise estimates of the degree of risk aversion. Despite different theoretical motivations and empirical procedures, his results are thus similar to Frankel's (1982). Mark can also test the validity of his model with the help of overidentifying restrictions. Here the results are mixed, partly depending on the choice of instrumental variables, but in two out of the twelve reported specifications, the model can be rejected at the 5 percent level. The evidence against the underlying asset pricing model is thus not as strong as in Hodrick and Srivastava (1984). However, given the general imprecision in the coefficient estimates, Mark's results cannot be said to offer much support for the particular constant relative risk aversion model that is tested. One possibility is of course that this parameterization is too restrictive, but more general specifications of utility functions might prove difficult to use in empirical work. These problems are not unique to international asset pricing, of course, and, in fact, Mark's results are quite similar to those obtained in similar tests of closed economy asset pricing models; see, e.g., Grossman, Melino, and Shiller (1985).

3.4 CONCLUDING COMMENTS

Static portfolio balance models usually rely on an assumption about imperfect substitutability between, e.g., assets denominated in different currencies. The degree of substitutability is crucial for the question of monetary autonomy, and imperfect substitutability should be reflected in foreign exchange risk premia. This has been our motivation for reviewing the theoretical and empirical literature on risk premia.

While there is a direct relation between asset stocks and risk premia, or interest rate differentials, in traditional portfolio balance models, intertemporal asset pricing models suggest that risk premia are complicated functions of the stochastic structure of the economy. Theory leads us to expect that relative asset prices may be more directly related to consumption than to asset stocks.

While there is a good understanding of the general nature of risk premia, based on theoretical developments, the empirical results are inconclusive. When attempts have been made to relate differences in asset returns to economic variables on which risk premia according to asset pricing theory should depend, the results have been rather negative. The inconclusiveness is characteristic of closed-economy applications as well as applications to international asset prices, and of tests using data on asset stocks as well as tests on consumption data.

On the other hand, there are several studies that show that UIP is violated, or that the forward exchange rate is not an unbiased predictor of the future spot rate. As pointed out by Huang (1984), it is relatively easy to reject unbiasedness against a very general alternative hypothesis, e.g., $\beta_1 \neq 1$ in (3.43), but when a more specific alternative is introduced, the tests seem to fail to reject unbiasedness. In other words, although much empirical evidence is consistent with the hypothesis that a risk premium exists, the results can also be attributable to, e.g., imperfect market integration or simple market inefficiency.

It can be argued that risk premia are unimportant and that other explanations to the observed bias should be tested. On the other hand, it is clear that the risk premium models tested are very crude and that empirical work in this field is plagued by difficult measurement problems. The inherent unobservability of many important variables means that the researcher has to resort to heroic assumptions, or basically ad hoc choices of instrumental variables.

Attempts to derive direct estimates of risk premia and exchange rate expectations through time series analysis have given mixed results. The strategy for future research should probably be to formulate and test time series models which are explicitly based on information about exchange rate policies and other institutional arrangements. A step in this direction, although admittedly a short step, is taken in the next chapter, where we focus our analysis on the Swedish currency basket system.

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4. The Foreign Exchange Risk Premium in a Currency Basket System*

4.1 INTRODUCTION

It is a standard result that under a fixed exchange rate system the possibilities for a small open economy to pursue an independent monetary policy depend on the degree of capital mobility and on the extent to which a domestic policy intervention is offset by capital inflows or outflows. If investors consider domestic and foreign assets to be perfect substitutes (on an uncovered basis), this offset will be complete.

In a world where exchange rates are not rigidly and permanently fixed, assets denominated in different currencies may not be perfect substitutes in investors' portfolios. The possibility of exchange rate changes may introduce a risk premium (or

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discount) that drives a wedge between the foreign and domestic interest rates. To the extent that this premium depends on variables that are subject to policy control, the interest rate differential can be influenced by the central bank and there will be room for an independent monetary policy.

After the breakdown of the fixed exchange rates regime under the Bretton Woods system a variety of exchange rate arrangements have emerged. While some of the major currencies are floating more or less freely relative to one another, a number of countries have tried to establish more stable currency arrangements. These attempts have been especially common in Western Europe, where, for example, the European Monetary System (EMS) is intended to maintain stable exchange rates within the European Community. Some of the non-member countries have chosen unilateral systems in which they tie their exchange rates to indices of foreign currencies, so called currency basket systems. If the currencies had been perfectly pegged to a basket index, a currency basket system would be equivalent to a system of rigidly fixed exchange rates. However, as implemented in practice there is usually some flexibility in the value of the currency index, which makes it meaningful to study risk premia in this context.[1]

The most common way to investigate the existence of risk premia is to test whether forward exchange rates are unbiased predictors of future spot exchange rates. This may be done by regressing realized spot exchange rates (or changes in rates) on forward rates (forward premia) and checking whether the coefficient estimates and the general statistical properties of

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1 Even if a currency is completely fixed in terms of a basket of other currencies, the (once-and-for-all) choice of weights in the basket involves a richer menu of policy options than if the currency were to be fixed in terms of a single foreign currency. Since international exchange rate agreements generally do not require rates to be completely fixed, the freedom to choose weights may be the most important difference between "currency basket" and traditional "fixed" regimes.

the regression are consistent with unbiasedness (see, e.g., Cumby and Obstfeld (1984), Fama (1984), and Gregory and McCurdy (1984, 1986)). Alternatively, one may test whether current information, other than the forward rate, helps predict future changes in the spot exchange rate by regressing the difference between the realized spot rate and the forward rate on relevant variables in the information set (see, e.g., Hodrick and Srivastava (1984, 1986)). If the current forward premium is the only explanatory variable used in the latter test, it gives exactly the same result as the former (cf. Fama (1984) and Section 4.4 below). Such (non-structural) tests for the existence of risk premia are usually conducted on bilateral exchange rates in isolation, and the null hypothesis of no premium (no bias) is generally rejected. It has proved difficult, however, to relate the deviations from unbiasedness to economic variables on which risk premia should depend, according to standard (structural) models of asset pricing theory. Frankel (1982) and Mark (1985) derive testable relationships between spot and forward exchange rates from models of one representative investor, but they are not (using different sets of U.S. dollar exchange rates) able to find any empirical support for the cross-equation constraints derived from theory or of risk aversion of the representative investor.

Some authors have noted that the efficiency of (non-structural) bilateral ordinary least squares (OLS) regressions may be improved by the use of the seemingly unrelated regressions (SUR) technique (see, e.g., Fama (1984) and Bailey, Baillie and McMahon (1984)). It is conceivable that the innovations in, e.g., the U.S. dollar/German mark exchange rate are correlated with those in the dollar/French franc rate, which means that there is a potential gain in efficiency from using SUR on the system of dollar exchange rate regressions rather than OLS on each equation independently. This conjecture is supported by the findings by Edwards (1982) and Diebold and Nerlove (1986).[2]

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2 It should be noted that the cross-equation constraints in the structural models of Frankel (1982) and Mark (1985) are

As pointed out by Fama (1984), the case for an integrated multi-currency framework is further strengthened by the fact that many currencies, such as the German mark and the French franc, are deliberately managed within formal international agreements.

To our knowledge, the intricacies of actual exchange rate policies have so far not been considered in unbiasedness tests of basket currencies such as the Finnish mark and the Swedish krona (see Haaparanta and Kähkönen (1985) and Oxelheim (1985), respectively).[3] The purposes of this chapter are to examine the theoretical foundations of risk premia determination in a currency basket system, and, in particular, to test for the existence of a risk premium on a currency that is tied to a basket, namely, the Swedish krona.

The chapter is organized as follows. In Section 4.2 we characterize a currency basket policy and in Section 4.3 we discuss the determination of the foreign exchange risk premium in terms of a portfolio optimization model used by Frankel (1982). In Sections 4.4 and 4.5 we use the methods applied by Fama (1984) and Engel (1984) to investigate whether there is a risk premium on the Swedish krona. Our results indicate that

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derived from the maximizing behavior of a risk averse investor, while Edwards' (1982) model builds on the assumption of risk neutrality. The argument for SUR in the latter study is based on the observation that the innovations (which are due, e.g., to monetary policy shocks) in the dollar/mark, dollar/franc and mark/franc exchange rates are related by the triangular arbitrage condition. Note also that Diebold and Nerlove (1986) are not concerned with the issue of unbiasedness but of excessive exchange rate variability.

3 Margarita (1987) examines risk premia on "EMS" vs. "rest of the world" assets, but does not discuss how these aggregates have been (or should be) defined. Hooper and Morton (1982) study the behavior of a trade-weighted index of U.S. dollar exchange rates, although there is reason to believe such an aggregate to be of less interest than official currency baskets. Abraham (1985) compares the behavior of a certain EMS rate, the Belgian franc/German mark rate, with that of the U.S. dollar/Belgian franc rate.

what could be considered a necessary condition for a small open economy to have some monetary independence is met in the case of Sweden. Some conclusions and caveats are discussed in Section 4.6.

4.2 CHARACTERISTICS OF A CURRENCY BASKET POLICY

The Swedish krona is tied to a currency basket, an index of fifteen foreign currencies. The index weights correspond to the relative shares in total Swedish trade, i.e., exports and imports. The exception is the U.S. dollar that has been given a weight which is twice the share of the U.S. in Sweden's total exports and imports. The other countries included are those whose trade shares exceed one percent and have convertible currencies. In principle, the value of the krona is fixed to this basket, at the same time floating bilaterally against all the individual currencies in the basket. In practice, this system is complicated by the facts that the central bank allows the krona to deviate from a benchmark value of the currency index, and that there is a non-zero probability of discrete changes in the benchmark value (i.e., of devaluations or revaluations).

When the currency basket was instituted in August 1977, the benchmark value of the index was set at 100. To date, there have been two changes in the benchmark value - devaluations of 10 % in September 1981 and 16 % in October 1982. After the latest devaluation the Riksbank set the benchmark at 132. The central bank at first declined to specify any exact bounds on the deviations from the benchmark value that it would permit. Deviations up to two percent have been observed, but in July 1985 the Riksbank officially announced bounds of ± 2 units (±1.5 percent). This is analogous to the fluctuations of ± 1 percent against the dollar that were permitted in the Bretton Woods system.[4]

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[4] For further discussions of the currency basket policy, see Franzén, Markowski and Rosenberg (1980), Franzén and

In order to illustrate how a currency basket system works, we will first invest in some notation. If we let s_t^j denote the log of the currency j/dollar exchange rate in period t, we can define the log of the index of the Swedish currency basket (I_t) as follows:

$$I_t = \omega' \left[\left[\iota s_t^{kr} - s_t \right] - \left[\iota s_o^{kr} - s_o \right] \right] + \left[1 - \omega' \iota \right] \left[s_t^{kr} - s_o^{kr} \right]. \quad (4.1)$$

Here, $s_t' \equiv [s_t^1, \ldots, s_t^m]$ contains all dollar exchange rates (in logarithms), except the krona/dollar rate, in period t; the (m×1) vector s_o contains the same exchange rates in the base period; s_t^{kr} is the krona/dollar exchange rate in period t (consequently, $s_t^{kr} - s_t^j$ is the krona/currency j exchange rate in period t); ι is a (m×1) vector of ones; and $\omega' \equiv [\omega^1, \ldots, \omega^m]$ contains the currency basket weights of all currencies except the dollar. The weight of the dollar is thus equal to $(1 - \omega'\iota)$.

From the definition of the index we can derive an expression for the depreciation of the krona against the dollar:

$$s_{t+1}^{kr} - s_t^{kr} = \omega' \left[s_{t+1} - s_t \right] + I_{t+1} - I_t. \quad (4.2)$$

Hence, an observed depreciation of the krona against the dollar can be due to an overall depreciation of the krona (an increase in the index of the currency basket) and/or to an overall appreciation of the dollar against an average of the non-krona currencies.

Our description of the currency basket given by (4.1) - (4.2) does not give a completely accurate description of the Swedish

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Rosenberg (1983), and Edison and Vårdal (1987). Hörngren and Viotti (1985) give a background to the July 1985 announcement of the bounds.

currency basket. First, the official index is not defined as a geometric average as in (4.1), but as an arithmetic average. This fact will be overlooked throughout our analysis. Second, the weights are not constant, but are changed on April 1 each year to reflect (long term) changes in the trade pattern. Since the annual changes in weights are small and can be fairly well predicted, they add no uncertainty of theoretical interest, although they have to be taken into account in empirical work.[5]

If it is assumed that

$$\mathrm{cov}\left[s^j_{t+1} - s^j_t,\ I_{t+1} - I_t\right] = 0, \qquad j = 1,\ldots,m, \tag{4.3}$$

where cov(x,y) denotes the covariance between x and y, the variance in the krona/dollar exchange rate can be decomposed into two components:

$$\mathrm{var}\left[s^{kr}_{t+1} - s^{kr}_t\right] = \omega'\Sigma\omega + \sigma^2_I, \tag{4.4}$$

where Σ is an m×m variance-covariance matrix with diagonal elements equal to $\mathrm{var}\left[s^j_{t+1} - s^j_t\right]$ and off-diagonal elements equal to $\mathrm{cov}\left[s^j_{t+1} - s^j_t,\ s^i_{t+1} - s^i_t\right]$; and where $\sigma^2_I \equiv \mathrm{var}\left[I_{t+1} -\right.$

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5 To take account of the changes in weights we should write

$$I_t \equiv \left[s^{kr}_t - s^{kr}_{o,t}\right] - \omega'_t\left[s_t - s_{o,t}\right], \tag{i}$$

$$I_{t+1} \equiv \left[s^{kr}_{t+1} - s^{kr}_{o,t+1}\right] - \omega'_{t+1}\left[s_{t+1} - s_{o,t+1}\right], \tag{ii}$$

where it is indicated that the base rates are changed every time the weights change. This is to guarantee that the changes in weights do not affect the index as long as spot rates are constant, i.e., that

$$s^{kr}_t - s^{kr}_{o,t+1} - \omega'_{t+1}\left[s_t - s_{o,t+1}\right] = I_t. \tag{iii}$$

Using (ii) - (iii) we can rewrite (4.2) as

$$s^{kr}_{t+1} - s^{kr}_t = \omega'_{t+1}\left[s_{t+1} - s_t\right] + I_{t+1} - I_t.$$

$I_t]$. In the theoretical analysis in Section 4.3 we will impose (4.3). Our motivation for doing this is that this condition comes close to a definition of a currency basket policy. A strong negative or positive correlation between the index and the dollar value of other currencies would make a distinction between a currency basket policy and an ordinary flexible exchange rate policy rather meaningless. If the central bank is successful in its aim to keep the krona stable in terms of the basket, and if the deviations from the benchmark value are primarily due to domestic (monetary policy) disturbances, then (4.3) should hold, at least approximately.

The sample (unconditional) variances and covariances displayed in Tables 1-2 do not lead one to reject (4.3) as a reasonable description (ex ante) of the currency basket regime. Correlations and covariances between the changes in the currency basket index and in its non-dollar currencies (in relation to the U.S. dollar) are close to zero, and generally much lower than within the group of non-dollar currencies. Correlation coefficients are somewhat higher for the period after the devaluation in October 1982, which simply reflects the fact that the variance of the index has been much lower in this period.

From Table 1 we can also see that there is a block of highly correlated currencies (i.e., in terms of changes relative to the U.S. dollar) consisting of the EMS currencies (DEM, DKK, FRF, NLG, BEC, ITL), the Spanish peseta (which is tied to an unofficial basket), the Austrian schilling (which has been pegged to the German mark), the Swiss Franc (which is, in principle, floating), and the "basket currencies" of Finland and Norway. Outside this block are the flexible currencies of the United Kingdom, Japan, and Canada. Not surprisingly, the latter currency is the one with the lowest variance.

Table 1. Sample correlations and covariances for the Swedish currency basket and dollar exchange rates, January 1980 - May 1987

Entries below the diagonal are correlations.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1. Index	3.48	-0.59	0.21	0.23	-0.43	1.72	-0.81	-0.69	-0.64	-0.32	-0.75	0.67	-0.61	0.07	-0.04
2. DEM	-0.09	12.79	7.30	9.35	12.3	8.90	11.8	12.3	12.5	11.0	12.8	8.24	12.5	8.80	1.70
3. GBP	0.03	0.60	11.36	7.01	7.34	6.62	7.23	7.53	7.39	6.07	8.02	6.15	7.10	6.81	1.87
4. NOK	0.04	0.87	0.69	9.06	9.19	7.74	8.84	9.08	9.23	7.99	9.49	7.03	9.07	7.23	1.11
5. DKK	-0.07	0.98	0.62	0.87	12.21	8.80	11.6	11.9	12.5	10.8	12.2	8.55	12.0	8.73	1.90
6. FIM	0.31	0.85	0.67	0.88	0.86	8.59	8.48	8.65	8.95	7.86	9.31	7.24	8.68	6.93	1.17
7. FRF	-0.12	0.94	0.61	0.84	0.95	0.82	12.33	11.5	11.8	10.6	11.9	8.08	11.6	8.7	1.65
8. NLG	-0.11	0.99	0.64	0.87	0.98	0.85	0.94	12.11	12.2	10.6	12.5	8.07	12.1	8.76	1.71
9. BEC	-0.09	0.95	0.59	0.83	0.96	0.82	0.91	0.95	13.66	11.1	12.3	8.28	12.4	9.04	1.78
10. ITL	-0.05	0.93	0.55	0.80	0.93	0.81	0.92	0.92	0.91	10.89	10.9	7.66	10.8	7.81	1.64
11. CHF	-0.10	0.92	0.61	0.81	0.90	0.82	0.88	0.92	0.86	0.85	15.09	9.63	12.5	8.84	1.88
12. JPY	0.10	0.63	0.50	0.64	0.67	0.67	0.63	0.63	0.61	0.63	0.68	13.46	7.95	6.14	1.48
13 ATS	-0.09	0.997	0.60	0.86	0.98	0.84	0.94	0.99	0.95	0.93	0.92	0.62	12.35	8.58	1.69
14. ESP	0.01	0.83	0.68	0.81	0.84	0.79	0.83	0.85	0.82	0.80	0.76	0.56	0.82	8.86	1.60
15. CAD	-0.01	0.35	0.41	0.27	0.40	0.29	0.34	0.36	0.35	0.36	0.36	0.30	0.35	0.39	1.86

"Index" is the percentage rate of change of the Swedish currency basket's index. DEM is the percentage rate of change of German mark/U.S. dollar exchange rate, and the other dollar exchange rates are those of the British pound (GBP), the Norwegian krona (NOK), the Danish krona (DKK), the Finnish mark (FIM), the French franc (FRF), the Dutch guilder (NLG), the Belgian Franc (BEC), the Italian lira (ITL), the Swiss franc (CHF), the Japanese yen (JPY), the Austrian schilling (ATS), the Spanish peseta (ESP), and the Canadian dollar (CAD).

Table 2. Sample correlations and covariances between the Swedish currency basket and dollar exchange rates, October 1982 - May 1987

	Index	DEM	GBP	NOK	DKK	FIM	FRF	NLG	BEF	ITL	CHF	JPY	ATS	ESP	CAD
Correlation with Index	1.00	-0.21	-0.08	-0.23	-0.20	-0.17	-0.26	-0.18	-0.19	-0.25	-0.20	-0.18	-0.20	-0.14	-0.04
Covariance with Index	0.17	-0.31	-0.12	-0.30	-0.28	-0.19	-0.36	-0.26	-0.28	-0.35	-0.31	-0.26	-0.29	-0.19	-0.02

In Table 3 we see that approximately one third of the variance in the changes in the krona/dollar rate since January 1980 has been accounted for by the variance in the change of the currency basket index. The corresponding figure for the period since the latest devaluation is 3 %. Insofar as the ex post unconditional variances tell something about the riskiness of different currencies ex ante, we can conclude that the risk associated with changes in the value of the krona relative to any single foreign currency is largely due to international movements in exchange rates. In particular, the variance in the krona/U.S. dollar exchange rate that is due to changes in the currency basket index within the official bounds is, judging from post-devaluation data, negligible. Table 3 also indicates that (4.4) can be treated as a valid condition for practical purposes.

Since large movements of the basket index within the bounds or discrete changes in the benchmark value cannot be ruled out ex ante, the variability in the currency index may, nevertheless, introduce a risk premium on the krona and, hence, possibly give some scope for an independent interest rate policy. We will elaborate on this point below and formalize our argument by analyzing a model of international asset pricing in which one country pursues a currency basket policy.

Table 3. Decomposition of the sample variance in the krona/dollar spot exchange rate

a. January 1980 - May 1987

1.	Variance in currency basket	3.48
2.	Variances and covariances in other dollar exchange rates	5.80
3.	Covariances between currency basket and other dollar exchange rates	-0.16
4.	Residual due to changes in weights	0.25
5.	Variance in the krona/dollar exchange rate	9.37

b. October 1982 - May 1987

1.	Variance in currency basket	0.17
2.	Variances and covariances in other dollar exchange rates	5.90
3.	Covariances between currency basket and other dollar exchange rates	-0.41
4.	Residual due to changes in weights	0.06
5.	Variance in the krona/dollar exchange rate	5.72

Note: The figures on rows 2 and 3 are equal to $\omega'\Sigma\omega$ and $2\ \mathrm{cov}[\omega'(s_{t+1} - s_t), I_{t+1} - I_t]$, respectively. They have been calculated using the currency basket weights for April 1985 - March 1986.

4.3 RISK PREMIA IN A CURRENCY BASKET SYSTEM

The starting point for our theoretical analysis is Frankel's (1982) international portfolio balance model. Consider a representative investor who maximizes a utility function of the mean and variance of his end-of-period real wealth (evaluated in U.S. dollars which is the reference currency). The investor's problem is thus to allocate his real wealth W_t among assets denominated in m+2 different currencies in order to maximize $F[E(W_{t+1}), Var(W_{t+1})]$. There is one nominally safe asset in each currency, and the investor chooses a vector x_t of portfolio shares. The only uncertainty in the model is related to exchange rate changes; in particular, nominal interest rates are non-stochastic. In order to illustrate that it is the real return that is important, it is assumed that the investor consumes goods from different countries. Each good is priced in the producing country's currency, and nominal prices are non-stochastic. Through changes in exchange rates, the real value of the portfolio will depend on the composition of his consumption basket, summarized by the vector α of consumption shares. For simplicity, the consumption pattern is exogenous and assumed to be constant over time.

Assuming asset supplies to be exogenously fixed, interest rate differences must in equilibrium satisfy:

$$r_t - \iota r_t^{\$} - E\left[s_{t+1}-s_t\right] = \rho\Sigma\left[x_t - \alpha + \left[x_t^{kr}-\alpha^{kr}\right]\omega\right], \qquad (4.5)$$

$$r_t^{kr} - r_t^{\$} - E\left[s_{t+1}^{kr}-s_t^{kr}\right] = \rho\omega'\Sigma\left[x_t - \alpha + \left[x_t^{kr}-\alpha^{kr}\right]\omega\right] + $$

$$+ \rho\left[x_t^{kr}-\alpha^{kr}\right]\sigma_I^2, \qquad (4.6)$$

where ρ is the coefficient of relative risk aversion ($\rho \equiv -F_2W_t2/F_1$); r^j is the safe one-period nominal interest rate on currency-j assets; and we have assumed (4.3) - (4.4) to hold.

In order to save space the derivation of (4.5) - (4.6) is left out; an explicit derivation is given by Frankel (1982) and a similar model is analyzed in detail in Chapter 3 of this thesis. Condition (4.5) is the equilibrium relation derived by Frankel (1982) except that in his model ω is a null-vector as there is no country pursuing a currency basket policy.

Equation (4.5) gives the relation between the dollar interest rate and all the other non-krona interest rates. The right-hand side is (by definition) a risk premium, and we see that uncovered interest parity (UIP) obtains either if the representative investor is risk neutral ($\rho = 0$) or if there is no randomness in exchange rate changes ($\Sigma = 0$). Otherwise, there will be risk premia and the signs and magnitudes of these depend, in addition to ρ and Σ, on $(x_t - \alpha)$, the difference between the outstanding supply of assets in a given currency and the consumption share of goods priced in that currency. This dependence is due to the fact that the greater the difference between portfolio and consumption shares, the greater is the uncertainty about the real value of the currency, other things equal. Whether there will be a premium or a discount depends not only on $(x_t - \alpha)$, however, but also on the covariance structure in Σ.

One implication of this mean-variance optimization model is that, as long as investors are risk averse, changes in relative asset supplies (x_t), e.g., via open market operations, affect the risk premia. There would thus be a direct channel through which monetary policy could influence the relative returns on domestic and foreign assets.[6]

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6 A model based on intertemporal utility maximization, as opposed to myopic mean-variance optimization, would, under the special circumstances considered by Frankel (1982), give the same optimality and equilibrium relations between interest rates, exchange rates, and asset stocks. Under more general circumstances, when, e.g., stochastic properties of interest and exchange rates depend on some fundamental state variables, an investor has to consider other information than that given by the variance-covariance matrix of

In order to get an expression for the risk premium on assets in kronor in relation to dollar assets, substitute (4.5) into (4.6) to get

$$r_t^{kr} - r_t^{\$} - E\left[s_{t+1}^{kr} - s_t^{kr}\right] = \omega'\left[r_t - \iota r_t^{\$} - E\left[s_{t+1} - s_t\right]\right] + $$
$$+ \rho\left[x_t^{kr} - \alpha^{kr}\right]\sigma_I^2. \qquad (4.7)$$

We see that this risk premium is determined by two factors: the risk premia between all other currencies and the dollar, and the uncertainty introduced by the central bank's currency basket policy. Thus, even if the krona were rigidly fixed to an index of all other currencies ($\sigma_I^2 = 0$), there would still be a risk premium between the krona and the dollar. This proposition is a general result which does not depend on the features of the specific asset pricing model used here.

Another exercise will be illuminating. Rewrite (4.7) to obtain the risk premium on the krona relative to the currency basket weighted portfolio:

$$r_t^{kr} - \omega' r_t - \left[1 - \omega'\iota\right] r_t^{\$} - E\left[I_{t+1} - I_t\right] = \rho\left[x_t^{kr} - \alpha^{kr}\right]\sigma_I^2. \quad (4.8)$$

If the currency index is fixed ($E(I_{t+1} - I_t) = \sigma_I^2 = 0$), there is no risk on a basket weighted position over and above that of a Swedish asset (remember that the consumption pattern and commodity prices are non-stochastic in this model). Hence, there will be no excess return on Swedish assets in comparison to a currency basket portfolio and complete interest rate dependence. The only difference then between a basket system and a regular fixed exchange rate is that the domestic interest rate has to equal a weighted average of interest rates rather

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exchange rates. For discussions of these issues, see, e.g., Merton (1973) and Stulz (1982).

than a specific foreign rate.

It is thus the variability in the currency index that (possibly) gives the central bank some independence. The choice to let the currency index vary can therefore be interpreted as an attempt to maintain some latitude for an independent monetary policy. From this line of reasoning it also follows that a test for a risk premium that is specific to the Swedish krona should not be performed on bilateral parity relations (such as (4.7)) but on krona interest rates relative to a basket-weighted portfolio of foreign assets (i.e., on (4.8)).

When formulating our empirical tests on krona exchange rates, we will not make further use of Frankel's (1982) structural portfolio balance model. Instead, we will apply the non-structural (or "atheoretical") approaches previously used by, e.g., Cumby and Obstfeld (1984), Fama (1984), and Engel (1984). Like Frankel (1982), these studies exploit the equivalence of UIP and unbiasedness which obtains under the assumption of covered interest parity (CIP).[7] The unbiasedness tests have the advantage of requiring data on forward exchange rates instead of interest rates. We are primarily interested in the risk premium on the currency basket, but, for comparison, results from bilateral tests on three important krona exchange rates will also be reported.

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7 The validity of this assumption is investigated by McPhee (1984) and Englund, McPhee, and Viotti (1985), who find that the deviations from CIP are within reasonable limits given the existence of transaction costs.

4.4 THE DATA AND THE FORMULATION OF TESTS

Table 4 shows some descriptive statistics for three krona exchange rates and for the official currency basket. (f_t^i and s_t^i are here the logarithms of krona/currency i forward and spot exchange rates, and $f_t^I - s_t^I$ is the forward premium on the currency basket, i.e., a weighted average of the individual forward premia.) The data are monthly observations from January 1980 to May 1987, i.e., a total of 89 observations. The exchange rate quotations are end-of-day buying rates, spot and thirty-day forward, on the last trading day of the month, obtained from SEB International and Götabanken.[8]

These figures can be compared to those reported by Fama (1984, Table 5) on nine dollar exchange rates (not including the Swedish krona). He notes that the standard deviations of $f_t^i - s_{t+1}^i$ are larger than those of $s_{t+1}^i - s_t^i$ in his data. This indicates that "the current spot rate is a better predictor of the future spot rate than the forward rate" (p. 323). As can be seen from Table 4, this pattern is present also in the Swedish data. This is also consistent with the findings of Meese and Rogoff (1983), who show that the current spot rate outperforms a number of standard models of exchange rate determination as predictors of the future spot rate, including the forward rate.

When studying the Swedish data, one may want to look at the time periods before, between, and after the two devaluations in September 1981 and October 1982 separately. For instance, from the whole period since January 1980 it does not seem as if the currency basket index has been much more stable than the bilateral exchange rates. On the other hand, once the effects

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8 Since the data are not sampled exactly at thirty-day intervals an error may be introduced by the mismatch between forward rates and the corresponding future spot rates.

Table 4. Krona exchange rates, January 1980 - May 1987

Country[a)]	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	ρ_7	ρ_8	ρ_9	ρ_{10}	ρ_{11}	ρ_{12}	Mean[c)]	Std.dev.[c)]
	Autocorrelations[b)]													
	$s_{t+1} - s_t$													
West Germany	0.15	-0.04	-0.02	-0.06	0.01	0.01	0.03	-0.10	-0.12	-0.01	0.07	0.04	0.42	2.50
U.S.A.	0.03	0.09	0.17	0.17	0.19	-0.05	0.13	0.10	0.13	0.10	-0.03	-0.07	0.48	3.06
United Kingdom	-0.02	-0.03	-0.06	-0.03	-0.16	-0.01	0.08	-0.10	-0.02	0.04	0.10	0.06	0.09	2.80
Index	-0.12	-0.00	-0.05	-0.03	-0.03	-0.02	-0.06	-0.03	-0.05	-0.00	-0.03	0.01	0.27	1.87
	$f_t - s_{t+1}$													
West Germany	0.16	0.04	-0.01	-0.04	0.02	0.02	0.02	-0.10	-0.11	-0.02	-0.06	0.04	0.07	2.51
U.S.A.	0.07	0.12	0.20	0.20	0.22	-0.01	0.16	0.13	0.16	0.12	-0.02	-0.04	-0.30	3.12
United Kingdom	-0.01	-0.03	-0.04	-0.02	-0.15	-0.01	0.06	-0.11	-0.03	0.04	0.09	0.06	-0.02	2.84
Index	0.12	-0.01	-0.05	-0.01	-0.02	0.00	-0.06	-0.02	-0.03	-0.01	0.03	0.02	-0.10	1.90
	$f_t - s_t$													
West Germany	0.54	0.44	0.45	0.37	0.20	0.10	0.11	0.00	-0.04	-0.03	-0.02	-0.08	0.50	0.22
U.S.A.	0.72	0.50	0.42	0.32	0.24	0.22	0.30	0.32	0.22	0.11	0.04	-0.02	0.18	0.27
United Kingdom	0.67	0.51	0.37	0.26	0.09	-0.11	-0.16	-0.28	-0.29	-0.34	-0.32	-0.23	0.07	0.23
Index	0.60	0.41	0.31	0.24	0.07	0.05	-0.05	-0.13	-0.17	-0.21	-0.26	-0.20	0.18	0.23

a) Note that the figures for West Germany and United Kingdom refer to krona exchange rates (krona/mark, krona/pound) rather than dollar exchange rates (as in Tables 1-2). The relative change in "Index" is equal to $I_{t+1} - I_t$.

b) Under the hypothesis that the true autocorrelations are 0.0, the standard error of the sample autocorrelations is about 0.106.

c) The variables are measured on a percent per month basis (logarithmic differences have been multiplied by 100). For example, the currency basket's index has increased by an average of 0.27 per cent per month between February 1980 and June 1987.

of the devaluations are eliminated, it can be seen that the standard deviation of the change in the index is much less than that of either bilateral exchange rate (cf. Table 5).

Table 5. Krona Exchange Rates, January 1980 - May 1987*

Country	Jan 80 - July 81 Mean	Jan 80 - July 81 St.dev.	Sep 81 - Aug 82 Mean	Sep 81 - Aug 82 St.dev.	Oct 82 - May 87 Mean	Oct 82 - May 87 St.dev.
			$s_{t+1} - s_t$			
West Germany	-0.59	1.52	0.26	1.04	0.33	1.42
U.S.A.	1.17	2.51	0.98	2.05	-0.27	2.39
United Kingdom	0.11	2.48	0.49	1.42	-0.35	2.26
Index	-0.05	0.35	0.11	0.49	-0.00	0.42
			$f_t - s_{t+1}$			
West Germany	1.04	1.62	0.07	1.09	0.23	1.41
U.S.A.	-1.14	2.50	-1.01	1.97	0.55	2.47
United Kingdom	-0.09	2.68	-0.51	1.49	0.45	2.30
Index	0.20	0.60	-0.08	0.57	0.22	0.46
			$f_t - s_t$			
West Germany	0.46	0.30	0.32	0.19	0.55	0.17
U.S.A.	0.03	0.35	-0.03	0.23	0.28	0.18
United Kingdom	0.02	0.39	-0.02	0.23	0.10	0.14
Index	0.15	0.32	0.02	0.32	0.22	0.15

* Cf. the notes to Table 4.

Evidently, there is autocorrelation in the forward premia (f_t^i - s_t^i) in Table 4. Exchange rate changes do not seem to be autocorrelated, however, nor do the differences between forward rates and future spot rates (except, perhaps, for the krona/U.S. dollar exchange rate). This may seem surprising, since

$$f_t^i - s_t^i = \left[s_{t+1}^i - s_t^i\right] + \left[f_t^i - s_{t+1}^i\right], \tag{4.9}$$

i.e., the sum of two variables that show no sign of autocorrelation is highly correlated over time. The pattern is the same in Fama's data. If we make the following definitions of the forecast error,

$$\epsilon_{t+1}^i = s_{t+1}^i - E\left[s_{t+1}^i\right], \tag{4.10}$$

and the risk premium,

$$p_t^i = f_t^i - E\left[s_{t+1}^i\right], \tag{4.11}$$

(4.9) can be written as

$$f_t^i - s_t^i = \left[-E\left[s_{t+1}^i - s_t^i\right] + \epsilon_{t+1}^i\right] + \left[p_t^i - \epsilon_{t+1}^i\right]. \tag{4.12}$$

Fama suggests that the autocorrelation of the risk premium and/or the expected changes in the exchange rate, which show up in the forward premium, are dominated in the time series of (s_{t+1}^i - s_t^i) and (f_t^i - s_{t+1}^i) by the high variability of the forecast error. This means that the observation that the difference between the forward rate and the realized spot rate appears to be white noise does not warrant the conclusion that there is no risk premium.

We will make a regression test for the existence of a (possibly time-varying and autocorrelated) risk premium on the currency basket. Specifically, we test the hypothesis of unbiasedness of the forward rate as a predictor of the future spot rate.

The hypothesis of unbiasedness can be tested using the regression model

$$s_{t+1} - s_t = \alpha_1 + \beta_1\left[f_t - s_t\right] + \epsilon_{t+1}, \qquad (4.13)$$

where the null hypothesis (no bias or zero risk premium) implies that $[\alpha_1, \beta_1] = [0, 1]$, and where superscripts have been dropped. Under rational expectations ϵ_{t+1} is orthogonal to $(f_t - s_t)$ and the parameters in (4.13) can be estimated by OLS. This is thus a joint test of unbiasedness <u>and</u> rational expectations.

Fama (1984) points out that since

$$s_{t+1} - s_t = -\left[f_t - s_{t+1}\right] + \left[f_t - s_t\right], \qquad (4.14)$$

an alternative to the regression model (4.13) may be formulated as

$$f_t - s_{t+1} = \alpha_2 + \beta_2\left[f_t - s_t\right] - \epsilon_{t+1}, \qquad (4.15)$$

where $\alpha_2 = -\alpha_1$ and $\beta_2 = 1 - \beta_1$. In the empirical literature both tests based on (4.13) and (4.15) are common.

A number of critical comments have been raised concerning the interpretation of the results of OLS regressions like (4.13) and (4.15). First, Hodrick and Srivastava (1986) point out that if there is a time-varying risk premium, the estimates will be biased. However, they also argue that this problem is unlikely to be severe, a conjecture that is confirmed as results from techniques that are not subject to bias confirm Fama's (1984) findings. We will thus use the simpler OLS technique.

Second, as stressed by Gregory and McCurdy (1984, 1986), a failure to reject the null hypothesis does not necessarily mean that there is no time-varying risk premium. One should also make sure that there are no signs of parameter instability or residual autocorrelation. In consequence, we make several diagnostic tests, including Chow tests of parameter instability and Box-Pierce tests for autocorrelation in the regression residuals.

Third, it is well known that UIP and unbiasedness may be violated even in the case of risk neutrality among investors, due to Jensen's inequality. The problem is not important in Frankel's (1982) simple model, where exchange rates are the only stochastic variables, and it may be unimportant even in practice (cf. McCulloch (1975) and Frenkel and Razin (1980)). However, Engel (1984) argues that for unbiasedness to be economically meaningful, it should be formulated as a test of the <u>real</u> return from speculation. Engel thus examines the statistical properties of

$$e_{t+1} = F_t/P_{t+1} - S_{t+1}/P_{t+1}, \tag{4.16}$$

where F_t and S_t are the levels of forward and spot exchange rates, respectively ($f = \ln F$, $s = \ln S$), and P_{t+1} is a relevant price index. In <u>Table 6</u> we give some descriptive statistics of

$$u_{t+1} = \left[f_t - s_{t+1}\right]\left[S_t/P_{t+1}\right], \tag{4.17}$$

which is approximately equal to e_{t+1}. In our case, P_{t+1} is measured by the Swedish consumer price index, and for comparison the levels of exchange rates have also been

Table 6. The realized excess real return on the forward market, January 1980 - May 1987

Autocorrelations

Country	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	ρ_7	ρ_8	ρ_9	ρ_{10}	ρ_{11}	ρ_{12}	Mean	Std.dev.
	$u_{t+1} = (f_t - s_{t+1})(S_t/P_{t+1})$													
West Germany	0.16	0.06	-0.00	-0.03	0.02	0.01	0.02	-0.10	-0.12	-0.01	-0.05	0.04	0.10	2.02
U.S.A.	0.08	0.11	0.20	0.20	0.21	-0.02	0.14	0.12	0.13	0.12	-0.04	-0.07	-0.31	3.56
United Kingdom	-0.06	-0.02	-0.04	-0.02	-0.14	-0.01	0.08	-0.11	-0.03	0.04	0.09	0.03	-0.02	2.43
Index	0.13	0.01	-0.06	-0.01	-0.02	0.01	-0.06	-0.02	-0.04	0.01	-0.03	0.02	-0.08	1.60

transformed to index form (with January 1980 = 1.0).[9]

By comparing Tables 4 and 6, we can see that the descriptive statistics for u_{t+1} and $(f_t - s_{t+1})$ are highly similar. While theoretically motivated, Engel's (1984) objection to regressions like (4.15) may thus be of little practical importance. Engel also reports that regression analyses of u_{t+1} (or, rather, e_{t+1}) yield about the same results as those based on $(f_t - s_{t+1})$. As a check for robustness, we will nevertheless run both the regression advocated by Fama (1984) (i.e., (4.13)) and an alternative regression suggested by Engel (1984).

Engel (1984) argues that a valid test for unbiasedness can be based on the regression model

$$u_{t+1} = \delta_0 + \sum_{i=1}^{4} \delta_i u_{t+1-i} + \nu_{t+1}, \qquad (4.18)$$

where the null hypothesis of no bias implies that $\delta_i = 0$ (for all i). It should be stressed that under the null hypothesis of no risk premium, <u>no</u> variable in the information set should help predict u_{t+1}; the choice of lagged u_t's is of course somewhat arbitrary. For example, one might use the forward premium in period t, which would make this test similar to Fama's (1984).[10]

Finally, it should be noted that inferences based on

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9 As noted by Engel (1984), the relevant price index is of a representative risk neutral investor. While the Swedish CPI seems a reasonable choice as far as the currency basket is concerned, it may be less appropriate in the cases of the bilateral exchange rates. Since we are not primarily interested in the bilateral relations, the Swedish CPI will be used throughout.

10 Engel (1984) also regresses u^i_{t+1} on lagged excess returns on other currencies, u^j_t. His conclusions are not affected.

regressions like (4.13) and (4.18) may be incorrect if ϵ_{t+1} and ν_{t+1} are heteroskedastic (although homoskedasticity is not necessary for unbiasedness). Cumby and Obstfeld (1984) and Engel (1984) use different versions of White's (1980) heteroskedasticity test in their studies of (4.13) and (4.18), respectively. Specifically, Cumby and Obstfeld (1984) examine whether the forecast error ϵ_{t+1} is homoskedastic under the null hypothesis of no bias, in which case $\epsilon_{t+1} = s_{t+1} - f_t$, and test whether $\phi_1 = \phi_2 = 0$ in the regression

$$\left[f_t - s_{t+1}\right]^2 = \phi_0 + \phi_1\left[f_t - s_t\right] + \phi_2\left[f_t - s_t\right]^2 + \eta_{t+1}. \quad (4.19)$$

Alternatively, one may want to examine whether the residuals associated with (4.13), $\hat{\epsilon}_{t+1}$, are homoskedastic by testing whether $\mu_1 = \mu_2 = 0$ in

$$\left[\hat{\epsilon}_{t+1}\right]^2 = \mu_0 + \mu_1\left[f_t - s_t\right] + \mu_2\left[f_t - s_t\right]^2 + \xi_{t+1}, \quad (4.20)$$

or, following Engel (1984), whether all $\pi_{ji} = 0$ in

$$\left[\hat{\nu}_{t+1}\right]^2 = \gamma + \sum_{i=1}^{4} \pi_{0i}\, u_{t+1-i} + \sum_{j=1}^{4}\sum_{i=1}^{4} \pi_{ji}\, u_{t+1-j}\, u_{t+1-i} + \psi_{t+1} \quad (4.21)$$

In the following section, we will report the results from applying (4.13), (4.18) and (4.19) - (4.21) on Swedish data.

4.5 REGRESSION RESULTS

The results from unbiasedness tests based on (4.13) and (4.18) are reported in Tables 7 and 8, respectively. Separate regressions have been run for the whole sample period, January 1980 - May 1987, and for the period after the devaluation in

October 1982. There are two reasons for our special interest in the post-devaluation period. First, evidence presented by McPhee (1984) and Englund, McPhee, and Viotti (1985) indicates that the CIP arbitrage condition was violated prior to 1982 even on major currencies. Consequently, the unbiasedness tests for that period cannot be interpreted as tests of UIP which is our main concern. Second, one may argue that there was a regime shift, as far as Swedish stabilization policy is concerned, at the time of the devaluation in 1982. The exchange rate target was officially given a larger weight in policy formation, and exchange rate expectations and risk premia should have been affected by this change. Since one cannot determine a priori whether any regime shift actually occurred, we view the overlapping regressions as complementary.

Looking first at the estimates for the bilateral exchange rates in Table 7, which are most easily compared to the results of earlier studies, we find significant deviations from unbiasedness for the dollar and the pound. For the latter currency, however, the joint hypothesis $[\alpha_1, \beta_1] = [0, 1]$ cannot be rejected at the 5 per cent level of significance (but at the 10 percent level) when the whole sample period is considered.

Table 7. OLS regressions

$$s_{t+1} - s_t = \hat{\alpha}_1 + \hat{\beta}_1(f_t - s_t) + \hat{\epsilon}_{t+1}$$

a.) January 1980 - May 1987

Country	$\hat{\alpha}_1$	$\hat{\beta}_1$	$s(\hat{\alpha}_1)$	$s(\hat{\beta}_1)$	H_0 (marg. sign. levels)	H_C (marg. sign. levels)	Q (marg. sign. levels)	DW	$s(\hat{\epsilon})$	R^2
West Germany	0.005	-0.137	0.006	1.209	0.62	0.88	0.70	1.70	0.025	0.00
U.S.A.	0.009*	-2.187*	0.004	1.206	0.02	0.00	0.92	2.09	0.030	0.04
United Kingdom	0.002	-1.820*	0.003	1.270	0.09	0.49	0.92	2.04	0.028	0.02
Index	0.004	-0.760*	0.002	0.862	0.12	0.48	0.83	1.76	0.019	0.01

b.) October 1982 - May 1987

Country	$\hat{\alpha}_1$	$\hat{\beta}_1$	$s(\hat{\alpha}_1)$	$s(\hat{\beta}_1)$	H_0 (marg. sign. levels)	H_C (marg. sign. levels)	Q (marg. sign. levels)	DW	$s(\hat{\epsilon})$	R^2
West Germany	-0.003	1.180	0.006	1.140	0.49	0.18	0.99	1.93	0.014	0.02
U.S.A	0.014*	-5.865*	0.006	1.668	-0.00	0.44	0.40	2.64	0.022	0.19
United Kingdom	-0.000	-3.241*	0.004	2.077	0.05	0.69	0.98	1.67	0.022	0.04
Index	0.001	-0.430*	0.001	0.375	0.00	0.57	0.85	1.49	0.004	0.02

s(•) denotes standard error of estimate. * indicates that the coefficient is significantly different from its value under the null hypothesis at the 5 per cent level. H_0 is a test of the joint hypothesis $[\alpha_1, \beta_1] = [0, 1]$. H_C is a Chow test for structural stability, where the samples have been split in December 1983 in panel (a) and December 1984 in panel (b). Q is the Box-Pierce test for autocorrelation. The marginal significance levels of the tests are based on the F-distribution (H_0 and H_C) and the χ^2-distribution (Q). DW is the Durbin-Watson statistic, and R^2 the conventional goodness-of-fit measure.

Table 8. OLS regressions

$$u_{t+1} = \hat{\gamma} + \sum_{i=1}^{4} \hat{\delta}_i \, u_{t+1-i} + \hat{\nu}_{t+1}$$

a.) May 1980 - May 1987

Country	$\hat{\gamma}$	$\hat{\delta}_1$	$\hat{\delta}_2$	$\hat{\delta}_3$	$\hat{\delta}_4$	h_0	H_C	Q	DW	$s(\hat{\epsilon})$	R^2
						(marg. sign. levels)					
West Germany	0.000	0.190**	0.028	-0.018	-0.030	0.64	0.93	0.96	2.00	0.020	0.04
	(0.002)	(0.111)	(0.112)	(0.109)	(0.108)						
U.S.A.	-0.002	0.031	0.082	0.181**	0.175	0.15	0.12	0.78	2.06	0.035	0.09
	(0.004)	(0.110)	(0.107)	(0.106)	(0.108)						
United Kingdom	0.000	-0.078	-0.037	-0.047	-0.032	0.98	0.44	0.93	2.01	0.025	0.01
	(0.003)	(0.112)	(0.112)	(0.112)	(0.112)						
Index	-0.001	0.132	0.004	-0.059	0.005	0.86	0.81	0.86	2.00	0.016	0.02
	(0.002)	(0.112)	(0.112)	(0.112)	(0.112)						

b.) February 1983 - May 1987

Country	$\hat{\gamma}$	$\hat{\delta}_1$	$\hat{\delta}_2$	$\hat{\delta}_3$	$\hat{\delta}_4$	h_0	H_C	Q	DW	$s(\hat{\epsilon})$	R^2
						(marg. sign. levels)					
West Germany	0.002	-0.018	0.100	0.123	-0.018	0.56	0.18	0.998	1.99	0.012	0.02
	(0.002)	(0.146)	(0.144)	(0.140)	(0.139)						
U.S.A.	0.003	-0.051	0.241**	0.191	0.124	0.13	0.14	0.995	2.03	0.030	0.12
	(0.004)	(0.145)	(0.142)	(0.142)	(0.144)						
United Kingdom	0.002	0.138	-0.158	0.097	-0.047	0.70	0.47	0.994	1.95	0.018	0.04
	(0.002)	(0.146)	(0.141)	(0.143)	(0.137)						
Index	0.002*	0.159	0.094	-0.238**	-0.026	0.00	0.11	0.978	1.83	0.003	0.09
	(0.001)	(0.143)	(0.138)	(0.136)	(0.123)						

Numbers in parentheses are standard errors. * (**) indicates that the coefficient is significantly different from zero at the 5 (10) percent level. h_0 is an F-test of the hypothesis that all regression coefficients are zero. Cf. the notes to table 7 for further information.

The β_1 coefficients in the U.S. dollar and British pound equations are markedly negative (although significantly different from zero only in the case of the dollar). In these respects our results are similar to Fama's (1984), although our estimates are far greater in absolute values than his. In the case of the U.S. dollar, the rejection of the unbiasedness hypothesis is further strengthened by the fact that the estimated equation shows signs of parameter instability (cf. Table 7 a).

The results for the German mark are quite different and although the β_1 estimate for the whole sample is not numerically close to unity, we cannot reject unbiasedness. However, we cannot show that β_1 is significantly different from zero neither for the whole sample period nor for the post-devaluation period, when the point estimate is close to unity. This illustrates the imprecision and power problem inherent in these tests. The hypothesis that the change in the krona/German mark rate is pure white noise cannot be rejected.

These results can be compared to those presented for krona exchange rates by Oxelheim (1985). He analyzes nonoverlapping three month forward rates, 1974-84, for five currencies, namely, those in Table 7 plus the Swiss franc and the Japanese yen. In regressions comparable to ours (Table 4.27, p. 186), he can in no case reject unbiasedness. The point estimates of β_1 are all positive, but only for the pound is it significantly different from zero. This gives an additional illustration of the power problem in the tests, but the reasons for the marked differences between his estimates and ours are difficult to determine. Apart from using a different observation interval, it should be noted that Oxelheim has five devaluations and the shift to the currency basket system in 1977 in his sample period. A priori, it seems likely that this should increase the errors and tend to reduce the forecast power. What we find, however, is point estimates that are closer to unity and standard errors of estimates that are considerably smaller than ours.[11] It is thus possible that there has been a change in the relations between the krona and, in particular, the dollar and the pound in recent years. Our analyses of the currency basket system in Sections 4.2 - 4.3 demonstrate, however, that this need not be due to domestic events as the bilateral relations are likely to be dominated by the internationally determined premia (or discounts) on the currencies in question.

This brings us to the more interesting test of the ability of a basket weighted index of forward premia to predict the future relative change in the currency index. The results are reported in the bottom lines of Tables 7 a - 7 b. The joint hypothesis $[\alpha_1, \beta_1] = [0, 1]$ can be rejected for the post-devaluation period, but not for the whole sample. However, the β_1 estimates are significantly less than unity (although not significantly different from zero), which indicates that the forward premium does not provide an unbiased prediction of the index. The coefficient of determination is far from impressive and considerably smaller than in the regressions for the krona/U.S. dollar and krona/pound rates. Whereas there is a significant relationship between the krona/dollar forward premium and the future change in the spot rate, albeit not at all the relation predicted by the unbiasedness hypothesis,[12] the changes in the currency basket index are more or less unrelated to observed forward premia (β_1 being close to zero both numerically and statistically).

Turning to the unbiasedness tests advocated by Engel (1984), reported in Table 8, we find that the joint hypothesis that realized excess real returns are white noise and thus

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[11] Oxelheim's (1985) β_1 estimate of 0.78 in the krona/dollar regression is also in contrast to the generally negative coefficients obtained by Fama (1984) for other dollar exchange rates in a sample period similar to Oxelheim's.

[12] In other words, dollar forward premia contain information about future spot rate changes even though they are not unbiased predictors.

impossible to predict from lagged returns, can be rejected for the currency basket if the study is limited to post-devaluation data. Coefficients are typically higher (in absolute terms) for the latter period, but so are standard errors. There seems to be a significant constant "excess return" on forward contracts in currency basket terms, and u^I_{t-2} helps predict u^I_{t+1}, at the 10 percent significance level (cf. the last row of Table 8 b). In most cases, however, u_{t+1} seems impossible to predict from lagged u_t's.

The homoskedasticity tests in Table 9 show, first, that there is significant heteroskedasticity in $(f_t - s_{t+1})$ for the krona/U.S. dollar exchange rate and the currency basket index in the post-devaluation period (but only for the krona/pound rate if the whole sample period is considered). To the extent that the heteroskedasticity is reflected in a time-varying risk premium, as suggested by Domowitz and Hakkio (1985) and Wolff (1987), this result is consistent with our conclusions from Table 7. Second, the residuals from the regressions in Tables 7-8 generally show no sign of heteroskedasticity, which means that the inferences drawn are not invalidated.

Table 9. Homoskedasticity tests

Dependent variable	Equation	Sample period	Country	Marginal Significance level(F-test)
$\left[f_t - s_{t+1}\right]^2$	(4.19)	80,1-87,5	West Germany	0.986
			U.S.A.	0.810
			United Kingdom	0.041
			Index	0.989
		82,10-87,5	West Germany	0.454
			U.S.A.	0.023
			United Kingdom	0.717
			Index	0.002
$\left[\hat{\epsilon}_{t+1}\right]^2$	(4.20)	80,1-87,5	West Germany	0.972
			U.S.A.	0.679
			United Kingdom	0.267
			Index	0.985
		82,10-87,5	West Germany	0.409
			U.S.A.	0.723
			United Kingdom	0.377
			Index	0.604
$\left[\hat{\nu}_{t+1}\right]^2$	(4.21)	80,5-87,5	West Germany	0.997
			U.S.A.	0.992
			United Kingdom	0.998
			Index	0.948
		83,2-87,5	West Germany	0.414
			U.S.A.	0.940
			United Kingdom	0.083
			Index	0.351

4.6 CONCLUDING COMMENTS

Before we summarize our results, some statistical caveats relating to our tests must be pointed out. In particular, one may have some doubts about whether the innovations in the currency index are normally distributed as implicitly assumed in our analysis. As the policy of the Riksbank is to keep the index within a certain band around the benchmark value, the normality assumption may not be justified when the index is close to one of the limits (and when the limits are credible). Experience should also have taught market participants that there is a non-negligible risk of a large discrete change in the benchmark value in the form of a devaluation.

Non-normality implies that classical significance tests (based on the F and t distributions) are not valid. It has been argued that the problem is one of small-sample inference.[13] If, e.g., agents (rationally) assign a positive probability to the event of a large devaluation, while the econometrician's sample does not include any, it will seem as if the market systematically overestimates the rate of depreciation. Since there is uniformly weaker evidence against unbiasedness when the Swedish 1981 and 1982 devaluations are included in the sample, the findings from post-devaluation data should perhaps be interpreted with caution.

However, it can also be argued that these problems of non-normality are not so severe in the period under study. First, the bounds for the currency index were not publicly announced until July 1985. Prior to that, the central bank had been working with a secret band which means that market participants could never know for sure that the index could go only in one direction. Second, the devaluation in October 1982 was announced as the definitely last attempt to cure the imbalances in the Swedish economy by means of major exchange rate changes. Although such an announcement in itself has little information value, it seems to have gained credibility, at least in a short run perspective. As we are studying one month ahead forward rates, it can be hoped that our estimates are not affected by these factors. To the extent that there really was a regime shift in October 1982, data from an earlier

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[13] The problem has been analyzed theoretically by Obstfeld (1987), and empirically by Boothe and Glassman (1987); these papers also contain further references to earlier studies on the subject.

period may be of limited interest to the question of Sweden's monetary autonomy today. On the other hand, the risk associated with exchange rate changes within the bounds may be rather negligible in comparison with the risk of devaluations, as indicated by the figures in Table 3. The theoretical, empirical, and econometric role of devaluations is thus an important question for future research.

With these caveats in mind, we can conclude that there are theoretical reasons to believe that investors' risk aversion should drive a wedge between domestic and foreign interest rates in a currency basket system of the Swedish type. On balance, our empirical results are also <u>consistent</u> with the existence of a risk premium on the krona. A necessary condition for Sweden to have some latitude for an independent monetary policy would thus be fulfilled. The fact that we obtained mixed results in the bilateral tests illustrates our point that these may be of limited interest for the question of monetary independence in a country pursuing a currency basket policy. For example, the failure to establish a non-zero risk premium (or, rather, to reject unbiasedness) on the krona relative to the German mark cannot be interpreted as evidence of lack of monetary autonomy. Rather, in light of the discussion in Section 4.3, it should be interpreted as an indication that the risk premium which is due to the variability in the index happens to be approximately equal (but opposite in sign) to the premium which is due to "international risk".

The conclusion that there is a risk premium does in no way demonstrate that Swedish monetary policy has been effectively used to control the domestic interest rate level, however. To introduce a risk premium, all the authorities have to do is let the currency index vary sufficiently, but it is an entirely different matter whether one can also influence the size of that premium in any useful sense. In the simple mean-variance model analyzed in Section 4.3, there is a direct connection between the risk premium and a policy variable, namely, the stock of assets in the economy, summarized by the vector x_t. As discussed in Chapter 3, this implies that open market operations can be used to influence the risk premium, just as in conventional macro portfolio balance models. Although it seems safe to assume that the conclusion that asset supplies affect asset prices should hold also in more general models, this very simple mechanism need not be invariant to modifications in the underlying asset pricing model. The questions of whether the risk premium can (and should) be exploited for stabilization policy purposes deserve further attention.

We should also stress that although we interpret our empirical results as broadly consistent with the existence of risk premia, it cannot be said that this proposition has been firmly established. What we have found is that forward premia are not very good, and typically biased, predictors of changes in future spot rates. The source of the bias and the variables in the information set that have larger predictive power are yet to be detected.[14]

In order to draw more specific conclusions about the nature of risk premia in currency basket systems, as well as in other policy regimes, one would have to go beyond the atheoretical approach used in this chapter and test the explanatory power of structural models along the lines of, e.g., Frankel (1982) and Mark (1985).

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[14] The efficiency of the estimates in the bilateral relations may, as pointed out in the introduction, be improved by use of SUR rather than OLS. However, this is not a relevant alternative for the regression analyses of the currency basket, which is our main concern.

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5. The Current Account, Supply Shocks and Accommodative Fiscal Policy*

5.1 INTRODUCTION

In policy discussions in small open economies the current account is frequently used as an important macroeconomic information variable or intermediate target. This practice is, explicitly or implicitly, based on certain opinions about what factors are important in explaining and forecasting the current account. It is, e.g., a widely held view that domestic wages and the terms of trade play important roles. Changes in national saving are also often seen as indicating that stabilization policy is overly expansive or contractive. In ex post interpretations of the current account development "wage shocks", "price shocks", and "policy shocks" are prominent "explanations". The primary aim of this chapter is to assess the importance of these types of shocks for the Swedish current account development during the post-war period.

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Recent theoretical work analyzing the current account in an intertemporal general equilibrium framework teaches that the directions of the effects of various macroeconomic disturbances are in general ambiguous and depend crucially on the exact nature of the model studied; see, e.g., Obstfeld (1982), Svensson and Razin (1983), and Persson and Svensson (1985) on the Harberger-Laursen-Metzler (terms of trade) effect; Svensson (1984) on the effects of oil price and labor supply changes under sticky and flexible wages; Sachs (1982) and Razin (1984) on the effects of changes in government spending, etc.

In trying to use these theoretical model structures as a basis for econometric studies of the current account we face the well-known problem that factors taken to be sources of exogenous disturbances in the analytical model (terms of trade, labor supply, government expenditures, etc.) cannot plausibly be assumed to be strictly exogenous in the econometric model. The endogeneity of most relevant factors is well illustrated by a brief sketch of the Swedish post-war current account history (see e.g. Lindbeck (1975), Lundberg (1985) and Bosworth and Rivlin (1987) for more thorough treatments of Swedish stabilization policy). Some relevant data are plotted in Figures 1a-d.

The current account deficits in 1947-48 and surpluses in 1949-53 have been viewed as consequences of the development of the nominal exchange rate, the terms of trade and real wages. In 1946 the krona was allowed to appreciate in an attempt to insulate the Swedish price level from the international inflationary tendencies. In 1949, in contrast, the krona depreciated by ten per cent against the most important trading partners' currencies. This shock to the exchange rate was followed by a gradual decline of the real wage. The terms of trade fell temporarily, but improved (likewise temporarily) when raw materials prices rose during the Korea war boom.

Figure 1 a: Current account/price of imports

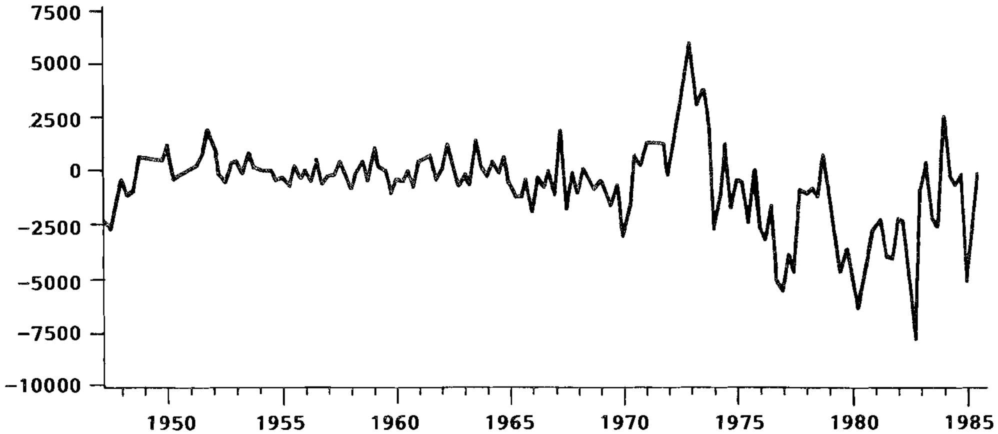


Figure 1 b: Log of real government consumption

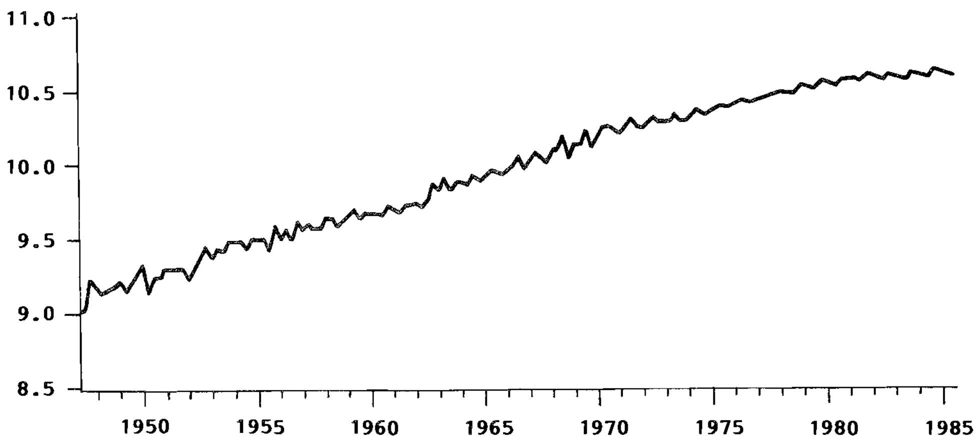


Figure 1 c: Log of terms of trade

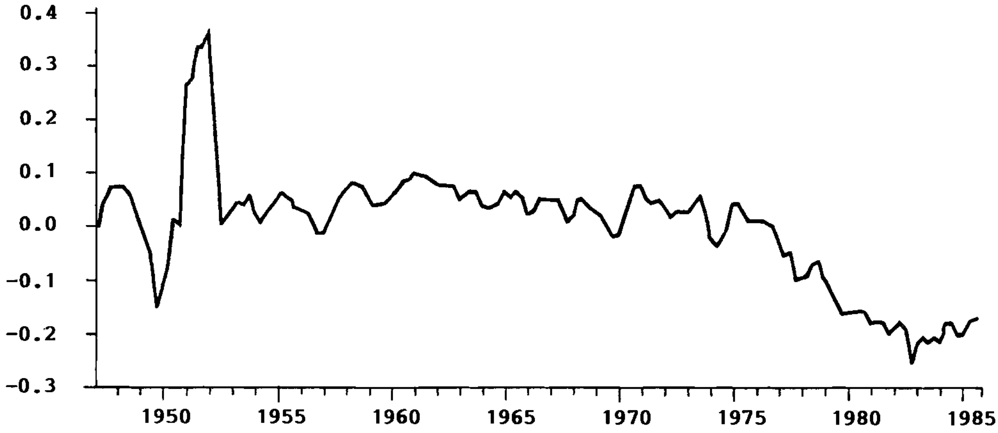
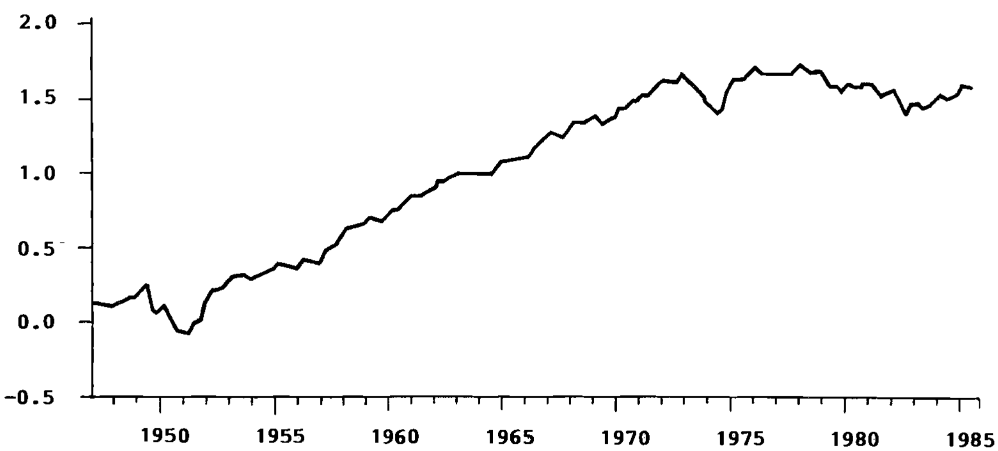


Figure 1 d: Log of real wage



The current account was approximately balanced over the decade 1954-1964, perhaps due to successful stabilization policies. The stimulative and contractive measures undertaken in the following decade do not appear to have been equally well timed. It has been claimed that fiscal policy shocks account both for the current account deficits in the late 1960's and the surpluses in 1971-1973.

The first half of the 1970's may be characterized by the combination of large supply shocks and policy shocks. When the world economy, following the first oil crisis, turned into a recession and the Swedish terms of trade deteriorated, Swedish economic policy was aimed at preserving a high level of employment. Government expenditures continued to increase rapidly, particularly in relation to the stagnating private sector development. International inflation, in combination with the design of economic policy, is believed to be the main cause behind the extreme increases in nominal wages: more than 40 per cent during 1975-76. Real wages also rose rapidly, despite the downward trend in the terms of trade. These developments were accompanied by a current account deterioration much stronger than the OECD average; cf. Sachs (1981).

The second half of the 1970's was a period of inflation and government budget and current account deficits. It is believed that the lingering external balance problems reflect a lag in the adjustment of real wages and overall spending to the international stagnation. It is also believed that the accommodative design of macroeconomic policies hindered a more rapid adjustment. Devaluations were undertaken in 1976, 1977, 1981, and 1982. Real wages started to fall in 1978, but the current account remained in deficit until 1984.

Interpretations of economic history tend to view causation as going from policy and external shocks to the variable of interest, in our case the current account. Such interpretations are complicated by the fact that some shifts in supply curves and policy have not been autonomous but are closely related to each other and to the development of the current account. The deterioration of the current account and budget balances in the 1970's may, e.g., be explained by increases in government spending in the form of employment benefits or public employment that resulted from the terms of trade and wage shocks, as suggested by Söderström and Viotti (1979). But some economists have argued that there may be a reverse causation in that the frequency and size of wage disturbances depend on the government's choice whether to accommodate supply shocks or not (see, e.g., Calmfors and Horn (1986)). Further, the current account may serve as a target for government policy. This has, e.g., been suggested by Summers (1987) as an explanation of the Feldstein and Horioka (1980) finding that savings and investment rates tend to be highly correlated. For a statement by Swedish policy makers about the importance attached to the current account see Heikensten and Åsbrink (1986). See also Söderström (1984) for a discussion of the relation between the current account and fiscal policy.

In accounting for interdependencies such as those mentioned above in econometric work there are two basic approaches. One is to attempt to formulate and estimate a structural model incorporating reaction functions on part of unions and the public sector. The alternative is to recognize that with many competing structural models, and the absence of strong prior beliefs in the correctness of any of these, the data should be allowed to speak for themselves with only a minimum of identifying assumptions imposed.

In this chapter, we choose the latter alternative and estimate a vector autoregression (VAR) model with the current account, the real wage, the terms of trade and government consumption. We use the estimated model to illuminate the role played by various shocks to the development of these variables. Following Sims and others, this is done by techniques of "innovation accounting" and "impulse response" analyses. In order to be able to do this we specify, and put restrictions on, a structural model that allows us to identify innovations to this model from the estimated VAR system. Our use of VAR analysis in this way follows recent work by Sims (1986), Blanchard and Watson (1986), and Bernanke (1986).

Our theoretical and methodological framework is discussed in the next section, and the empirical results are presented and interpreted in Section 5.3. A principal result is that the forecast error variance in the current account is to a very limited extent accounted for by shocks to the terms of trade, wage, or government consumption. We suggest that domestic productivity shocks and domestic and international demand shocks may be the dominant sources of current account variations. In contrast, terms of trade shocks are a major source behind the uncertainty about the development of the real wage.

5.2 THE ECONOMETRIC MODEL

Our purpose is to assess the impact and importance of various types of shocks on the Swedish current account by means of interpreting estimated vector autoregressions via impulse response functions and innovation accounting. The impulse response is the analog of a comparative static effect, i.e., the effect over time on a certain endogenous variable from a particular shock holding other stochastic terms fixed. Innovation accounting amounts to a decomposition of the variance of the forecast error of a certain variable into the contributions of the different shocks to the system.

An unrestricted vector autoregression model can be seen as a reduced form from any of a family of structural models containing the variables included in the VAR system. Hence, the residual in a particular equation will be some combination of shocks to the underlying model. This means that in order to give a structural meaning to the variance decompositions and impulse response functions we have to make assumptions that allow us to identify the shocks to the structural model.

In Section 5.2.1 we outline a model of a small open economy, which is broadly in line with recent models aimed at analyzing policy options in small open economies with strong labor unions and a large public sector; see, e.g., Persson and Svensson (1987). This model provides a framework for interpreting the results. Specifically, we use it to motivate our choice of variables to include in the VAR system and the assumptions made that enable us to identify the structural shocks. Following a brief description of the VAR methodology in Section 5.2.2 the identification problem is discussed in Section 5.2.3.

5.2.1 A model of the current account

Almost all recent analytical studies of the determinants of the current account employ a deterministic framework.[1] Several authors, e.g., Persson and Svensson (1985), analyze the difference between fully anticipated and fully unanticipated disturbances in deterministic terms, but there are no stochastic models in the literature that are sufficiently rich to serve directly as a framework for econometric modelling. The model presentation in this section follows the standard practice of grafting a simple stochastic structure onto a deterministic model.

The following features of the model are worth emphasizing. First, it is a real model, where inflation and nominal exchange rates are absent. Second, neither wages nor goods prices are necessarily market clearing, but are thought of as being set by labour unions and other price setters without full information

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1 One exception is the work by Clarida (1986a,b) analyzing stochastic general equilibrium models of a world comprised of a continuum of small economies all subject to productivity shocks. Surpluses and deficits to the balance of payments result from the desire to smooth consumption relative to the income pattern.

about contemporaneous market conditions. Third, government expenditure is taken to be endogenous with the aim of accommodating tendencies to unemployment that may result from private sector behaviour. Fourth, exports may be large relative to world market demand, i.e., the terms of trade are not a priori assumed to be strictly exogenous.

The equations in the model are subjected to a vector of fundamental stochastic shocks, u_t, which are serially uncorrelated. The model contains both contemporaneous and lagged variables, but we will not be explicit about the exact role played by the lagged variables. They may represent the direct impact of past decisions due to transactions and adjustment costs as well as the informational content in past observations for making predictions about the future. We are also agnostic about what lagged variables enter into what equation and simply represent all lagged variables by an unspecified vector Ω_{t-1} which is the same in each equation. In contrast a careful specification of contemporaneous interactions is crucial in order to discuss how the various structural shocks may be identified from the estimated VAR system.

A crucial step in any vector autoregression is the choice of variables to include. In the present study we limit ourselves to four: the current account, the terms of trade, the real wage, and government consumption. At this stage one aspect of this choice merits mentioning. As the modern theory of current account determination is explicitly intertemporal it would be natural to include an interest rate among the variables. Our reason for not doing so is that regulations both in the domestic credit market and with regard to international capital flows have for most of the period under study been so prominent in Sweden as to make interest series hard to interpret. It is an important challenge for research, however, to construct a data series that adequately represents the rate of discount relevant to Swedish decision makers.

We may now outline the model. There are two goods. The production of home goods, Y, is used both for consumption, C^h, and investment, I, with the remainder being supplied to the world market. With market clearing world market prices exports, X, equals $Y - C^h - I$. In general we do not assume prices to clear the export market, however, as is further discussed below. Foreign goods are used for consumption, C^f, and as intermediary inputs in production, M.

The focus of analysis is on the current account defined by

$$CA_t = p_t X_t - C_t^f - M_t + r_t F_t, \tag{5.1}$$

where F_t is net foreign assets, r_t is the interest rate, and p_t is the price of home goods in terms of foreign goods, i.e., the terms of trade. Foreign assets evolve according to

$$F_t = F_{t-1} + CA_{t-1}. \tag{5.2}$$

The representative <u>firm</u> produces home goods using capital, K, labour, L^h, and intermediary goods, M, as inputs;

$$Y_t = Y(K_t, L_t^h, M_t, u_t^y), \tag{5.3}$$

where u^y is a productivity shock. The firm maximizes its market value treating the price of home goods, p, and the wage level, w, as exogenously given. Both these prices are in terms of the world market price of foreign goods which serves as the numeraire. This gives rise to the factor demand equations

$$L_t^h = L^h(w_t, p_t, \Omega_{t-1}, u_t^l), \tag{5.4}$$

$$I_t = I(w_t, p_t, \Omega_{t-1}, u_t^i), \text{ and} \tag{5.5}$$

$$M_t = M(w_t, p_t, \Omega_{t-1}, u_t^m), \qquad (5.6)$$

where the lagged variables Ω_{t-1} are relevant due to adjustment costs and/or in affecting expectations, and there are separate but possibly correlated shocks to each of the factor demand equations. On the other hand, factor demands are unaffected by the current productivity shock u_t^y which we assume is not observed by firms when hiring decisions are made. The rate of discount should also enter the factor demand equations, but it is suppressed since it will not be a part of our VAR representation of the model. The development of the capital stock is given by

$$K_t = (1-\delta)K_{t-1} + I_{t-1}, \qquad (5.7)$$

where δ is the rate of depreciation.

The <u>public sector</u> produces government consumption goods according to the production function

$$G_t = G(L_t^g). \qquad (5.8)$$

In deciding about employment in the public sector the government attempts to offset variations in private sector employment that result from union set wages. It also tries to adjust public employment in order to supply G according to consumer preferences. In these decisions it uses whatever available information variables that are related to its goals. We assume that the government observes contemporaneous prices, i.e. p and w, but not contemporaneous quantities, e.g. CA or Y.[2] We may then write the government's decision rule as

$$L_t^g = L^g(w_t, p_t, \Omega_{t-1}, u_t^g). \qquad (5.9)$$

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2 One motivation for this assumption may be that national accounts statistics are typically produced with a lag of at least a quarter.

The fiscal policy shock u^g may be seen as representing the peculiarities of the political decision making process and the preferences of the ruling party.

The representative consumer maximizes discounted expected lifetime utility, with instantaneous utility derived from the consumption of home goods, C^h, foreign goods, C^f, government goods, G, and working time. The working week is fixed and all consumers want to work. Assuming labour demand not to exceed potential supply this means that working time is given by L^h + L^g. The representative consumer can then be viewed as maximizing utility over C^h and C^f restricted by his net wealth, defined as the discounted value of future production net of taxes minus foreign indebtedness, and by given values of G and L^h + L^g. This gives rise to demand functions

$$C_t^j = C^j(Y_t,\ p_t,\ G_t,\ L_t^h+L_t^g,\ \Omega_{t-1},\ u_t^j) \qquad j = h,\ f, \quad (5.10)$$

where the interest rate is again suppressed. Preferences are assumed to be subjected to random shocks. Note that taxes are not present in (5.10), which means that we have imposed the assumption of "Ricardian equivalence". This is a strictly empirical hypothesis, which will be indirectly tested as we check the sensitivity of our regression results to the inclusion of the government budget balance.

Wages are set by the the representative labor union, which maximizes the expected discounted utility of its representative member. In doing this it takes the full structure of the model into account. This means that it has the same maximand as the union member, but it maximizes over the wage restricted by its expectations of the economy's resource constraint. We assume that the labour union may possibly observe the current value of government consumption, G, and the terms of trade, p, but not the current values of production or the current account. Alternatively, it may be assumed that the union maximizes a function of real wages and employment, in which case the current value of CA is not a relevant variable, not being an argument in either the factor demand functions or the public sector decision function. These considerations give rise to

$$w_t = w(G_t, p_t, \Omega_{t-1}, u_t^w). \tag{5.11}$$

The wage shock u^w represents the particular preferences of the union leadership, e.g., the weight put on real wages in relation to employment.

We assume that import prices are exogenously determined, the reason for this being that the country is small relative to the market for foreign goods. On the other hand, we assume that the domestic production of the representative home good is large relative to the size of the world market for these goods, and so the volume of exports may have an impact on world market prices. This, of course, is not in conflict with the assumption made above that the representative domestic firm is a price taker in the world market. The world market demand curve for home goods may be written

$$x_t = x(p_t, \Omega_{t-1}, u_t^x), \tag{5.12}$$

where u^x is a shock to world market demand and the vector Ω represents relevant variables in the information sets of international agents. Assuming market clearing (5.12) may be inverted to yield the <u>terms of trade</u> as a function of exports

$$p_t = p(x_t, \Omega_{t-1}, u_t^x). \tag{5.13}$$

Alternatively world market prices may be taken to be pre-determined. More precisely it is assumed that prices are set without access to any contemporaneous information, in particular about current supply. This implies that the terms of trade equation should be written

$$p_t = \tilde{p}(\Omega_{t-1}, u_t^p), \tag{5.14}$$

where u_t^p is a shock to the price setters' behavior. Note the difference in interpretation between the shocks to (5.13) and (5.14). With contemporaneous market clearing a price shock is a shock to the world market demand curve. With predetermined prices u^p is an autonomous shock to price setting which is unrelated to the contemporaneous demand shock.

If p is predetermined the home country may find itself rationed in the export market. Let us assume that the export volume is given by the minimum of demand and supply, i.e.,

$$X_t = \begin{cases} Y_t - C_t^h - I_t & \text{if } Y_t - C_t^h - I_t < X(p_t, \Omega_{t-1}, u_t^x) \\ X(p_t, \Omega_{t-1}, u_t^x) & \text{if } Y_t - C_t^h - I_t \geq X(p_t, \Omega_{t-1}, u_t^x) \end{cases}, \tag{5.15}$$

where p_t is given by (5.14). We must also make assumptions about what happens with those goods that are not exported when $Y - C^h - I \geq X(p, \Omega, u^x)$. The simplest assumption is that they are neither storable to the next period nor made available for consumption and investment in the present period. Alternatively, they may be stored and supplied to the market in the next period. In any case the decision problem facing the agents in the economy will be affected relative to a world of market clearing. In particular there will be an extra intertemporal link in that today's world market prices will affect tomorrow's decisions via its effects on the inventories carried over. This will not, however, introduce any new arguments into any of the equations as defined above as lagged world market prices are contained in the vector Ω.

Let us now rewrite the model in terms of the four endogenous variables w, G, CA, and p. Among these w is already expressed as a function of G and p by (5.11), and government consumption is simply given by substituting (5.9) into (5.8) as

$$G_t = G(w_t, p_t, \Omega_{t-1}, u_t^g). \tag{5.16}$$

Further, substitution from (5.2) - (5.10) and (5.15) into (5.1) yields

$$CA_t = CA(w_t, p_t, G_t, \Omega_{t-1}, u_t^y, u_t^l, u_t^i, u_t^m, u_t^h, u_t^f, u_t^x), \tag{5.17}$$

where $u^x(u^i, u^h)$ only appears to the extent that domestic export supply does not fall short of (exceed) the demand for exports.

Finally, we have the terms-of-trade equation. With p predetermined it is simply given by (5.14). With contemporaneous market clearing substitution from (5.1) into (5.13) gives p as a function of CA, C^f, and M. After substitution from (5.2) - (5.4), (5.6), (5.8), and (5.10) we then have

$$p_t = p(CA_t, w_t, G_t, \Omega_{t-1}, u_t^y, u_t^l, u_t^m, u_t^f, u_t^x). \tag{5.18}$$

Equations (5.11), (5.16), (5.17) and (5.18), or (5.14), form an interdependent system from which CA_t, p_t, G_t, and w_t can be solved as functions of the vector u_t and Ω_{t-1}. In order to understand what information we may gain about this system from a vector autoregression we will devote the next section to a brief methodological overview.

5.2.2 Vector autoregression methods

A vector autoregression model is a system of n equations

$$Z(t) = C(L)Z(t) + v(t), \tag{5.19}$$

where Z(t) is a variable vector, C(L) is a matrix of lag polynomials defined by

$$C(L)Z(t) \equiv \sum_s C_s Z(t-s), \qquad s > 0$$

and v(t) is a vector of white noise residuals. This system can be seen as a reduced form of the "structural" model

$$Z(t) = B_0 Z(t) + B(L)Z(t) + Au(t), \tag{5.20}$$

where B_0 is a coefficient matrix of contemporaneous relations (with zeros on the diagonal), B(L) a matrix of lag polynomials, u(t) a vector of structural disturbances, and A a coefficient matrix. Off-diagonal elements of A indicate that a structural disturbance affects more than one equation. The elements of u are assumed to be uncorrelated, i.e. $E(u_t u_t') = \Sigma$ is a diagonal matrix. The coefficients and residuals in the reduced form VAR model are related to the structural model by

$$C(L) = (I-B_0)^{-1}B(L) \tag{5.21}$$

$$v(t) = B_0 v(t) + Au(t). \tag{5.22}$$

Equation (5.22) is a purely contemporaneous structural model. Since there are n(n+1)/2 distinct elements in the variance covariance matrix vv′ and Σ is diagonal, giving n variances to estimate, it is possible to identify a maximum of n(n-1)/2 distinct parameters of B_0 and A.

The estimated VAR model may be used to do innovation accounting and to calculate impulse response functions. To do this rewrite the VAR model into the moving average system

$$Z(t) = H(L)u(t), \text{ where} \tag{5.23}$$

$$H(L) = (I-C(L))^{-1}(I-B_0)^{-1}A. \tag{5.24}$$

The moving average representation (5.23) is sometimes called the <u>impulse response</u> function as it gives the impact on the vector Z in period t of a specific innovation in a certain earlier period. Based on this representation of the model one may also decompose the variance of the k period ahead forecast error of variable i into the effects of the variances of the innovations,

$$E\{[Z_i(t+k)-E_tZ_i(t+k)]^2\} = \sum_{s=0}^{k-1} \sum_j H_s(ij)^2\sigma_j, \qquad (5.25)$$

where $H_s(ij)$ is an element of the coefficient matrix H(L) at lag length s and σ_j is the j-th diagonal element of Σ. A decomposition of the variance for the i-th variable into the contributions of innovations in the different structural equations j is called <u>innovation accounting</u>.

As should be clear from this discussion innovation accounting and impulse response calculations are done based on a particular orthogonalization of the errors to the VAR system. The appropriate way to do this is to identify and estimate the parameters of B_0 and A in the structural contemporaneous model (5.22). The most widely used method for doing this assumes that A = I and that the B_0 matrix is lower triangular, i.e., that the contemporaneous model is recursive. In this case the parameters of B_0 may be estimated by OLS.

<u>5.2.3 Identifying assumptions</u>

Our model of the current account summarized in equations (5.11), (5.16), (5.17), and (5.18), or (5.14), can be rewritten so that it corresponds to the structural model (5.20). We assume that the vector Ω_{t-1} consists only of lagged values of the endogenous variables in this model. Then the reduced form of the model is a system of vector autoregression equations corresponding to (5.19) stating CA_t, w_t, p_t, and G_t as functions of lagged values of these variables and contemporaneous shocks. We note that our structural model is highly interdependent. In particular this is so under the assumption of market clearing with the terms of trade given by (5.18). In that case the assumptions made about contemporaneous interactions only restrict two of the (off-diagonal) parameters of the matrix corresponding to B_0 to zero; G_t and w_t do not depend on CA_t. Further, the (composite) shocks to the terms of trade and current account equations are correlated even if all elements of the vector u are assumed uncorrelated.

To achieve identification we will assume that prices are predetermined according to (5.14). This may either be interpreted as a small country assumption, in which case prices are exogenous, or as an assumption that prices are fixed by long term contracts that are made without information about the current state of the world. Predetermined terms of trade ensures that shocks are uncorrelated across equations. Let us further assume that w_t does not depend on G_t, i.e., that the labour unions in setting the wage level only have access to information about current terms of trade, whereas the government in deciding about public expenditure can observe both current terms of trade and wages. In other words, we assume that the labor union does not know the extent to which a wage disturbance will be accommodated by fiscal policy.

These assumptions give us a recursive system with the ordering p - w - G - CA, i.e., the matrix corresponding to B_0 is lower triangular under this ordering, and its elements may be estimated by OLS regression of the residuals from a standard VAR estimation. Assuming the elements of u to be uncorrelated the matrix corresponding to A will be an identity matrix. It is now possible to interpret each shock as pertaining to a particular equation of the structural model. The wage, terms of trade, and government consumption shocks correspond directly to u^w, u^p, and u^g, and the current account shock, which we denote by u^{ca}, is some combination of export demand, domestic productivity, factor demand and preference shocks.

Since the model is exactly identified it is not possible to test the identifying assumptions. What may be done is to investigate the sensitivity of the results, i.e. the impulse response functions and the variance decompositions, to alternative exactly identifying assumptions.[3] If the results would vary strongly when such untestable assumptions were altered this could be seen as an indication that it is not possible to make any structural interpretation of the innovations. On the other hand, if results were relatively insensitive, this might indicate that it was permissible to regard the innovations as shocks to the structural equations.

It bears emphasizing that by investigating alternative identifying assumptions we do not just mean mechanically changing the recursive ordering, a practice which was common in early VAR studies and which is forcefully criticized by Cooley and LeRoy (1985). Indeed there is only one other recursive ordering (p - G - w - CA) that is compatible with our theoretical model, and if p was not taken to be predetermined the system would be fundamentally non-recursive, since CA_t by definition depends on p_t. Such non-recursivity would affect the estimation methods which could be by instrumental variables as in Blanchard and Watson (1986) or by methods of moments as in Bernanke (1986). Further it would affect the structural interpretation of the innovations; e.g., the terms-of-trade innovation would now reflect, among other things, the innovation to export demand.

It may be regarded as a weakness that results are potentially sensitive to untestable identifying assumptions. It need be kept in mind, however, that the alternative modelling strategy, to which VAR analysis is a reaction, is to impose a lot of overidentifying restrictions at the outset. Vector autoregressions may be regarded as a way of investigating how

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3 See Blanchard (1986) for an example of systematic sensitivity testing.

far, if anywhere, one can get with a minimum of structural assumptions.

In the next section we report the results of a study where we first estimate an unrestricted vector autoregression corresponding to (5.19), then estimate the parameters of B_0 and Σ based on the assumed recursive ordering p-w-G-CA and finally use these estimates for innovation accounting and impulse response calculations, where we identify the innovations as innovations to particular structural equations.

5.3 RESULTS

5.3.1 Data description

Our four variable VAR system is estimated on quarterly observations from 1948:2 to 1985:3. The data series used are plotted in Figures 1a-d. The terms of trade (p) are defined as the ratio between the export and import price indices. The real wage (w) is the index for labor costs in the industrial sector divided by the import price index. For real government consumption (G) no quarterly series exists before 1970. We have constructed quarterly data prior to 1970 by using the yearly government consumption series together with the quarterly series of central government expenditure. Similarly, no quarterly data for the current account (CA) exist before 1970. The series used has been constructed from the quarterly trade balance statistics. See appendix A for further details.

The original current account and government consumption series showed marked seasonal patterns. Due to our construction of the quarterly data for the earlier years these patterns were different before and after 1970. The terms of trade and the real wage on the other hand show no clear seasonalities (cf.

Figures 1c-d). In our estimations we have thus used seasonally adjusted series of G and CA, where the seasonal components have been calculated from OLS regressions of each series on quarterly dummies and a set of powers of time. Different regressions were run for the two subperiods; see appendix B for further details on the seasonal adjustment of the data. Quarterly dummy variables were included in the estimated VAR system to capture possible deficiencies in the method used for deseasonalization.

Before presenting the estimated model, we should comment on the problem of drawing inferences from vector autoregressions of non-stationary data. Table C1 in appendix C gives the results of testing whether the univariate time series are integrated of order one, i.e., whether their first differences are stationary. For each of the series contained in our model we find that first order integration cannot be rejected. This is well in accord with the results of Nelson and Plosser (1982). We have not, however, tested for the presence of cointegration among these series, i.e., whether linear combinations of any of the series are stationary. With more than two variables, and the possibility of more than one cointegrating vector, such testing becomes quite complex; see Engle (1987) for a survey and a discussion. Since we are not interested in cointegration per se we have chosen to estimate our model on the original data in levels despite their possible non-stationarity. In doing this we rely on results of Sims, Stock and Watson (1987) showing that the asymptotic distribution for the coefficient estimates of an unrestricted vector autoregression in levels is identical with that for a model where the cointegrating vector is known exactly a priori and this is imposed as a restriction on the estimation.[4]

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4 In small samples on the other hand there are differences. Engle and Yoo (1987) report a Monte Carlo forecasting experiment, comparing a vector autoregression in levels with the Engle and Granger (1987) two step method. They find that the former yields better forecasts over very short horizons but that the latter is superior after about four periods.

We have investigated the sensitivity of our results by running a regression on differenced data, which would be the appropriate thing to do if the series were first-order integrated but not cointegrated. The differences in results are mostly minor with one or two exceptions which will be commented on below.

5.3.2 The estimated VAR model

The estimated VAR system is presented in appendix C, Table C2. It includes four quarters of lagged variables. None of the equations show significant residual autocorrelation.[5] The covariance matrix of the residuals is displayed in Table 1. There is considerable correlation between the residuals of the wage, price and current account equations, whereas the residual associated with government consumption appears largely uncorrelated with the other residuals.

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5 When estimating on first differenced data there is significant autocorrelation in the current account equation.

Table 1

Covariance matrix of residuals
(Entries below the diagonal are correlations.)

	v^p	v^w	v^g	v^{CA}
v^p	.00092	0.00032	.000003	10.883
v^w	.36	.00087	-.00008	10.999
v^G	.003	-.09	.00088	-2.007
v^{CA}	.26	.27	-.05	1.859.400

Table 2

Tests of Marginal Predictive Power of (4 lags of)
Row Variables for Column Variables
(Marginal Significance Levels)

	p	w	G	CA
p	.000	.000	.503	.969
w	.422	.000	.105	.887
G	.006	.196	.000	.293
CA	.636	.262	.768	.000

Chow tests indicate some parameter instability within the sample period. Dividing the sample in 1970 gives significant differences between the subperiods for the terms of trade and wage equations. Since the Korea boom is often found to be hard to accommodate within the same model as the period thereafter we also estimated the model for 1954:2-1985:3. Again, Chow tests show signs of instability of the terms of trade and wage equations before and after 1970. While the main results remain unaltered between the periods we shall see that there are some interesting differences, e.g., with regard to the exogeneity of the terms of trade.

Even though the estimated system in itself is not of primary interest a few brief comments should be made. It is striking that the variables included contribute much less to explaining the variations of the current account than they do for the other variables; the coefficient of determination is only .44 for this equation against over .9 for the other equations.[6] Considering that the current account is the difference between two macroeconomic aggregates it may not be surprising that it is harder to predict than the other series. It is a bit surprising, though, that the explanatory power is so low, considering the fact that we have taken account of the variation in three variables which are usually thought of as the most important sources behind the fluctuations in the current account.[7]

The trend terms turn out to be relatively unimportant. They are quantitatively rather small, and three out of four are not significantly different from zero. The only significant trend term is that of the terms of trade equation, which contributes to a quarterly decline of the Swedish terms of trade by .19 percent.

In general we find that few variables other than lagged values of the dependent variable itself are significant. Table 2 gives the results of Granger causality tests, i.e., tests for the marginal predictive power of all lagged values of a variable in

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6 For the subperiod 1946-69 it is not even possible to reject the hypothesis that the current account is white noise.

7 Three potentially important variables which have not been incorporated in the VAR model are interest rates, the nominal exchange rate and the government budget deficit. The reason for excluding the interest rate has been discussed. We have chosen not to include any exchange rates, since changes in nominal exchange rates are believed to affect the current account primarily through changes in real wages or terms of trade. Inclusion of the (seasonally adjusted) government budget balance does not significantly improve the fit of the CA equation (cf. Table C7).

an equation. We can reject the hypotheses that the terms of trade are not Granger caused by government consumption and that the wage is not Granger caused by the terms of trade. Apart from these two cases, however, only lagged values of the dependent variables themselves have significant explanatory power. We cannot reject the hypotheses that government consumption and the current account are exogenous.[8]

Some of the results with regard to Granger causality change when the system is estimated on differenced data (with the trend excluded). In this case we cannot reject that w is exogenous; it Granger causes p (marginal significance .001), whereas p does not seem to Granger cause w (marginal significance .09). G still Granger causes p, and it remains that one cannot reject exogeneity of CA (cf. Table C4). These results were also obtained when the system (in levels) was estimated using eight lags instead of four, except that in this case a significant influence from p on w was also found.[9]

When only post-1954 or post-1970 data are used, the exogeneity of p cannot be rejected (cf. Tables C5-6). The exogeneity of G with respect to w is rejected for the period 1954:2-1985:3, but not for the periods 1949:2-1969:4 or 1970:1-1985:3. The result with regard to the exogeneity of the current account is, however, very stable across different specifications and variable definitions.[10] In particular, inclusion of the

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8 Granger non-causality is a necessary, but not sufficient, condition for exogeneity (cf. Cooley and LeRoy (1985)).

9 For the VAR model as a whole, it is restrictive to limit the lag length to four quarters, at least according to the likelihood ratio test suggested by Sims (1980a, p. 18). It is only in the terms of trade equation, however, that there is significant explanatory power attached to the group of variables with 5-8 lags (cf. Table C3).

10 For instance, CA remains exogenous when w, G, and CA are normalized by division by industrial production (with no variables expressed in logarithms, and industrial production not seasonally adjusted). This normalization could, perhaps, be motivated as an attempt to transform the original data to stationary series. Neither does exclusion of the trend from

(seasonally adjusted) government budget balance did not significantly improve the fit of the CA equation (cf. Table C7).

It may be tempting to interpret, e.g., the exogeneity of p in the post-1970 data set as an indication that Sweden is now a small open economy, or the exogeneity of CA with respect to the government budget balance as consistent with the "Ricardian equivalence" hypothesis. As we have not made any structural assumptions to account for the role of lagged variables we are not entitled to make such interpretations.

5.3.3 Responses to structural shocks

In interpreting our VAR system via impulse response functions and variance decompositions we will assume as discussed in Section 5.2.3 that the contemporaneous part of the model is recursive in the order p - w - G - CA. This assumption allows us to identify the shocks to the structural model, i.e., the elements of the u vector. As we have seen from Table 1 that the stochastic disturbances of the reduced form VAR system - particularly v^p, v^w, and v^{ca} - are correlated, it is clear that our interpretations may be sensitive to this recursivity assumption. Modifying the recursive ordering to p - G - w - CA does not change any of the results markedly.

Let us with this caveat in mind look at Table 3, which displays our estimates of what corresponds to the non-zero elements of B_0 of (5.20).[11] Our interpretation of this is that a positive terms of trade shock leads the labour unions to revise their wage demands upwards and that the instantaneous

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the VAR model lead to rejection of the exogeneity of CA. These regressions are not reported.

[11] The parameters are estimated from equation (5.22), i.e., using the residuals from the estimated VAR system. The standard errors reported in the table are calculated as though we had access to the actual values of v. They are therefore biased.

Harberger-Laursen-Metzler effect is positive. We also see that the current account is instantaneously improved by a positive wage shock. This indicates that the negative effect on private consumption, via employment and production, is strong enough to outweigh other effects that go in the opposite direction.

<u>Table 3</u>

The contemporaneous model
("standard errors" in parentheses)

$$v_t^W = \underset{(.0743)}{.3535}\; v_t^p \qquad \bar{R}^2 = .13 \quad DW=2.04$$

$$v_t^G = \underset{(.0860)}{.0387}\; v_t^p - \underset{(.0883)}{.1010}\; v_t^W \qquad \bar{R}^2 = .00 \quad DW=2.08$$

$$v_t^{CA} = \underset{(3761)}{8533}\; v_t^p + \underset{(3876)}{9272}\; v_t^W - \underset{(3592)}{1505}\; v_t^G \qquad \bar{R}^2 = .09 \quad DW=2.00$$

The contemporaneous effects in Table 3 are the first steps of the impulse response functions plotted in <u>Figures 2a-d</u>. We see that the effects of shocks in general are quite persistent; the 24-quarter response is in many cases about as large as that of the quarter next after the innovation. An exception to this is the current account equation, where the effects that persist after a couple of years are negligible relative to the response within a quarter. Another general feature is that the effects from shocks to the dependent variable itself are largest in absolute magnitude over the first year after the shock. Over a longer horizon the interdepence of the system is strong enough to make the response to impulses elsewhere in the model more important.

Figure 2 a: Effects on CA of innovations in p, w, G and CA

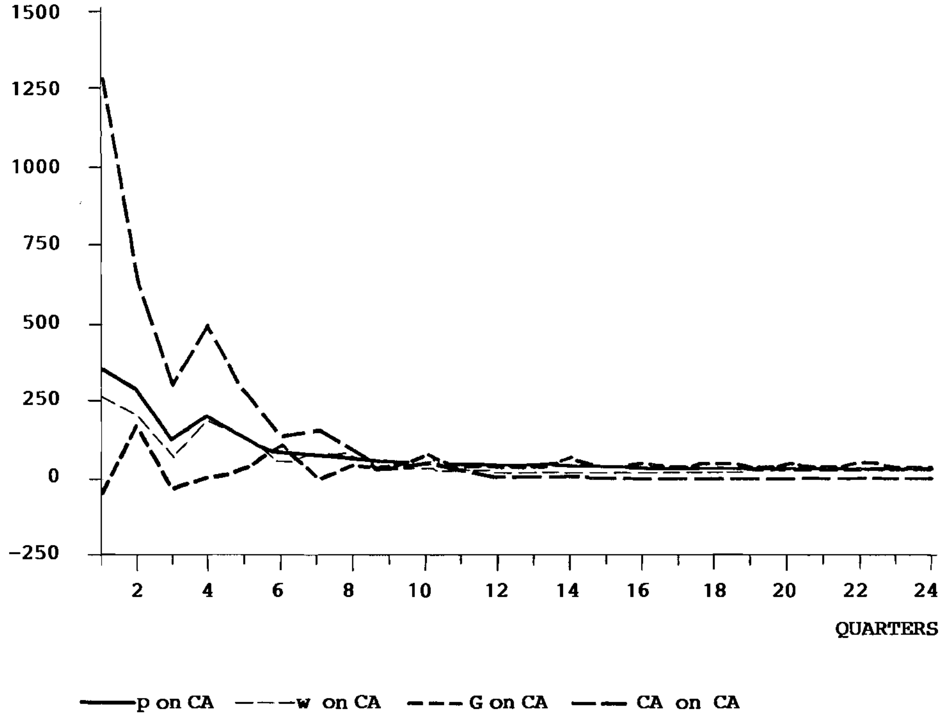

Figure 2 b: Effects on G of innovations in p, w, CA and G

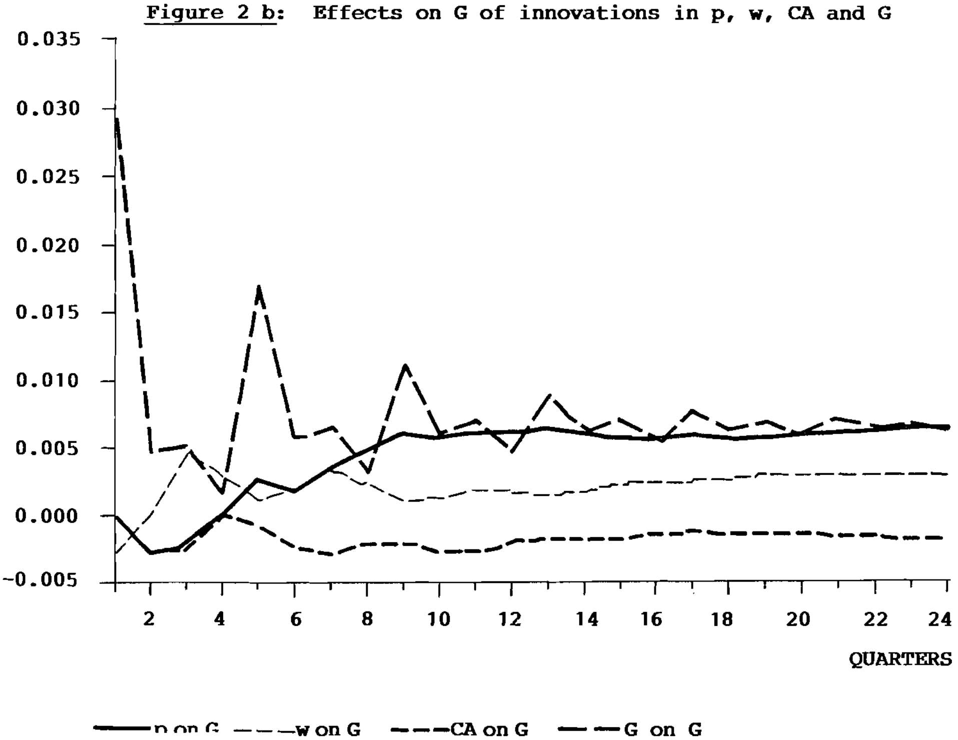

Figure 2 c: Effects on w of innovations in p, G, CA and w

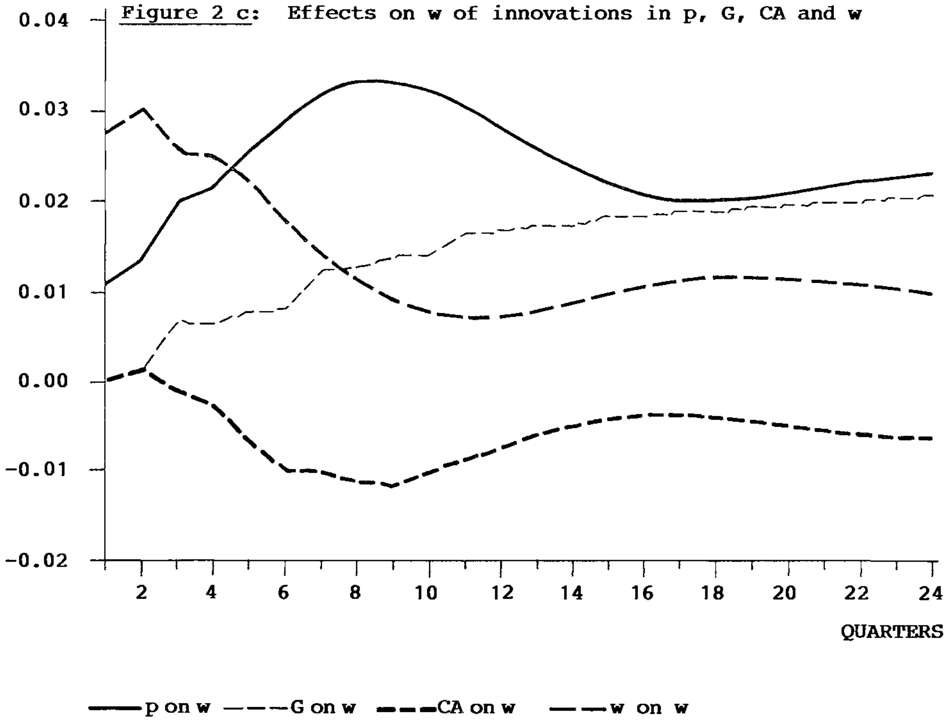

Figure 2 d: Effects on p of innovations in CA, w, G and p

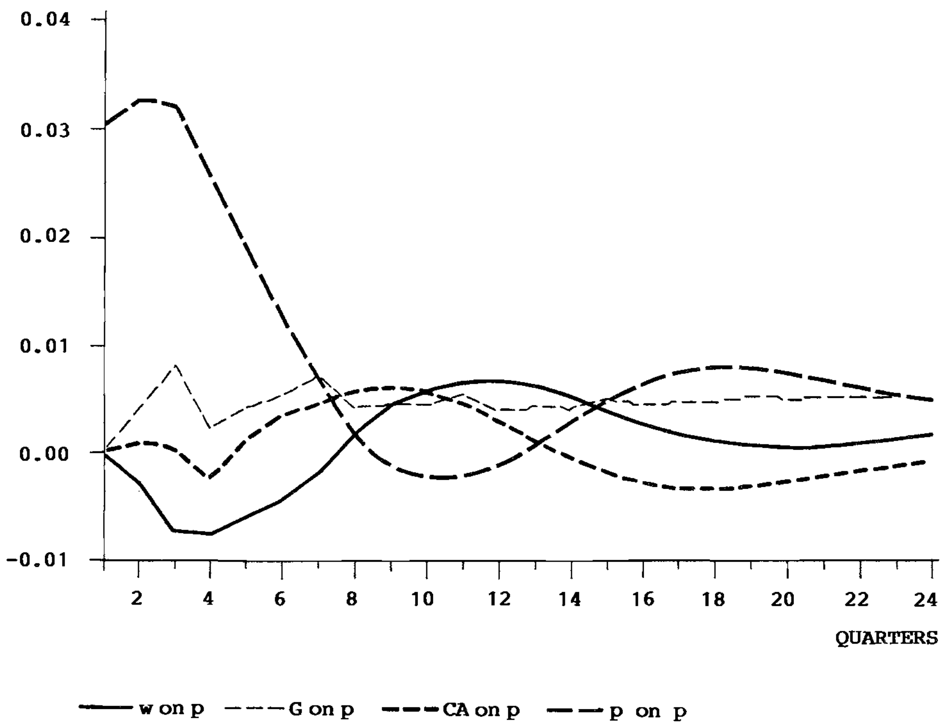

Table 4

Decomposition of Variance

a. Terms of trade

Innovation to	p	w	G	CA
Quarter				
4	94.5	3.0	2.2	0.2
8	90.4	3.8	4.2	1.5
12	84.6	6.4	5.6	3.3
16	81.9	7.8	6.8	3.4
24	79.4	7.2	9.5	3.9

b. The real wage

Innovation to	p	w	G	CA
Quarter				
4	27.5	70.2	2.0	0.2
8	49.2	41.7	5.2	3.9
12	57.3	28.3	9.4	5.0
16	57.1	24.3	14.2	4.4
24	54.0	20.6	21.4	4.0

c. Government consumption

Innovation to	p	w	G	CA
Quarter				
4	1.2	3.6	93.6	1.5
8	3.9	4.0	89.7	2.4
12	10.9	3.6	82.3	3.2
16	15.6	3.7	77.5	3.2
24	21.8	5.0	70.1	3.1

d. The current account

Innovation to	p	w	G	CA
Quarter				
4	9.5	5.2	1.1	84.2
8	10.0	5.8	1.5	82.8
12	10.2	5.8	1.7	82.3
16	10.3	5.8	1.9	82.0
24	10.5	5.8	2.2	81.5

Entries show percentage of forecast error variance of each variable at different horizons attributable to innovations in estimated equations associated with each variable.

In Table 4 the innovation accounting results are presented. For three of the equations own innovations account for more than 70 percent of the forecast error variance even over 24 quarters. The exception is the wage equation, where terms-of-trade innovations account for more than half of the variance over this horizon with wage innovations explaining a mere 20 percent. In forecasting the current account, shocks to other equations account for less than 20 percent of the variance.

It may be worth pointing out that the dominance of own effects even in the longer run in terms of innovation accounting, is not in contrast with the fact that in the long run own effects are no larger than other effects in the impulse response graphs. The forecast error at t+k is the combination of long run impulse responses to innovations close to t and short run responses to innovations close to t+k. This means that short run impulse responses are important even for long run forecast errors. In particular this is so for equations, such as the CA equation, where the impulse responses are much larger in the short than in the long run.

Most of the innovation accounting results are stable across different specifications. Current account innovations regularly account for around 80 percent of the forecast error variance of the current account itself, whereas the importance of such innovations are rather negligible in the other equations. The main difference when limiting the study to the post 1970 period is that innovations in the current account gain importance to the forecast error variances of the other three variables; it now accounts for 20 per cent of the variance of w. The results with regard to the wage are more sensitive to model specification. The result in Table 4 that terms-of-trade innovations account for the major part of the uncertainty about the development of the real wage changes drastically when differenced data are used. In this case innovations to the real wage itself account for 86 per cent of the 24-quarter horizon forecast error variance. It should also be mentioned that when the government budget balance is included in the model, it accounts for 25 percent of the variance of p, and 51, 22, and 2 percent of the variances of w, G, and CA respectively.

Let us now attempt an interpretation of the impulse response and innovation accounting patterns depicted in Figures 2a-d and Table 4. A shock to the current account equation has a strong short run impact on the current account. This effect vanishes rather quickly over around two years. The effects on the other equations are rather negligible. This pattern is consistent with the interpretation that the current account shock is mainly a temporary shock to domestic productivity and/or to world market demand. Such temporary shocks should have little impact on permanent income and hence on consumption. Consequently, savings should increase but investment would be unaltered as the shock is temporary. This implies a temporary improvement of the current account. One interpretation of the very small effects on the other equations is that labour unions and the government correctly understand the shocks to be temporary, and do not let them affect their policies.

A terms-of-trade shock has an impact on the terms of trade which remains for a year and a half. To the extent that we regard p as exogenous this is simply a statement about the degree of autocorrelation in international prices. Even though it is a temporary shock to the terms-of-trade equation it is a lasting shock to the terms of trade as seen from the point of view of Swedish decision makers. This is the shock with the largest cross effects in all equations; it accounts for more than 10 per cent of the variance of CA, 20 per cent of the variance of G and 50 per cent of the variance of w. The effect of a terms-of-trade shock on the current account is seen to be positive and quantitatively not negligible. It is known from the theoretical literature on the Harberger-Laursen-Metzler effect that the sign of this effect in general is indeterminate. Our result indicates that the so called direct effect not only dominates in the very short run but also over the longer run with more time for behavioral response and various substitution effects. The positive effects of u^p on w and G may come about because decision makers correctly perceive that a terms of trade shock increases wealth. The sign of the effect on G is not necessarily inconsistent with the hypothesis of accommodative fiscal policy (according to which a negative terms-of-trade shock would lead to an increase in government consumption); after five quarters the wage "overshoots" the terms-of-trade, and this is when the effect on G turns positive.

Wage shocks typically have smaller long run effects than terms-of-trade shocks. Certainly they appear less important than commonly perceived in the Swedish debate. They are of limited importance even to the forecast error with regard to the wage level itself (except in the very short run), which indicates that labour unions have a limited influence on real wages. The effect on the current account is positive in both the short and the long run. One interpretation of this is that a wage shock has an immediate negative effect on consumption and thereby a positive effect on exports which is larger than the negative effect on production. The impact of a wage shock on government consumption is positive (with the exception of the instantaneous effect in the first quarter), which is consistent with an accommodative fiscal policy.

Shocks to government consumption have long run effects on the current account which are comparable to those of terms of trade and wage shocks. Innovations to government consumption account for only 2 per cent of the forecast error variance for the current account, but for one fifth of the variance in the case of the real wage. This may reflect, e.g., that an expansive fiscal policy, which increases employment in the public sector, leads to more aggressive wage demands from the labour unions, but in the absence of a deep structural model with assumptions about the expectations formation of different groups, we cannot discriminate between this and other possible interpretations.

Our finding of a negligible effect from innovations in government consumption on the current account may be contrasted with the study by Ahmed (1987) of government spending and the balance of trade in Britain between 1732 and 1913. Decomposing government spending into one permanent and one transitory part, he finds negative effects on the balance of trade from increases in both components, with transitory shocks exerting a larger influence. He also finds insignificant effects from adding the government budget deficit to the list of explanatory variables, which he interprets as consistent with the "Ricardian equivalence" hypothesis.

To use our results for policy analysis is of course a treacherous exercise, in view of the weak restrictions that have been imposed on the estimated model. Let us, nevertheless, conclude this section with a few comments on their relevance for economic policy.

Since G is the only policy variable included in the model it is really only fiscal policy that we are entitled to make statements about. As we have seen fiscal policy surprises appear to have rather limited effects. The most important effect is on the long run development of the real wage, even if their contribution is smaller than that of terms of trade shocks (cf. Figure 2c). The relative importance of fiscal policy (in terms of innovation accounting) is larger if shocks to the government budget balance are considered, but in neither case do policy shocks (or supply shocks) matter as far as the current account is concerned.

It is often said that policy measures undertaken in order to improve the current account are successful only to the extent that they affect real wages and the relation between the prices of domestic and foreign products. Our study gives mixed results with regard to the small open economy hypothesis of exogenous terms of trade; whether it is rejected or not depends on the sample period under study, and the terms of trade equation shows signs of parameter instability. Let us assume that p is exogenous with respect to the nominal exchange rate. It may then make sense to view a devaluation as a negative real wage shock, which we have seen has a slight negative impact on the current account.

5.4 CONCLUDING COMMENTS

The aim of the research presented in this chapter is to contribute to the understanding of the role played by different factors in determining the current account. In particular we have aimed at distinguishing between domestic wage shocks, international terms of trade shocks, and policy shocks to government consumption.

Vector autoregression methods offer a way to study patterns in time series data with a limited amount of a priori restrictions from economic theory. Nevertheless such restrictions must necessarily be entered at a couple of stages of the work. Since many early studies using vector autoregression methods have, rightly, been subjected to the critique of drawing structural conclusions without being explicit about the structural assumptions made, we should stress the role played by such assumptions in the present study.

One critical aspect is the choice of variables to include. The relevant theory mentioned in the introduction certainly suggests that the variables actually included should be of central importance. It would nevertheless be of interest to investigate the sensitivity of the main results to the inclusion of one or more monetary aggregates and/or interest rates. The inclusion of an interest rate is, e.g., known to affect results on money-income causation; see Sims (1980b). Given that it plays such an important role in intertemporal theories of the current account, its omission from the present study is a potentially serious problem. It may also be of interest to investigate a system where savings and investment (or exports and imports) enter separately rather than just the balance between them. Such an approach might also contribute to resolving the Feldstein and Horioka (1980) puzzle of high correlation of domestic savings and investment rates.

It has been a main theme in the paper that the orthogonalization underlying the impulse response functions and the associated innovation accounting reflects structural assumptions about the contemporaneous relations between the variables. The recursive structure of the B_0 matrix assumed here presumes among other things that international prices may be taken to be predetermined at a quarterly basis. Even if we regard this as a sensible assumption it is essential to investigate the sensitivity of the main results to alternative assumptions to identify the B_0 matrix.

Keeping in mind that much sensitivity analysis of the type mentioned above remains to be done, there is one "negative" conclusion to be drawn from this study: the variance of neither terms of trade shocks, nor wage shocks nor government consumption shocks explain more than a small fraction of the variance of the current account. This casts doubt on much of the debate, at least in Sweden, on these issues. Instead it suggests that other shocks are the dominant sources of current account variations.

Related to the innovation accounting results is the finding that we cannot reject the hypothesis that the current account is not Granger caused by other variables. Similar results have also been reached by Backus (1986) with regard to the Canadian trade balance. These time series patterns are somewhat reminiscent of the random-walk hypothesis of consumption associated with the work of Hall (1978), since the current account is income minus consumption minus investment. In future work it may be interesting to relate our result to explicitly stochastic dynamic equilibrium models. One example of such a model is that of Clarida (1986b), where the current account reflects consumption smoothing in response to random productivity shocks, the only shock present in the model. It is found, however, that the current account cannot be represented as a Markov process; the current account in t+1 is a function not only of the current account in t but also of the productivity shock in t. It should be interesting to augment this type of model to including at least two different shocks.

Appendix A: Data description

The data series described in Figures 1a-d are defined as follows. The terms of trade are defined as the ratio between the export and import price indices (for total exports and imports of commodities). The real wage is the index for labor costs in the industrial sector, divided by the import price index. Wage and price indices refer to the middle month of each quarter. The terms of trade, wage and import price series have been normalized to be around 1.0 in 1947. In the regression analyses (as well as in Figures 1c-d) logarithms of terms of trade and real wages have been used. The current account figures are the current account balance in current prices, divided by the import price index. Before 1970, no quarterly data on the current account were available, so we have been forced to use the quarterly commodity trade balance figures instead. To these were added 25 % of the annual service account balance (incl. net interest payments and other transfers from the rest of the world). The government consumption figures are the deflated data given by the national accounts (with 1980 as the base year). Again, no quarterly figures exist before 1970. The annual figures for earlier years were therefore split on quarters according to the pattern of central government outlays. The government consumption data in Figure 1b (which have also been used in the regressions) are expressed in logarithms.

The government budget balance (GB), referred to in Section 5.3.2 and Table C7, is defined as the decrease in government debt. The series has been seasonally adjusted in the same way as G and CA (cf. appendix B). The industrial production series mentioned in note 10 is simply the industrial production index.

Most of the data have been obtained from Statistics Sweden (the Central Bureau of Statistics). Monthly data on export and import prices, wages, industrial production, commodity trade, government debt, and central government outlays, are published in the Monthly Digest of Swedish Statistics ("Allmän månadsstatistik"; "Kommersiella meddelanden" until the middle of the 1960's). The government consumption data are taken from the national accounts (e.g., "BNP kvartal 1985:3").The current account data have been obtained from the Central Bank of Sweden.

Appendix B: Deseasonalization

In this appendix we describe the procedure that has been used to eliminate the seasonal components of the current account and government consumption series. Let the vectors of observations be denoted by CA and G, respectively. The following regressions were estimated by OLS:

$$G = \sum_{i=1}^{4} t_i \alpha_i + \sum_{i=1}^{4} Q_i \beta_i + \epsilon^G$$

$$CA = \sum_{i=1}^{4} t_i \gamma_i + \sum_{i=1}^{4} Q_i \delta_i + \epsilon^{CA}$$

where $t_i' = [1^i, 2^i, 3^i, \ldots, N^i]$, N being the number of observations, and $Q_1' = [1, 0, 0, 0, 1, 0 \ldots 0]$, $Q_2' = [0, 1, 0, 0, 0, 1, 0 \ldots 0]$, etc. The seasonal components for government consumption were defined as

$$g_j = \hat{\beta}_j - \bar{\beta}$$

where $\bar{\beta}$ is the average value of the $\hat{\beta}_j'$s, the OLS estimate of the β_j's. The seasonally adjusted data for G were then obtained by subtracting $\sum_{i=1}^{4} Q_i g_i$ from G. The current account data were adjusted in the same way. This method of adjustment follows Johnston (1972).

The seasonal adjustments were made before data were transformed to logarithms, and separate sets of seasonal components were calculated for the periods 1947:2 - 1969:4 and 1970:1 - 1985:3.

The seasonal components are given in the table below.

	1947:2 - 1969:4		1970:1 - 1985:3	
	g_i	ca_i	g_i	ca_i
i				
1	-802	-973	1424	-58
2	1589	347	2080	938
3	-811	271	-6064	-916
4	24	355	2560	38

Appendix C: Tables

Table C 1

Tests for autoregressive unit roots

$$z_t = \hat{\mu} + \hat{\gamma} t + \hat{\rho}_1 z_{t-1} + \sum_{i=2}^{k} \hat{\rho}_i (z_{t-i+1} - z_{t-i}) + \hat{u}_t$$

Series	T	k	$\hat{\mu}$	$t(\hat{\mu})$	$\hat{\gamma}$	$t(\hat{\gamma})$	$\hat{\rho}_1$	$\tau(\hat{\rho}_1)$	$s(\hat{u})$	DW
Terms of trade	145	8	0.023	2.45	-0.0003	-2.75	0.88	-2.59	0.032	2.06
Real wages	145	8	0.014	1.63	0.00005	0.20	0.99	-0.55	0.036	1.97
Government consumption	145	8	0.0002	0.00	-0.0002	-0.29	1.00	0.07	0.032	2.02
Current account	145	8	287.4	0.99	-5.10	-1.49	0.76	-2.40	1393.0	1.98

$t(\hat{\mu})$ and $t(\hat{\gamma})$ are the ratios of the OLS estimates of μ and γ to their respective standard errors. $\tau(\hat{\rho}_1)$ is the ratio of $\hat{\rho}_1-1$ to its standard error. The critical value of this statistic is 3.45 for a sample size of 100; see Fuller (1976). $s(\hat{u})$ is the standard error of the regression and DW is the conventional Durbin-Watson statistic.

Table C 2

Terms of trade, real wages, government consumption, and the current account: VAR representation

Dependent variable
(standard errors in parentheses)

Regressors	p_t		w_t		G_t		CA_t	
p_{t-1}	1.09	(0.09)	0.04	(0.09)	-0.09	(0.09)	2559	(4155)
p_{t-2}	-0.04	(0.13)	0.23	(0.13)	-0.003	(0.13)	-2272	(6011)
p_{t-3}	-0.20	(0.13)	-0.22	(0.13)	0.08	(0.13)	-678	(5993)
p_{t-4}	-0.03	(0.08)	0.18	(0.09)	0.02	(0.09)	144	(4000)
w_{t-1}	-0.09	(0.10)	1.09	(0.09)	0.04	(0.09)	3245	(4306)
w_{t-2}	-0.06	(0.14)	-0.25	(0.14)	0.14	(0.14)	-4922	(6514)
w_{t-3}	0.13	(0.14)	0.20	(0.14)	-0.14	(0.14)	4793	(6498)
w_{t-4}	0.01	(0.09)	-0.13	(0.09)	0.02	(0.09)	-2847	(4245)
G_{t-1}	0.14	(0.08)	0.04	(0.08)	0.14	(0.08)	6390	(3560)
G_{t-2}	0.09	(0.08)	0.16	(0.08)	0.17	(0.08)	-5665	(3504)
G_{t-3}	-0.22	(0.08)	-0.08	(0.08)	0.01	(0.08)	-129	(3536)
G_{t-4}	0.14	(0.07)	0.02	(0.07)	0.48	(0.07)	442	(3357)
CA_{t-1}	0.0000007	(0.0000021)	0.0000009	(0.0000020)	-0.0000022	(0.0000020)	0.49	(0.09)
CA_{t-2}	-0.0000005	(0.0000022)	-0.0000022	(0.0000021)	-0.0000006	(0.0000022)	0.002	(0.10)
CA_{t-3}	-0.0000015	(0.0000023)	0.0000001	(0.0000022)	0.0000013	(0.0000022)	0.28	(0.10)
CA_{t-4}	0.0000031	(0.0000021)	-0.0000028	(0.0000021)	0.0000002	(0.0000021)	-0.12	(0.10)
C	-1.36	(0.92)	-1.22	(0.90)	1.79	(0.90)	-9257	(41461)
T	-0.0019	(0.0009)	-0.0002	(0.0008)	0.001	(0.0008)	-20.8	(39.4)
Q2	-0.006	(0.009)	0.01	(0.008)	-0.002	(0.008)	122	(394)
Q3	0.001	(0.009)	-0.03	(0.009)	-0.005	(0,009)	124	(399)
Q4	-0.009	(0.009)	-0.02	(0.0008)	-0.005	(0.009)	128	(395)
Stand.err.	0.033		0.032		0.032		1470.4	
$\bar{R}^2$	0.911		0.997		0.995		0.437	
Q	26.103		16.923		29.062		44.306	
(Significance)	(0.888)		(0.997)		(0.787)		(0.161)	

The definitions of p, w, G, and CA are given in appendix A. C is a constant, T is a linear trend, and Q2-4 are dummy variables for quarters 2-4. Q is the Box-Pierce statistic for autocorrelation, and the marginal significance level of the test is based on the chi-square distribution (36 d.o.f.).

Table C 3

Tests of Marginal Predictive Power of (8 lags of)
Row Variables for Column Variables

	p	w	G	CA
p	.000	.000	.107	.995
w	.014	.000	.605	.930
G	.004	.088	.000	.928
CA	.161	.532	.482	.000
$\bar{R}^2$	.935	.997	.995	.440
Q	19.274	11.095	30.967	27.052
(Significance)	.990	.999	.707	.859
Marg. sign. of lags 5-8	.000	.148	.147	.378

Table C 4

Tests of Marginal Predictive Power of (4 lags of) Row Variables for Column Variables

	$p - p_{-1}$	$w - w_{-1}$	$G - G_{-1}$	$CA - CA_{-1}$
$p - p_{-1}$	.082	.087	.147	.980
$w - w_{-1}$	.001	.010	.077	.894
$G - G_{-1}$	.004	.126	.000	.312
$CA - CA_{-1}$	.658	.839	.766	.000
$\bar{R}^2$	.198	.225	.516	.117
Q	34.450	17.334	24.488	53.434
(Significance)	.542	.996	.927	.031

Table C 5

Tests of Marginal Predictive Power of (4 lags of)
Row Variables for Column Variables

a. Estimation period 1949:2 - 1969:4

	p	w	G	CA
p	.000	.019	.663	.638
w	.003	.000	.676	.873
G	.033	.636	.050	.695
CA	.025	.057	.899	.239
$\bar{R}^2$	.824	.996	.981	.026
Q	18.907	18.599	12.936	10.266
(Significance)	.873	.884	.990	.998

b. Estimation period 1970:1 - 1985:3

	p	w	G	CA
p	.000	.049	.292	.518
w	.440	.000	.292	.824
G	.297	.843	.000	.407
CA	.782	.592	.201	.001
$\bar{R}^2$	.964	.872	.985	.438
Q	28.144	10.136	17.848	20.276
(Significance)	.136	.977	.659	.504

Table C 6

Tests of Marginal Predictive Power of (4 lags of) Row Variables for Column Variables

Estimation period 1954:2 - 1985:3

	p	w	G	CA
p	.000	.104	.147	.431
w	.781	.000	.014	.670
G	.693	.557	.000	.356
CA	.705	.441	.716	.000
$\bar{R}^2$	.967	.996	.995	.443
Q	29.403	21.580	42.320	41.727
(Significance)	.647	.936	.128	.142

Table C 7

Tests of Marginal Predictive Power of (4 lags of)
Row Variables for Column Variables

	p	w	G	GB	CA
p	.000	.038	.386	.928	.909
w	.005	.000	.306	.199	.856
G	.001	.174	.000	.652	.233
GB	.000	.007	.464	.000	.897
CA	.737	.071	.828	.047	.000
$\bar{R}^2$	.925	.997	.995	.832	.424
Q	34.456	19.861	28.615	33.711	43.899
(Significance)	.542	.986	.804	.578	.172

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