Chapter V:
A Monetary Policy Strategy of Direct Managed Floating

In this Chapter we will provide a rationale for the second type of a central bank's reaction to fear of floating. While in the previous Chapter indirect managed floating turned out to be a robust monetary policy strategy under purely market determined exchange rates, we now introduce direct and sterilised foreign exchange market interventions as an additional policy tool in a strategy of direct managed floating. In particular, we will show that the motive for these interventions and their effectiveness can only be explained on the basis of the failures of a perfectly holding UIP condition.

According to the classification scheme of monetary and exchange rate strategies set up in Chapter I, the characteristics of direct managed floating are as follows. Concerning (i) the role of the exchange rate, under direct managed floating the exchange rate is controlled by the central bank through direct interventions in the foreign exchange market. Unlike in systems of purely market determined exchange rates the movements in the exchange rate are not predominantly market determined, but policy determined. Concerning (ii) the implementation of monetary policy, under direct managed floating the central bank has a double operating target: the nominal exchange rate and the nominal short-term interest rate. The interest rate is controlled – like in systems of purely market determined exchange rates – through direct interventions in the domestic money market. Unlike in systems of pre-announced crawling pegs or fixed exchange rates the central bank targets an exchange rate path that is not pre-announced. The independence of the two operating targets is guaranteed by sterilisation of the foreign exchange market interventions which distinguishes a direct managed float from (idealised) systems of pre-announced crawling pegs or fixed exchange rates in which the interest rate is subordinated to the exchange rate target. Concerning (iii) the nominal anchor, the primary goal of monetary policy is a preannounced target rate of inflation. As neither the exchange rate path nor the short-term interest rate are pre-announced, they cannot serve as a nominal anchor. Thus, in this respect, direct managed floating is similar to inflation targeting strategies under market determined exchange rates.

The remainder of this Chapter is structured as follows. In the first Section we will begin by taking a closer look at the central bank's additional operating target, the nominal exchange rate.

While the mechanics and the effectiveness of interventions in the domestic money market to target a short-term nominal interest rate are uncontroversial and identical to strategies with a single operating target (see Section IV.1.2), the effectiveness of sterilised foreign exchange market interventions to target a level of the nominal exchange rate has to be seen in a close context to the question of how the exchange rate is determined. We present a range of intervention channels and we critically discuss the related empirical literature. In Section V.2 we develop a policy rule for the two operating targets of a direct managed floating central bank and we show how the central bank adjusts its operating targets in response to shocks. Section V.3 finally compares the strategy of direct managed floating with the strategies of independently floating and indirect managed floating.

V.1 The exchange rate as operating target under direct managed floating

An important difference to a central bank's intervention in the domestic money market is that in the foreign exchange market the central bank no longer acts as a monopolist. It rather appears as an additional customer on the inter-bank foreign exchange market (besides non-financial corporations and institutional investors) who carries out trades with market makers or brokers through buying and selling orders (see Section V.1.2.3.2 below). Thus, in order to understand how additional supply of or demand for foreign exchange following a central bank intervention affects the exchange rate, we have to discuss the channels by which the equilibrium exchange rate is determined in general (i.e. independent of who creates additional demand or supply). And this discussion is typically done in the context of various models of exchange rate determination. For each of the channels that are presented in the following Sections we proceed as follows. We begin by presenting the underlying model of exchange rate determination. We then describe how interventions are supposed to affect the exchange rate. In order to answer the crucial question whether interventions in the foreign exchange market are effective we finally summarise the empirical evidence related with each channel.

V.1.1 Non-sterilised interventions and the 'monetary channel' of exchange rate determination

Non-sterilised interventions involve a one-for-one change in the central bank's net foreign assets and the monetary base. Thus, they are simply a variant of a central bank's interest rate policy that can be distinguished from conventional open market operations only in the type of asset being exchanged for base money. The change in base money leads to a change in the short-term interest rate, and hence to a modified exchange rate path. This effect can be demonstrated by solving the UIP equation of our baseline model presented in Section IV.1.1 for s_t:

$$\text{(V.1)} \qquad s_t = E_t \sum_{j=0}^{\infty} \left(i^f_{t+j} - i_{t+j} + u^s_{t+j} \right).$$

Accordingly, a one-time rise in domestic interest rates in time t ($j = 0$) leads to an appreciation of the contemporaneous spot rate, everything else being equal. In sum, non-sterilised interventions do not provide an additional and independent instrument for a central bank under independently floating exchange rates.

As the term ‘monetary channel’ in the title of this Section already indicates, the literature usually discusses the effects of this type of non-sterilised interventions within the framework of monetary models of exchange rate determination. Thus, instead of focusing on the intervention’s impact on short-term interest rates, the supply of a broad monetary aggregate (such as M1) is affected by a change in the monetary base B via the money-multiplier relationship. Since monetary models of the exchange rate start from the definition of the exchange rate as the relative price of two monies, changes in the domestic money supply, relative to the foreign money supply, lead to a change in the exchange rate (see Section II.2 for a presentation of the monetary model). However, as is the case in most modern dynamic monetary models, our model totally neglects the role of monetary aggregates in the determination of output, prices, and the exchange rate. Thus, the effects of non-sterilised interventions via the monetary channel are exclusively captured by movements in the short-term interest rate.

Astonishingly, the effectiveness of the monetary channel under floating exchange rates is rarely questioned. In contrast, many authors argue like Marston (1988, p. 97): “There is virtually unanimous agreement among economists that non-sterilised intervention can affect exchange rates, just as more conventionally defined monetary policy can undoubtedly affect exchange rates” (see also Edison, 1993, p. 8, and Sarno and Taylor, 2001a, p. 841, for similar statements). This is in particular astonishing in view of the poor empirical evidence for a stable relationship between short-term interest rates and exchange rate changes via UIP or between changes in a monetary aggregate and exchange rate changes as predicted by the monetary model of exchange rate determination (see for example the survey article on exchange rate economics of one of the above authors, namely Taylor, 1995).

Nonetheless, it should be mentioned that, with regard to the assignment of the operating targets made in Section I.3.2, the monetary channel constitutes a central channel of monetary policy under absolutely fixed exchange rates, in particular in a currency board arrangement. This can easily be shown with the help of a stylised currency board balance sheet (see Figure V.1). In pure currency board systems the monetary authority does not have any domestic credit instruments at its disposal. Hence, the only source of base money creation are changes in the NFA which cannot be sterilised. As soon as the domestic short-term interest rate deviates from the 'policy rule' given by equation (II.30) (see Section II.3.4), capital flows put pressure on the fixed exchange rate. The monetary authority has to intervene in the foreign exchange market in order to keep the exchange rate unchanged. Capital inflows, for example, lead to an increase in NFA, and hence to B, which in turn lowers short-term domestic interest rates, and hence the source of the capital inflows (see Berensmann, 2002, for a detailed analysis).

Figure V.1: A stylised currency board balance sheet

assets	liabilities
NFA	B

V.1.2 Sterilised interventions

It should be clear from the last Section that the monetary channel of foreign exchange market interventions subordinates the interest rate instrument to the exchange rate instrument. Thus, in order to have an independent exchange rate instrument, the effects of foreign exchange market interventions on base money have to be sterilised. Before we discuss the channels through which sterilised interventions are supposed to work, the next Section presents the mechanics of sterilisation on the basis of some simple balance sheet identities.

V.1.2.1 Sterilisation of foreign exchange market interventions

In broad terms sterilisation can be defined as any off-setting measure by the central bank in response to changes in the NFA so as to leave the monetary policy instrument unaffected. In this context the term ‘instrument’ has been somewhat loosely used. This stems from the fact that the earlier literature in which central banks were assumed to control the supply of a monetary aggregate usually made no difference between base money (B) and broad money (M) (see e.g. Argy and Kouri, 1974). It was simply assumed that there was a stable relationship between these two aggregates via the money multiplier.

As we focus solely on short-term interest rates as monetary policy instrument (or, to be precise, as operating target), the mechanics of sterilisation are quite straightforward. As each sale or purchase of foreign exchange leads to an equivalent change of the foreign component of base money (the net foreign assets, NFA)

$$\text{(V.2)} \qquad I = \Delta NFA$$

and thus to a change of total base money

$$\text{(V.3)} \qquad \Delta NFA + \Delta NDA = \Delta B\,,$$

the short-term interest rate would deviate from its optimum value (see Figure V.2 for a presentation of a sterilised intervention in T-accounts). To avoid this, each purchase (sale) of foreign exchange has to be offset by a corresponding decrease (increase) of net domestic assets (ΔNDA)

$$\text{(V.4)} \qquad \Delta B \overset{!}{=} 0 \Rightarrow \Delta NDA = -\Delta NFA$$

so that in the end the foreign exchange market intervention leaves the domestic short-term interest rates constant. In practice, the sterilisation can be accomplished either by an opposite change in domestic assets ($\Delta DA = -\Delta NFA$, sterilisation 1 in the lower left panel of Figure V.2) or by a corresponding change in domestic liabilities ($\Delta DL = \Delta NFA$, sterilisation 2 in the lower right panel of Figure V.2). In the first case an official purchase, for example, of foreign exchange can be offset through a corresponding open market sale of domestic assets by the central bank or by a repayment of the lending facilities previously used by the commercial banks. In the second case the increase in foreign assets is neutralised by a placement of excessive commercial banks' funds at the central bank (via the deposit facility) or through sales of domestic currency-denominated short-term securities by the central bank.

Figure V.2: The mechanics of a sterilised foreign exchange market intervention

before intervention

assets	liabilities
NFA	B
DA	
	DL

after intervention, before sterilisation

assets	liabilities
NFA	B
I = ΔNFA	
DA	ΔB
	DL

after intervention, with sterilisation (option 1)

assets	liabilities
NFA	B
I = ΔNFA	
DA	DL
-ΔDA	

after intervention, with sterilisation (option 2)

assets	liabilities
NFA	B
I = ΔNFA	
DA	DL
	ΔDL

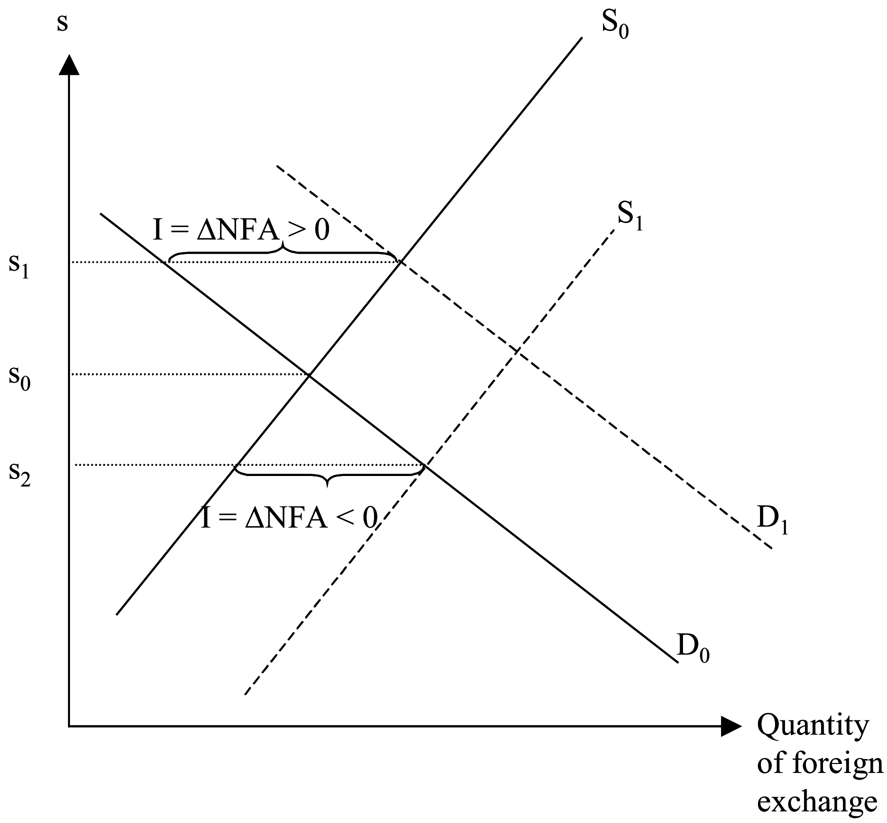
Since the short-term interest rate remains unchanged the question arises of how the change in the net foreign assets impacts on the exchange rate. In the following we will discuss a range of intervention channels which are all based on specific models of exchange rate determination.

V.1.2.2 Immediate effects of sterilised interventions through the balance of payments flow channel

Prior to the 1970s, the dominant approach to exchange rate determination was to view the exchange rate as the equilibrium price of flows of foreign exchange passing through the foreign exchange market. The primary source of flow demand for and flow supply of foreign exchange are current account and capital account transactions that are recorded in the balance of payments. Probably the most influential application of this approach to the determination of the exchange rate is the Mundell-Fleming model. Although the primary aim of this model was not to explain exchange rate movements, the balance of payments equilibrium is only guaranteed by changes in the exchange rate. Thus, foreign exchange was largely thought to be a medium of exchange for executing international transactions instead of a store of value which was considered as the primary function of foreign exchange under the subsequent asset market approach to exchange rate determination (see Section II.1 for a presentation of the Mundell-Fleming model).

Interventions that are assumed to operate on the basis of this balance of payments view alter the flow supply of foreign exchange relative to the demand for foreign exchange. The idea behind this channel is that the central bank intervenes in order to accommodate temporary imbalances on the foreign exchange market that result in short-run deviations of the exchange rate from its long-term flow equilibrium. Additional demand for (I > 0) or supply of (I < 0) foreign exchange by the central bank temporarily affects the flow equilibrium in the foreign exchange market (see Figure V.3).

Figure V.3: The flow channel of foreign exchange market interventions



It is normally uncontested that sterilised interventions exert an immediate effect on the exchange rate simply by the flow it creates. However, as such an intervention does not fundamentally change the determinants of the flow demand for foreign exchange, the demand curve would shift back to its initial position (D_0). Consequently, in order to keep the exchange rate at s_1, the central bank has to keep on intervening as long as the temporary supply disturbance has disappeared. Thus, the success of interventions through that channel ultimately hinges on the central bank's potential to create a temporary shift of the flow equilibrium that results in an exchange rate s_1 or s_2. Kenen (1987) refers to this kind of intervention policy as a 'brute-force policy' as continuing flow interventions are required to prevent market forces from reverting the exchange rate back to s_0. By arguing this way, he implicitly assumes that the central bank provokes a temporary stock disequilibrium on the international asset market.

If we believe in the asset market approach to exchange rate determination, then we have to apply a stock supply/demand framework. Macroeconomic flow approaches are only relevant for determining the equilibrium market price of a perishable good or service because such items exist only over short intervals of time.[64] The fact that we used UIP as the behavioural relationship of international investors makes it clear that we view the exchange rate as the price of financial assets – which are infinitely durable and which can be transferred but not destroyed. According to UIP investors are assumed to decide on the (stock) composition of their portfolios so that expected (and eventually risk-adjusted) returns on short-term, interest-bearing assets denominated in different currencies are equal. As sterilised interventions based on the balance of payments flow approach only alter the current spot rate (say from s_0 to s_1), an initial stock equilibrium on the international financial markets given by

$$\text{(V.5)} \qquad i_t = i_t^f + E_t s_{t+1} - s_0 + u_t^s$$

turns into a stock disequilibrium

$$\text{(V.6)} \qquad i_t > i_t^f + E_t s_{t+1} - s_1 + u_t^s$$

which triggers capital (in)flows and hence a reverting pressure on the domestic exchange rate.

[64] The label 'macroeconomic' flow approach was used to distinguish it from the microstructure flow approach which will be introduced in the next Section.

This example shows that there is an important relationship between the stock and the flow perspective. Obviously, foreign exchange is used as both a medium of exchange and a store of value, so an overall equilibrium in the foreign exchange market requires a balance in both flow and stock aspects of the market (see Levich, 2001, appendix 6.1, for a simple model). Thus, the discussion of the balance of payments flow channel provides a useful insight into the basic issues of determining the exchange rate. We will come back to the flow approach below when we discuss foreign exchange market interventions on the level of the microstructure theory of exchange rates.

The central message of the Section is that if we want to have a persistent effect on the level of the exchange rate we have to change the behaviour of international investors. In our view there are at least three channels based on the asset market (and hence stock) approach to the determination of the exchange rate by which sterilised foreign exchange market interventions have a persistent impact on the exchange rate: the portfolio balance channel, the signalling (or expectations) channel and the noise trading (or coordination) channel. All channels have the common factor that the central bank changes important behavioural patterns of financial market participants.

V.1.2.3 The portfolio-balance channel of sterilised interventions and the portfolio-balance model of exchange rate determination

V.1.2.3.1 The traditional macroeconomic approach

The idea of this channel is derived from the portfolio-balance models of exchange rate determination. This class of models is based on a two-country-two-currency world with two composite private sectors. International investors are supposed to hold two interest bearing assets in their portfolios: domestic government bonds denominated in domestic currency, and foreign government bonds denominated in foreign currency. The remainder is held as non-interest bearing domestic money so that the total wealth of the investor is defined as the sum of the three assets.[65] Since imperfect substitutability between domestic and foreign assets and risk aversion of

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[65] In a more generalised version of the portfolio-balance model investors additionally hold non-interest bearing foreign money so that the investors' portfolios contain four assets (Branson and Henderson, 1985). For empirical purposes the assumption is often made that currency substitution is irrelevant, thus reducing the number of

the investors is assumed, the uncovered interest parity condition has to be adjusted by a risk premium. In the UIP equation the risk premium u_t^s is defined as the rationally expected excess return that a domestic investment must offer in order to induce international investors to willingly hold the existing supply of domestic and foreign assets. Thus if $u_t^s < 0$ $(u_t^s > 0)$ the expected return on the foreign country's asset which is measured by $i_t^f + E_t\Delta s_{t+1}$ is greater (smaller) than that on the home country's asset which is measured by i_t because foreign assets are viewed as more (less) risky than home assets. According to the portfolio balance approach, the demand for any of the financial assets depends on the total wealth of the investor and the expected return on domestic and foreign bonds. The stock supply of the financial assets is determined by the interaction of monetary policies, budget deficits, and central bank interventions in the foreign exchange market. In the short-run, in the absence of any official intervention, it is assumed to be constant so that any exogenous change in the demand for foreign bonds results in an adjustment of the exchange rate. Thus, the exchange rate is the equilibrium price on the stock market for interest bearing and imperfectly substitutable assets (see Hallwood and MacDonald, 2000, chapter 11, for a textbook treatment).

Under the aforementioned assumptions, asset holders will not be indifferent to the currency composition of their portfolios. Thus, if interventions are assumed to work through a portfolio-balance channel they affect the exchange rate by inducing investors to rebalance their portfolios. As an example, Figure V.4 illustrates a situation in which the initial equilibrium on the international financial market (D_0, S_0, s_0) is disturbed by a positive exogenous risk premium shock (u_1^s). The change in the investor's degree of risk aversion shifts the demand for domestic assets (DA) relative to foreign assets (FA) to the left (①, D_1). Since the relative supply is given by S_0, an adjustment of the structure of the portfolio is not possible. Thus, private investors will force an increase in the expected yield of the domestic asset relative to the foreign asset. For given exchange rate expectations $\overline{E_t s_{t+1}}$ and a given interest differential $\overline{i_t - i_t^f}$, the spot exchange rate rises (depreciates) from s_0 to s_1:

(V.7)
$$\begin{aligned} \overline{i_t - i_t^f} &= \overline{E_t s_{t+1}} - s_0 = \\ &= \overline{E_t s_{t+1}} - s_1 + u_1^s. \end{aligned}$$

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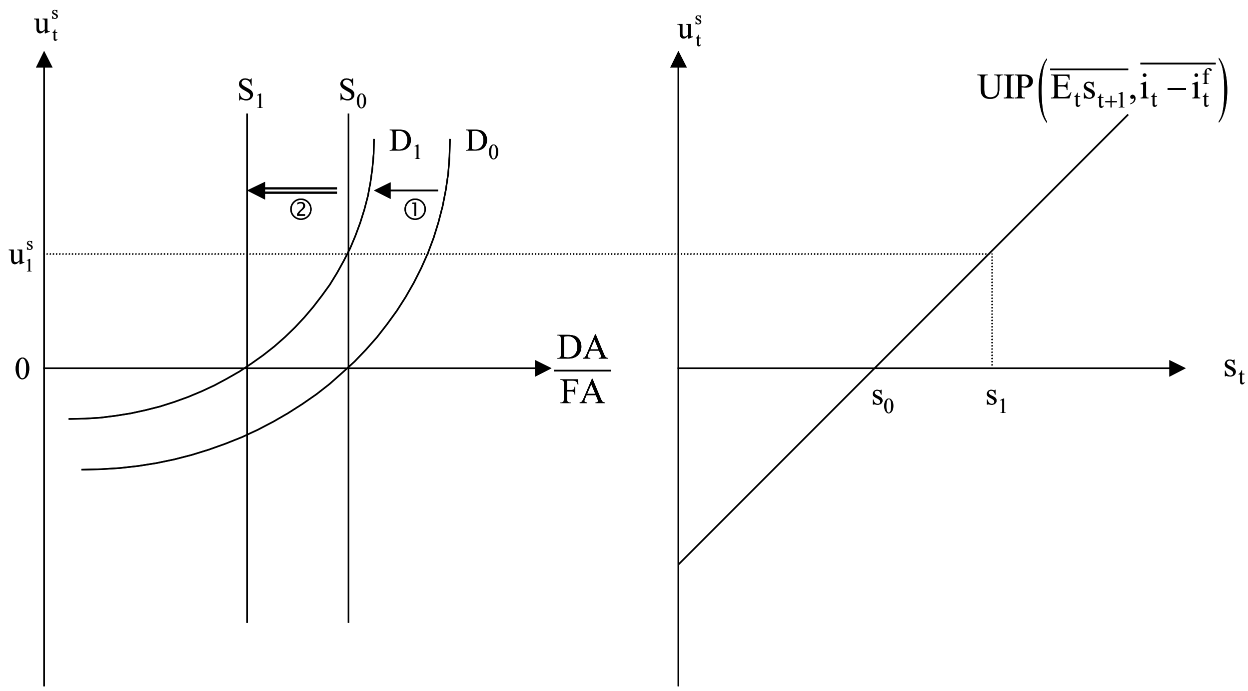
potential assets to three. Note that the complete model nevertheless contains four assets as domestic residents and

Figure V.4: The portfolio-balance channel of sterilised foreign exchange market intervention



Assume that the central bank's objective is to prevent its currency from depreciating to s_1. With sterilised foreign exchange market interventions (purchase of domestic assets against foreign assets) it changes the relative supply of assets (②) and hence, the stock of domestic relative to foreign assets that the private sector has to hold in its portfolio (S_1). However, the imperfect substitutability assumption implies that investors are only willing to hold the changed asset stock if the risk premium and with it the spot rate (given again the interest rate differential $\overline{i_t - i_t^*}$ [66] and the exchange rate expectations $\overline{E_t s_{t+1}}$ [67]) changes. The reason why the risk premium must fall in the case of a sterilised sale of foreign assets by the domestic central bank is that asset holders must be compensated by a higher expected return on foreign assets in order to induce them to buy the decreased relative supply of domestic relative to foreign assets. Thus, instead of viewing the disturbances to UIP as purely exogenous, the portfolio balance approach suggests the following decomposition of u_t^s (McCallum, 2000)

foreigners are regarded simultaneously.

[66] Above all the domestic interest rate remains unchanged because of the sterilisation of the sale of foreign assets.

[67] As already mentioned in Chapter III, the risk premium explanation of the forward discount bias hinges on the assumption that market participants have rational expectations. Thus, the portfolio-balance channel of sterilised interventions applies only to UIP deviations that result from shocks to the risk aversion.

(V.8) $$u_t^s = \lambda\left[da_t - \left(fa_t - s_t\right)\right] + v_t^s$$

where da_t and fa_t are logs of domestic and foreign assets held by the public and v_t^s is an exogenous auto-correlated risk premium shock. If UIP is hit by a positive exogenous risk premium shock v_t^s (①), sterilised purchases of domestic assets against foreign assets by the central bank (da_t falls whereas fa_t rises) offset the resulting change in the spot rate from s_0 to s_1 by counteracting (②) the change in the risk premium.

In the empirical literature it is common practice to verify the portfolio channel by estimating an (inverted[68]) asset-demand function which is derived from a mean-variance optimisation. The risk premium which is defined as the rationally expected deviation from UIP is modelled as function of the portfolio composition x_t (either domestic assets to foreign assets, foreign assets to total wealth, or domestic assets to total wealth) which is assumed to change in response to sterilised interventions:

(V.9) $$i_t - i_t^f - E_t s_{t+1} + s_t = f\left(x_t\right).$$

Most studies in the 1980s that were based on this approach led to rather disappointing results.[69] While researchers typically concluded that risk premia exist and that they vary through time, they have not succeeded in relating these changes to relative asset supplies. With near unanimity, researchers have found the relationship to be either statistically insignificant or quantitatively unimportant. If there was significant evidence, the effects on the exchange rate were too weak in order to attribute any importance to this channel (see for example Almekinders, 1995, Dominguez and Frankel, 1993b, Edison, 1993, and Sarno and Taylor, 2001a, for comprehensive overviews).

[68] According to the portfolio balance model of exchange rates the relative demand for assets is – among other things – a function of the risk premium. By inverting the asset demand function we can express the risk premium as a function of the aggregate supplies of assets (see equation (V.9)).

[69] We do not review the results in detail since they are rather unison and well-documented in the reviews quoted at the end of this paragraph.

According to Dominguez and Frankel (1993b) all these studies were confronted with two major problems, both of which are related to measurement difficulties. The first involves specifying the intervention variable. As shown on the right hand side of equation (V.9) the intervention activity is captured by the variation of relative asset supplies where adequate data sets are hardly available, and if so, only on a monthly or quarterly base (see for example the studies by Gosh, 1992, Obstfeld, 1983, and Rogoff, 1984).

The second difficulty refers to the measurement of exchange rate expectations. All the weak results of the studies based on the portfolio-balance channel were produced via application of the rational expectations approach. Recall that the risk premium explanation of UIP deviations critically hinges on the assumption that exchange markets are rational in the sense of using all available information and of not making systematic forecast errors. Thus, the market's failure to exploit all profitable interest opportunities must reflect a risk premium, not market inefficiencies. In contrast to the rational expectations studies which simply took ex post changes in the exchange rate as an unbiased measure of expected exchange rate changes Dominguez and Frankel (1993a) introduced the survey data approach where expectations are directly derived from private exchange market participants. By constructing measures of the risk premium on the basis of survey data on expectations they come to the conclusion "that the consensus view in the early 1980's, that intervention policy is largely ineffective, is no longer supported by the data" (Dominguez and Frankel, 1993a, p. 1366). In contrast to the mixed results obtained by previous studies their results indicate that interventions had a statistically significant effect on the risk premium.

We will come back to the process of expectations' formation and to the implications of alternatives to the efficient markets hypothesis for a central bank's intervention policy below in Section V.1.2.5. We will show that market inefficiencies open an alternative channel for foreign exchange market interventions. Before getting there, however, we cast doubt on the typical conclusion made by most economists that due to the mixed evidence of the portfolio channel there is no room for an efficient additional central bank instrument. In our view, the criticism that is pronounced against the portfolio balance channel of sterilised interventions is of a rather myopic nature. Recall that the basic assumption of this channel is that in the absence of interventions the exchange rate is determined according to the portfolio balance model described at the beginning of this Section. A short look however at the empirical literature on exchange rate models shows that the evidence in favour of portfolio balance models is weak. Frankel and

Rose (1995, p. 1697), for example, summarise the findings as follows: "Early empirical tests of the portfolio-balance model (…) were not particularly successful, even in-sample. The outlook did not much improve when researchers did a more careful job of measuring asset supplies." In particular, as is the case in all fundamentals-based exchange rate models, coefficients in the exchange rate equations are subject to structural instabilities. For this reason, Hallwood and MacDonald (2000, p. 246) conclude: "Although the extant econometric evidence is perhaps not encouraging (…), casual empiricism suggests that the approach may, at least at certain times, be a useful framework for analysing the determination of the exchange rate." Thus, in accordance with these findings, the empirical results for the portfolio balance channel of interventions vary with the underlying estimation period. The question now arises of why interventions that change a fundamental determinant of the exchange rate should lead to different and in particular better results than other sources of changes in the fundamentals (like a central bank's open market policy or a government's bond issue). Or, to put it differently, is it scientifically correct to dismiss the effectiveness of interventions by using a model of exchange rate determination that is only casually suitable for explaining and predicting exchange rate movements? In our view it is not, and in particular it is inconsistent with the conclusions drawn in the context of the monetary channel. As mentioned above, it is generally argued that non-sterilised interventions unquestionably work through that channel while at the same time the monetary model of exchange rate determination is rejected in the literature – like the portfolio balance models.

"Another argument for the relatively lesser importance of the portfolio balance channel is that the typical size of intervention operations is a very tiny fraction of total foreign exchange market turnover" (Sarno and Taylor, 2001a, p. 862).[70] According to surveys of the Bank for International Settlements global turnover in traditional foreign exchange market segments (spot transactions, outright forwards, and foreign exchange swaps) grew from 600 billions of US dollars in 1989 per day to 1200 billions of US dollars per day in 2001 (Galati, 2001). With the US dollar being involved in between 40 and 45 percent of these transactions, the average absolute amount of US dollars used in foreign exchange market intervention by the Fed in the mark/dollar market between 1991 and 1999 was only 0.3 billions of US dollars. Although this argument seems to be convincing at first sight, there is again an important inconsistency if it is applied in the context of the macroeconomic view of the portfolio balance channel. As already mentioned in the previous Section, the sole determinants of the exchange rate in macroeconomic asset market models are

[70] For a similar view see Almekinders (1995, p. 79) and Ramaswamy and Samiei (2000, p. 9).

relative stocks of assets. Thus, there is no room for explaining trading volumes since analyses on the macro level only capture the developments in the exchange rate from one stock equilibrium to another. Instead of arguing on the basis of trading volumes, it is more consistent to relate the intervention activity to average sizes of outstanding government debt. Humpage (1991, p. 15) puts this as follows: “The total stock of publicly held U.S. government securities, for example, was nearly $2.3 trillion at the end of 1989. U.S. intervention amounted to $22 million that year, a record volume, but it was less than 1 percent of the total stock of publicly held U.S. securities. Even if dollar interventions of the other 10 major industrial countries are included, the total amount represents only about 3 percent of publicly held debt.” Although he uses these figures to argue against the efficiency of the portfolio balance channel of sterilised interventions, it should be clear that taking the US as an example involves, on the one hand, a central bank that is among the quantitatively least engaged central banks in the foreign exchange market (see Bofinger and Wollmershäuser, 2001, for the calculation of an index of intervention activity), and, on the other hand, the biggest public debt securities market of the world (see the domestic debt securities tables published in the statistical annex of the ‘BIS Quarterly Review: International Banking and Financial Market Developments’). We will come back to the importance of the volume and the intensity of foreign exchange market interventions below in Section V.1.3.2.

V.1.2.3.2 The microstructure approach

In recent years, the criticism of the portfolio balance approach to the determination of the exchange rate seems to be challenged by the use of real-time data on a microstructure level. “Instead of starting with a set of macroeconomic relations (…) which are used to solve for the exchange rate (…), the microstructure literature analyzes the behavior and interaction of individual decisionmaking units in the foreign-exchange market. Simply put, the microstructure literature is concerned with the details of the mechanics of foreign-exchange trading, whereas the macroeconomic approach typically dismisses the details as unimportant” (Sarno and Taylor, 2001b, pp. 1). One strand of the literature on the microstructure view of the exchange rate highlights the role of order flow for the explanation of exchange rate behaviour. Order flow is defined as the net of buyer-initiated and seller-initiated orders in the inter-bank foreign exchange market (see below for institutional details). The basic idea is that order flow communicates information that is not common knowledge. This information needs to be aggregated by the market, and microstructure describes how that aggregation is achieved (see Lyons, 2001b, for a textbook treatment).

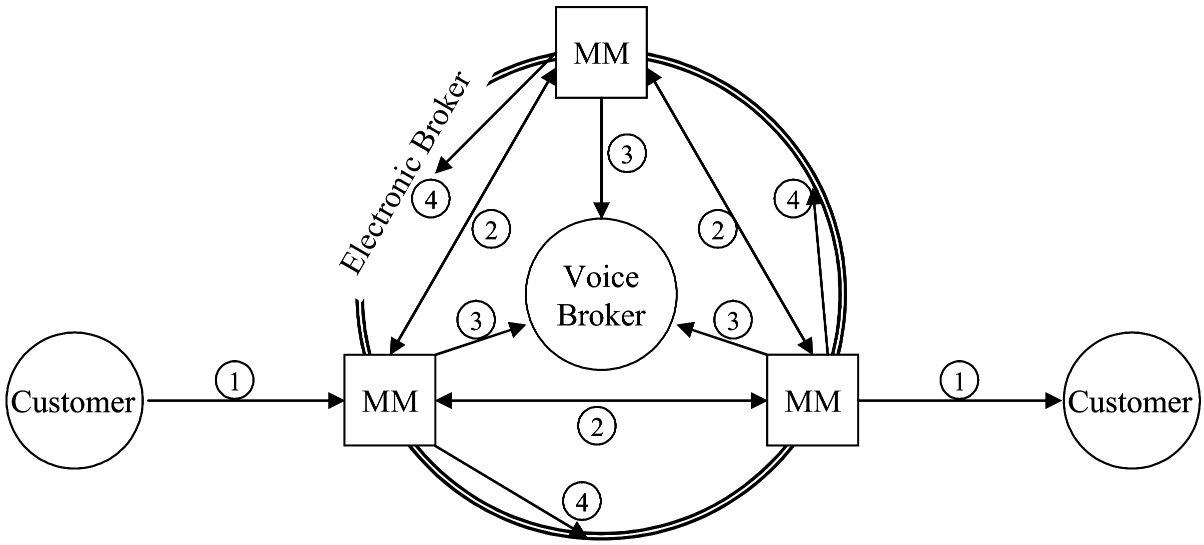
The advantages of the microstructure approach are twofold. On the one hand the measurement difficulties that are particularly related with macroeconomic portfolio-balance models can be overcome by the microstructure approach. “Macro fundamentals in exchange rate equations may be so imprecisely measured that order-flow provides a better ‘proxy’ of their variation” (Evans and Lyons, 2001a, p. 5). Instead of measuring *asset supplies* or making assumptions about how the market forms expectations about future fundamentals, shifts in *public demand* for foreign currency assets are the basic determinants of the exchange rate. The shifts themselves can be exactly measured by the order flow that occurs in the inter-bank foreign exchange market.

On the other hand the microstructure approach provides a rationale for the remarkably high trading volume that can be observed in the foreign exchange market and that is incompatible with the macro approach. Frankel and Froot (1990, p. 92) describe the underlying logic of the latter as follows: “When a new piece of information becomes available, if all investors process the information in the same way and are otherwise identical, no trading needs to take place. The price of the asset should simply jump to its new value.” Thus, the macro view implicitly assumes a Walrasian auctioneer who first collects preliminary orders and who then uses them to find the market-clearing price. Accordingly, the auctioneer’s price adjustment is immediate and no trading needs to occur in transition (see also Evans and Lyons, 2001a). Frankel and Froot (1990, p. 92) continue: “To explain the volume of trading, some heterogeneity of investors is required.” And indeed, the foreign exchange market is characterised by a high degree of heterogeneity concerning the access of the market’s participants to fundamental information. To understand this we have to take a deeper look at the specific structure of the global foreign exchange market.

In contrast to many other markets, the foreign exchange market has to be understood as a complex system with three major groups interacting with each other: market makers (MM), brokers, and customers (for a general text dealing with the nature of markets see Goodhart (1989, chapter I); for a recent survey of the structure of the foreign exchange market see Sarno and Taylor (2001b)).

Generally speaking, the spot foreign exchange market is a decentralised multiple-dealer market with continuous trading. Foreign exchange dealers are *market-makers*. They guarantee the immediacy[71] of the market by continuously standing ready to give two-way quotes to another dealer at request. In order to do so, market makers need to act as principals, with purchases and sales on their own accounts, and thus with varying inventory of foreign exchange over time. When there is a temporary excess supply in the market, the dealer will buy at his announced bid price, thus increasing his inventory of the currency being sold, and when there is a temporary excess demand, the dealer will sell out of his inventory at his ask price, independently of whether he is willing to hold the respective position or not. Thus, direct inter-dealer trade (indicated by the encircled ② in Figure V.5) is best described by the formula 'trading begets trading' which arises from the repeated passage of inventory imbalances among dealers. As a central result, pricing is continuous over time and the trading volume at the foreign exchange market is extremely high.

Figure V.5: Structure of the foreign exchange market



Brokers facilitate trades between dealers (indirect inter-dealer trade) either through radio-networks (the so-called traditional voice brokers) or through electronic communication networks (the so-called electronic brokers) (see Bjønnes and Rime, 2000, for a detailed discussion). They only collect two-way quotes from many dealers and match the lowest ask and the highest bid price. More generally, a broker is best described as an auctioneer who serves as a clearing house. With a view to the trading volume, brokered transactions only occur if both parties (demand and

[71] Immediacy is the characteristic that both buyers and sellers have the opportunity to deal as and when they want.

supply) are willing to take the respective position. Together with the market makers they establish the inter-bank foreign exchange market.

The final category of participants in the foreign exchange market are the *customers* of the market-making banks. Corporate customers can be divided into non-financial firms (exporters and importers) and financial firms (institutional investors). The customer's demand for and supply of currency represent portfolio shifts coming, for example, from changing hedging demands, changing transactional demands, or changing risk preferences (and hence from the customer's activities in international trade and investment). They deal only with market makers and they never go through brokers as the access to the inter-bank market is available only at some fixed costs which are prohibitive for low-transactions volumes. Central banks can also be viewed as customers. They intervene in the foreign exchange market by selling foreign exchange to and buying foreign exchange from market-making banks.

With these three groups in mind, it is now possible to describe the mechanism of price discovery and hence, information dissipation in the foreign exchange market. Generally speaking, the inter-dealer trade has to be understood as a mechanism that maps new information (additional demand and additional supply from outside the inter-dealer market, that is from customers) to prices. The crucial point now is that these initial customer orders ① are not publicly known, with the exception of the dealer who was contacted by the customer.[72] This new information is communicated to the remaining dealers via inter-dealer order flow. The inter-dealer trade itself is characterised by different degrees of transparency, depending on the way the trade is carried out:

- Direct trades between market makers ② are typically unknown except to the two parties in trade. Thus, in order to disperse the new information to all dealers, a multiplicity of direct inter-dealer trades is necessary which sums up to the huge amount of foreign exchange turnover.
- In indirect trades with voice brokers ③, a small subset of trades is communicated to the market via intercom. In general, voice brokers have open telephone lines to many trading desks, so that a market maker dealing in a specific currency can hear over squawk boxes continuous oral reports of the activity of brokers in that currency, the condition of the market, the number of transactions occurring, and the rates at which trading is taking place, though traders do not hear the names of the two banks in the transaction or the

[72] See Figure V.5 for the encircled numbers.

specific volume of the trade (Federal Reserve Bank of New York, 1998). Thus, trades only take place when two dealers within the subset are found that are willing to transact at the new equilibrium price. None the less, part of the new information (especially the transaction price) is communicated to the subset of dealers by the broker.[73]

- In indirect trades on electronic broker systems ④, however, all trades are communicated to the dealers via computer screens. It is the most transparent form of inter-dealer trade as every dealer has access to the systems.

Accordingly, the total inter-dealer trade is simply a mechanism to turn private information into public information. The more transparent the way the inter-dealer trade is carried out, the more informative the trades are assumed to be (Bjønnes and Rime, 2000). Inter-dealer trading which is quantified by the observable order flow can therefore be understood as a means by which market makers ‘sell’ each other information about their transactions with outside customers. They capture the informational rent associated with receiving the private information from customer orders. Thus, “order flow conveys information about dispersed fundamentals because it contains the trades of those who analyse/observe those fundamentals. It is a transmission mechanism” (Lyons, 2001a, p. 2). If fundamental information is not publicly known, non-zero order flow will continue to occur. In sharp contrast to the Walrasian auctioneer based macro approach, the foreign exchange market does not immediately jump from one equilibrium to another. As a decentralised multiple-dealer market the foreign exchange market can rather be viewed as a complex system that is characterised by a permanent disequilibrium (Chakrabarti, 2000).

Evans and Lyons (2001a, 2002b) developed a theoretical model that incorporates the above institutional elements and that yields a testable exchange rate equation. In the following we will present the basic features of the so-called *portfolio shifts model*.

The model assumes that a period (usually a day) is divided into three stylised trading rounds. In the first round dealers trade with the customers (① in Figure V.5). Each of the N dealers, indexed by i, receives stochastic customer orders $C^1_{i,t}$. All dealers’ customer orders sum up to the aggregate public demand C^1_t. The superscript indicates the round in which the orders are assumed to occur. The bid and ask rates the dealers quote to their customers depend on the

[73] For the reasons on why a market maker contacts a broker instead of another market maker see Luca (2000, chapter 10) and Levich (2001, chapter 3).

information that is available to the dealers in round 1. Below we will specify this information as interest rate differential. For the moment however we will concentrate on the influence of the new information resulting from the customer orders that is only observed by the contacted dealer.

In round 2 the risk averse dealers trade among themselves to share the risk related with holding positions they would not hold otherwise (② in Figure V.5).[74] This is the round in which order flow comes into play. A period's net inter-dealer order flow is defined as

(V.10) $$X_t = \sum_{i=1}^{N} T_{i,t}^2$$

where $T_{i,t}^2$ denotes the round-2 net inter-dealer trade initiated by dealer i. Evans and Lyons (2001a) show that for each individual dealer the optimal strategy is to realise a trading volume that is proportional to the customer orders he receives in round 1:

(V.11) $$T_{i,t}^2 = \alpha C_{i,t}^1 .$$

The coefficient α is positive and equal to all dealers. If all inter-dealer trades are executed at the end of the period, the dealers have learnt about the total position the public needs to absorb from order flow X_t

(V.12) $$X_t = \alpha C_t^1 .$$

The crucial point of the portfolio shifts model is that the dealer-customer trades (round 1) which are not observable on a market-wide level are gradually reflected in inter-dealer trades (round 2) which are observed market-wide. Once observed, this information is impounded in the exchange rate in round 3 when dealers are assumed to trade again with the customers (① in Figure V.5). Dealers know that the public needs to be induced to reabsorb the initial aggregate portfolio shift

[74] An important drawback of the Evans and Lyons (2001a, 2002b) model is that brokered trading is not captured by the model. Only about 60 percent of the inter-bank trading volume is direct (i.e. between market makers). The remaining part are indirect (brokered) trades (see Evans and Lyons, 2001a, footnote 15).

C_t^1 since the dealers themselves do not hold any interest-bearing overnight positions.[75] From this follows that $C_t^3 = -C_t^1$ so that each dealer ends the day with no net position. However, the public's total demand in round 3, C_t^3, is not perfectly elastic. As the public is not indifferent with regard to the composition of their portfolio, it requires a price adjustment to clear the market. This finally produces a testable relation between the observable inter-dealer order flow and the subsequent adjustment of the exchange rate:

(V.13) $$\Delta s_t = \alpha_1 \left(i_{t-1} - i_{t-1}^f \right) + \alpha_2 X_t + \varepsilon_t$$

where $\Delta s_t = s_t - s_{t-1}$ spans the period from the end of round 3 of the previous day (which is equal to the beginning of today's round 1 since foreign exchange trading is continuous) to the end of today's round 3. If the end-of-period public demand were perfectly elastic (i.e. the customers' aggregate risk-bearing capacity is infinite), order flow would still convey information about the portfolio shift, but the shift would not affect the end-of-period exchange rate (i.e. $\alpha_2 = 0$). Thus, imperfect substitutability of different-currency assets and risk aversion of the public requires a coefficient α_2 to be positive and significantly different from zero. The inclusion of the interest rate differential turns the portfolio shifts model into a hybrid model combining both, microstructure elements (institutional features, non-public information about fundamentals) and macro elements (public information about fundamentals, specifically interest rates).[76]

Evans and Lyons (2001a, 2002b) estimated the model with daily data from May to August 1996 for the DM/US-$ spot rate. The coefficient α_2 was found to be statistically significant with the correct sign. Accordingly, $1 billion of net dollar purchases appreciate the dollar by 0.54 percent. The explanatory power of this regression was due to order flow: regressing the change in the exchange rate only on the interest rate differential produces an R^2 statistic of below 1 percent and a coefficient α_1 that is insignificant (hence, the typical UIP result for UIP estimations; see Chapter III). Adding order flow increases R^2 to 64 percent. In two related papers Evans and Lyons (2001b, 2002a) present a somewhat more refined intra-day model. Working

[75] In reality, dealers hold open positions overnight, however within prudential limits set by their bank (Goodhart, 1988). A study by Yao (1998) shows that only 4 percent of the total trading volume of a representative New York based market maker can be identified as open positions.

[76] Equation (V.13) is very similar to the typical regression model for testing UIP, of course without the order flow term.

with higher-frequency data allows to distinguish between temporary portfolio balance effects stemming from (intra-day) inter-dealer trades and persistent portfolio balance effects stemming from the customers' (and hence the foreign exchange market's) risk aversion. The result slightly differs from that of the daily model (which was estimated for the same underlying period). According to the authors, the difference can be explained by order flow being positively auto-correlated at the hourly frequency. They find that \$1 billion of net dollar purchases now appreciate the dollar by 0.44 percent whereof 80 percent persist indefinitely.

Many economists might be tempted to ask: But what drives order flow? Admittedly, this question is of crucial importance for macroeconomists. However, it is not important for our analysis (those who are interested in this question are referred to Lyons, 2001a, 2001b). What matters for the present analysis is that portfolio shifts coming from outside the inter-bank foreign exchange market provoke exchange rate changes. This attributes an important role to central bank interventions, in particular to foreign exchange market interventions that are sterilised, conducted secretly (i.e. anonymously and unannounced) and that convey no signal of future monetary policy.[77] In fact, modelling a central bank's intervention that way makes them indistinguishable from other customer orders. Thus, the approach chosen by Evans and Lyons is an indirect one since interventions do not necessarily have to occur during the estimation period. It simply provides evidence for the old idea that forcing international investors to adjust their portfolios consisting of different-currency assets requires an adjustment of the exchange rate as long as investors care about the currency denomination of their assets. In contrast to the macro approach, now the asset supply is assumed to be constant. Evans and Lyons (2002a, p. 24) interpret their results as follows: "We find strong evidence of price effects from imperfect substitutability, both temporary and persistent. This contrasts with the common belief that these effects (from interventions or otherwise) are too small to be detectable. Not only are they detectable, they are also economically significant, leading us to conclude that portfolio balance theory is more applicable than many believe." A prime example for the common belief that is based on the poor evidence of the macro approach is the survey article of Sarno and Taylor (2001a, p. 862). With respect to the importance of the portfolio balance channel they point out that, if it is effective at all, its importance will diminish over time "- at least among the major industrialised countries - as international capital markets become increasingly integrated and the

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[77] This ensures that only portfolio-balance effects impact on the exchange rate. If interventions convey signals of future monetary policy an alternative intervention channel applies (see Section V.1.2.4).

degree of substitutability between financial assets denominated in the major currencies increases."

Finally, it should be stressed that the argument according to which the high daily trading volume in the foreign exchange market reduces the potential power of interventions considerably is not valid anymore if one takes the microstructure of the foreign exchange market into account. The multiplier effect resulting from the market maker principle that governs the organisation of the foreign exchange market equally applies to each customer transaction, be it a private customer order or a central bank intervention (Bofinger, 2000). In the words of Baillie and Osterberg (1997, p. 913): "Hence the volume of 'market moving' transactions may well be considerably smaller than the \$1000 bn stated earlier and hence allows a potentially greater role for central bank intervention."

V.1.2.4 The signalling / expectations channel of sterilised interventions and the news approach to the determination of the exchange rate

The previously presented asset market approaches to the determination of the exchange rate focused on the identification of the assets for which the exchange rate is regarded as relative price. So far, however, we totally neglected the role of expectations and the forward-looking nature of the exchange rate. If the exchange rate is viewed as the price of a durable asset then the current exchange rate should reflect the market's expectation concerning present and future economic conditions relevant for determining the appropriate value of this durable asset. Changes in the spot rate should be largely unpredictable and reflect primarily new information that alters expectations concerning these present and future conditions. While the previously presented exchange rate models tell us how the exchange rate should respond to each news report, we now concentrate on the occurrence of news and their impact on the exchange rate without further specifying these news. In particular, the exchange rate should change only in response to new pieces of unanticipated information (the so-called news). This leads to the well-known efficient markets hypothesis underlying the news approach to the determination of the exchange rate. If foreign exchange markets were perfectly efficient, all the relevant information concerning the determinants of the currencies should be reflected in their exchange rate.

In the following we present the basic framework of an asset pricing model of the exchange rate in a fairly general way (see Levich, 2001, chapter 6, for a textbook treatment). As with other asset prices, the exchange rate is forward-looking and a function of its own expected future value. The current spot exchange rate can thus be expressed as

$$s_t = x_t + \alpha_1 \left(E_t \left[s_{t+1} \middle| \Omega_t \right] - s_t \right), \tag{V.14}$$

where x_t represents the fundamentals, $E_t[\ldots]$ denotes the expected rate of change of the exchange rate conditional on the information set Ω at time t, and α_1 measures the elasticity of the current exchange rate with respect to expectations. Solving equation (V.14) for s_t yields the following stochastic difference equation

$$s_t = \frac{1}{1+\alpha_1} x_t + \frac{\alpha_1}{1+\alpha_1} E_t \left[s_{t+1} \middle| \Omega_t \right]. \tag{V.15}$$

By forward iteration, the solution of equation (V.15) is obtained which leads to the more commonly used formulation of the nominal exchange rate

$$s_t = \frac{1}{1+\alpha_1} \sum_{j=0}^{\infty} \left(\frac{\alpha_1}{1+\alpha_1} \right)^j E_t \left[x_{t+j} \middle| \Omega_t \right] \tag{V.16}$$

as a discounted sum of current and expected future fundamentals conditional on currently available information.[78]

According to this model, every piece of additional information that is relevant for the determination of the exchange rate influences the market expectations and consequently changes the current exchange rate. Under these assumptions the sole consequence of central bank intervention I_t is to alter the information set from Ω_t to $\Omega_t^{'} = \Omega_t + I_t$ by conveying inside information to the market (Watanabe, 1994). The effect on the exchange rate is then captured by

$$\Delta s_t = \frac{1}{1+\alpha_1} \sum_{j=0}^{\infty} \left(\frac{\alpha_1}{1+\alpha_1} \right)^j \left(E_t \left[x_{t+j} \middle| \Omega_t^{'} \right] - E_t \left[x_{t+j} \middle| \Omega_t \right] \right). \tag{V.17}$$

With respect to our baseline model presented in Chapter IV we can now specify the fundamentals determining the current exchange rate. The asset market relationship is given by UIP without taking into account a risk premium in order to distinguish this intervention channel from the portfolio balance channel.[79] Rewriting the UIP condition as an equation for the current exchange rate without restricting the coefficients gives

$$\text{(V.18)} \qquad s_t = \alpha_1 E\left[s_{t+k} \middle| \Omega_t\right] + \alpha_2 \left(i_t - i_t^f\right),$$

where k is the maturity of the interest rate. Under strict UIP, implying unbiased efficiency, α_1 would be equal to 1 and α_2 equal to –1. The rational expectations solution to equation (V.18) is

$$\text{(V.19)} \qquad s_t = \alpha_2 \sum_{j=0}^{\infty} \alpha_1^j E\left[\left(i_{t+j} - i_{t+j}^f\right) \middle| \Omega_t\right].$$

As the current interest rate is assumed to remain unchanged due to sterilisation of the foreign exchange market interventions, the current exchange rate is the result of investor's portfolio decisions that are taken on the ground of expectations about future interest rates (i.e. $j > 0$). Thus, for central bank interventions to be effective, it is assumed that the central bank possesses resources and knowledge not available to the public, the so-called inside informations. The literature basically distinguishes between two types of informational asymmetries.

First, as Mussa (1981, p. 15), one of the first to describe the expectational effects of interventions, writes: "A central bank can use its knowledge of its own future policy to guide its speculations in foreign exchange and, if the need arises, can use its control over monetary policy to guarantee the success of its speculations." According to this hypothesis operations in the foreign exchange market by the central bank may be used to signal future changes in monetary policy instruments (i.e. changes in i_{t+j} for $j > 0$). Sterilised intervention is more effective than a simple announcement, because by buying (selling) foreign assets the central bank stakes its own

[78] The solution presented in equation (V.16) is only valid for $\alpha_1/(1+\alpha_1) < 1$. If it is greater than unity, we have to add a second term to equation (V.16) which is often referred to as a rational bubble.

capital in support of the future policy and hence "can purchase credibility" (Mussa, 1981, p. 17). If the market participants believe the signals provided by the intervention, they will influence exchange rates by betting with the central bank. Thus, the credibility of the signal results from the reputational costs associated with false signals. These costs are the loss of both, reputation and international reserves resulting from interventions in the wrong direction. We refer to this kind of expectations channel as the policy signalling channel.

Within the setting of our rational expectations model, however, it is not clear why the private sector should have informational disadvantages concerning the future interest rate policy as long as the central bank continues to commit to a publicly known policy rule and as long as all agents (including the central bank) agree on the model describing the behavioural relationships of the economy.[80] Thus, many economists rely on an alternative rationale for interventions within the framework of the news model of exchange rates and view interventions as a means "to improve the flow of information in disorderly markets" (Rosenberg, 1996, p. 306). It is assumed that central banks can judge the current development of the exchange rate as primarily driven by non-rational behaviour (speculative bubbles and herding) with the consequence that fundamental information is not correctly incorporated in the exchange rate. Therefore central banks intervene in order to give the market a signal about its view of the correct exchange rate (Eijffinger and Gruijters, 1992). Thus, markets are viewed as weak-form efficient, while central banks are assumed to possess superior information. This branch of the expectations channel is often referred to as the market efficiency channel.

However, in our view, this last interpretation of the expectations channel is not consistent with the underlying news approach to the determination of the exchange rate which basically assumes foreign exchange market efficiency. Certainly, collective irrational behaviour of the market is an important issue for understanding the misalignments of freely floating exchange rates. Thus, in Section V.1.2.5 we will consider an intervention channel that exploits the properties of exchange

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[79] Under such circumstances, investors are indifferent between these two assets only if the expected return on foreign bonds equals the domestic interest rate. In contrast to the portfolio channel, expectations affect the exchange rate even if domestic and foreign bonds are perfect substitutes.

[80] Humpage (1991, p. 17) 'saves' the policy signalling channel as follows: "In attempting to explain the signaling mechanism, many economists have argued that the importance of intervention centers not on its ability to herald policy changes, but on its ability to cement governments' commitment to those policy changes. Even when governments announce an optimal policy today, they can face incentives to renege on that policy tomorrow. Markets, of course, realize this and factor into their expectations the likelihood that policy makers will not follow through on their pronouncements. Policies allowing no opportunity for backing down, consequently, can have very different effects than similar policies that permit reneging."

rates that are driven by chartist behaviour. In this Section we will rather concentrate on the first interpretation of the expectations channel of sterilised foreign exchange market interventions – the policy signalling channel – which assumes a fully efficient foreign exchange market.

One popular approach to test empirically the signalling hypothesis is to directly estimate the news character of current intervention on the exchange rate. Based on equation (V.17) one can derive the following estimation equation which takes into account two sources of new information:

(V.20) $$\Delta s_t = \alpha_0 + \alpha_1 x_t + \alpha_2 I_t + \varepsilon_t^s .$$

x_t denotes fundamental news, while intervention activity is captured by I_t. Thus, the basic technique of this approach is to directly estimate the influence of current interventions on the exchange rate, over and above the contribution of the current fundamental. Due to the importance of the informational content of interventions, the signalling approach offers the opportunity to compare the impact of different forms of interventions. Most studies differentiated between secret and public interventions[81] (Dominguez and Frankel, 1993b, Fischer and Zurlinden, 1999, Zurlinden, 1996), initial and subsequent interventions[82] (Dominguez and Frankel, 1993b, Eijffinger and Gruijters, 1992, Fischer and Zurlinden, 1999, Humpage, 1988, Ito, 2002, Zurlinden, 1996) or coordinated and unilateral interventions[83] (Dominguez, 1990, Dominguez and Frankel, 1993b, Eijffinger and Gruijters, 1992, Humpage and Osterberg, 1992). Unfortunately, the results vary considerably. The studies of Dominguez and Frankel (1993b), Fischer and Zurlinden (1999) and Ito (2002) provide strong statistical evidence supportive of the

[81] This group of empirical work compares the effects of reported and non-reported interventions on the exchange rate. One basic message of the signalling channel is that only publicly known (and thus announced by the central bank) interventions can affect the expectations of private agents and therefore have an influence on the exchange rate as described in the asset pricing model.

[82] The idea behind this distinction is that the news effect plays a dominant role in the determination of the exchange rate. If interventions are clustered, i.e. several intervention operations are conducted consecutively in a short period of time, then the signalling hypothesis suggests that only those interventions can alter current exchange rates that are providing new information. In contrast to subsequent interventions, the initial intervention is supposed to have that announcement effect, and thus the news content of initial interventions is supposed to be larger than the news content of the subsequent interventions. Accordingly, the effectiveness of initial interventions is expected to be higher.

[83] An intervention is said to be coordinated or concerted if at least two central banks intervene on the same day in the same direction, i.e. in support of or against the same currency. An outcome of the signalling channel should be that coordinated interventions affect the exchange rate more effectively than unilateral interventions. The underlying rationale is that concerted interventions are assumed to convey multiple coordinated signals which increases the probability that the signal is true.

effectiveness of sterilised interventions through the signalling channel. In particular, they found that initial interventions that are made public and that are coordinated with interventions of other central banks are most effective. In contrast to this, the other studies are far from conclusive. Depending on the underlying sub-period and the intervening central bank, coefficients of the intervention variable are sometimes correctly signed and significant, sometimes insignificant, and sometimes significant and wrongly signed.

An extension of the direct approach to estimating the effects of interventions on the exchange rate was introduced by Baillie and Humpage (1992). Instead of using traditional OLS estimates, they took account of the fact that the variance of short-term exchange rate changes is variable over time[84] and therefore used a GARCH-model on the basis of daily exchange rate data. This methods allows the investigator to examine the effect of interventions on both, the conditional volatility and the level of the exchange rate. The literature using this method almost exploded in recent years due to the better availability of high frequency data (see Aguilar and Nydahl, 2000, Baillie and Osterberg, 1997, Beine et al., 2002, Chang and Taylor, 1998, Dominguez, 1998, Morana and Beltratti, 2000, Osterberg and Humes, 1995). Most of the studies conclude that the effects of interventions on the level of the exchange rate are insignificant and that intervention activity typically increases the volatility.[85]

Recently, three types of criticism have been pronounced against the time series approach of the above studies. First, they can only capture the short-term (day-to-day or even intra-day) effects (or non-effects) of the intervention on the exchange rate. However, as Baillie et al. (2000, p. 414) put it, “in general, little is known about the duration of price discovery in the foreign exchange market following an intervention.” Second, the lower the frequency of the data, the higher the probability that the estimations are biased due to simultaneity as the causes and the effects of the intervention become blurred. To avoid this, researchers either use high frequency (tick-by-tick) data which is subject to the first criticism, or they lag intervention relative to the exchange rate

[84] This observation (which goes back to Hsieh, 1989) violates the central assumption of every OLS estimation according to which the residuals ε_t have to be normally distributed with a constant variance (i.e. homoscedastic). Hsieh found evidence that the distribution of daily exchange rate changes is characterised by heteroskedasticity and leptokurtosis (i.e. large changes are followed by large changes, and small changes by small changes). GARCH models therefore take account of the persistence in the effects of shocks in period t onto the conditional variance in later periods.

[85] It is often argued that a purpose of central bank interventions is to calm disorderly markets – besides targeting a level for the exchange rate (see e.g. Almekinders and Eijffinger, 1996, and Frenkel and Stadtmann, 2001). Thus, it may be of interest to measure the impact of interventions on the volatility of the exchange rate. However, the

which may introduce a specification error (see Almekinders and Eijffinger, 1994, and Humpage, 1999). Finally, Fatum (2000, pp. 5) recognised that while “exchange rates are typically highly volatile on a day-to-day basis, intervention tends to come in sporadic clusters – viewed in this light it may seem less surprising that time series based studies tend not to find strong evidence for a systematic link between exchange rate movements and intervention operations.”

Thus, a new strand of empirical literature emerged that focused on singular intervention episodes rather than on a time series approach. A common feature of this literature is that the appropriate measure of successful intervention is not the daily or hourly instantaneous impact on the exchange rate while the intervention activity is ongoing, but the cumulative effect after its completion. Catte et al. (1994) who were among the first to implement this approach found in their descriptive study that all of the intervention episodes under investigation (G3 interventions between 1985 and 1991) were effective. Using a statistically more refined event study approach typically employed in the finance literature, Fatum (2000) and Fatum and Hutchison (2002c) (for mark/US dollar interventions), Fatum and Hutchison (2002a) (for euro/US dollar interventions) and Fatum and Hutchison (2002b) (for yen/US dollar interventions) found strong evidence in favour of short-term effectiveness (i.e. up to 15 days following the intervention event) of sterilised interventions. Estimating a binary choice (logit) model Humpage (1999, 2000) and Fatum (2002), moreover, found that the probability of success increases when intervention operations are coordinated.

A fundamentally different approach to test the signalling hypothesis is to measure the ability to forecast movements in the future monetary policy variables. Instead of directly testing the impact of interventions on the exchange rate (on the basis of equations (V.17) and (V.20)), now the effectiveness of interventions is indirectly investigated by using equation (V.19) as the starting point. If a central bank aims at signalling, for example, a more contractionary policy in the future, it buys domestic currency today. Therefore, the expectations of future tighter monetary policy make the domestic currency appreciate, even though the current monetary effects of the intervention are sterilised by the central bank. The majority of studies (Fatum and Hutchison, 1999, Kaminsky and Lewis, 1996, Klein and Rosengren, 1991, Lewis, 1995a) comes to rather mixed and inconclusive results – although the methods they used were quite different. Above all, the “evidence suggests an interpretation of the typical finding in the literature that the

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definition of direct managed floating given in Chapter I clearly defines the objective of the central bank as effectiveness of intervention appears to depend upon the sample period" (Kaminsky and Lewis, 1996, p. 308). Contrary to this conventional wisdom, Watanabe (1994) found that in the majority of cases under investigation intervention policy was consistent with the subsequent interest rate policy. Interestingly, he studied the intervention policy of the Bank of Japan, whereas the other papers focused on US monetary policy.

We will finish the discussion of the signalling channel with some critical remarks. First, as has already been pointed out by Obstfeld (1990), Gosh (1992) and Reeves (1997), sterilised interventions should no longer be considered as independent monetary policy tool, if the information revealed contains own future policy intentions. If the signals transmitted by the central bank shall retain credibility in the future (what is a central requirement for the signalling channel to be effective; see e.g. Dominguez, 1998), central banks should avoid reneging on prior policy announcements. This suggests that initially sterilised interventions have to be ultimately monetised. Notwithstanding this credibility aspect, if sterilised interventions only worked through this channel, one has to ask why the liquidity effect caused by the variation of the foreign exchange reserves should be compensated by sterilisation at all when it will be backed sooner or later by monetary policy steps 'in the same direction'.[86] Moreover, the credibility requirement for the effectiveness of the signalling channel may also lead to problems in the context of coordinated interventions. A very common strategy of central banks is to 'lean against the wind' irrespective of the actual course of monetary policy. If, for example, a central bank actually pursues a policy of monetary contraction, it may well be involved in a concerted intervention to weaken its own currency in order to break a current trend away from what central banks deem appropriate. Such a contradiction in policy intentions certainly does not enhance the credibility needed for interventions to be effective within the framework of the signalling channel. Note that, unlike the signalling channel, the balance of payments flow channel and portfolio balance channel make no prediction as to the direction of future changes in the monetary policy.

Besides being credible, a further requirement for interventions to be effective is that the signals of the central bank have to be unambiguous. If the signalling channel is taken seriously, then the

targeting an exchange rate path, and hence a level for each point in time.

[86] See footnote 80 for a possible, albeit not convincing, explanation. There are certainly better commitment technologies for a central bank (e.g. the pursuance of a simple policy rule; see Chapter IV) compared to sterilised foreign exchange market interventions.

question emerges of why many actual intervention operations in the foreign exchange market are secret (the so-called 'secrecy puzzle'; see Dominguez and Frankel, 1993b, and Sarno and Taylor, 2001a). A hidden intervention cannot provide any news to private agents, and thus, expectations about future exchange rate determinants, and hence the current exchange rate, cannot be adjusted.

The third type of criticism refers to the underlying exchange rate model. Dominguez (1998) emphasises that a basic assumption related with this approach is that foreign exchange markets need to be fully efficient in the sense that the current exchange rates reflect all the relevant information available. Thus, each econometric model based on asset price relations like (V.17) involves a joint hypothesis: the efficiency of the foreign exchange market and the effectiveness of the intervention policy. Most economists (in particular those using time series analyses) argued that their results indicate that interventions cannot be viewed as an effective policy tool, thereby assuming that the foreign exchange market efficiently maps new information into prices. From this point of view it is perfectly consistent to investigate the immediate effects of interventions on the exchange rate by using daily or intra-daily data. However, if one rejects the efficient markets hypothesis, it is not allowed to draw any conclusions with regard to the effectiveness of interventions on the basis of models that basically rely on this assumption. So the crucial question emerges if it is permissible to question the validity of the efficient markets hypothesis. This is certainly not the place to address this question in detail. However, it should be clear from Chapter III that inefficiencies (in the sense of collective non-rationality) play a dominant role in explaining the various exchange rate anomalies. With respect to the news model of the exchange rate De Grauwe and Grimaldi (2001, pp. 459) state: "There is increasing evidence that the efficient market hypothesis fails as a theory. For example it has been shown that most of the movements of the exchange rate cannot be associated with news (…). Unanticipated shocks in the fundamental variables explain only a small fraction of the unanticipated changes in the exchange rates. Typically over forecast horizons of up to one year, news in output, inflation, and interest rates explains less than 5% of the movements of the exchange rate. About 95% of the latter is attributable to the news in the exchange rate itself" (see also the literature cited there). In a recent empirical study Galati and Ho (2001) come to qualitatively similar results. In particular, they point out that the influence of news on exchange rates exhibits considerable time variation. Thus, in accordance with the line of arguments of the previous fundamentals-based exchange rate channels, it is not surprising that the results of time-series based studies of interventions are rather inconclusive, given the inappropriateness of the news model. Baillie and Osterberg (2000, p. 365), who take shocks to monetary aggregates as an example for the driving force of exchange rate movements, come to a similar conclusion: “The lack of success of the signalling hypothesis does not seem particularly surprising given the monetary model’s apparent failure to predict exchange rate movements. If money has little direct role in the short term exchange rate changes, then it is also unclear why signalling monetary policy should matter.”

V.1.2.5 The noise trading / coordination channel of sterilised interventions and the inefficient foreign exchange markets hypothesis

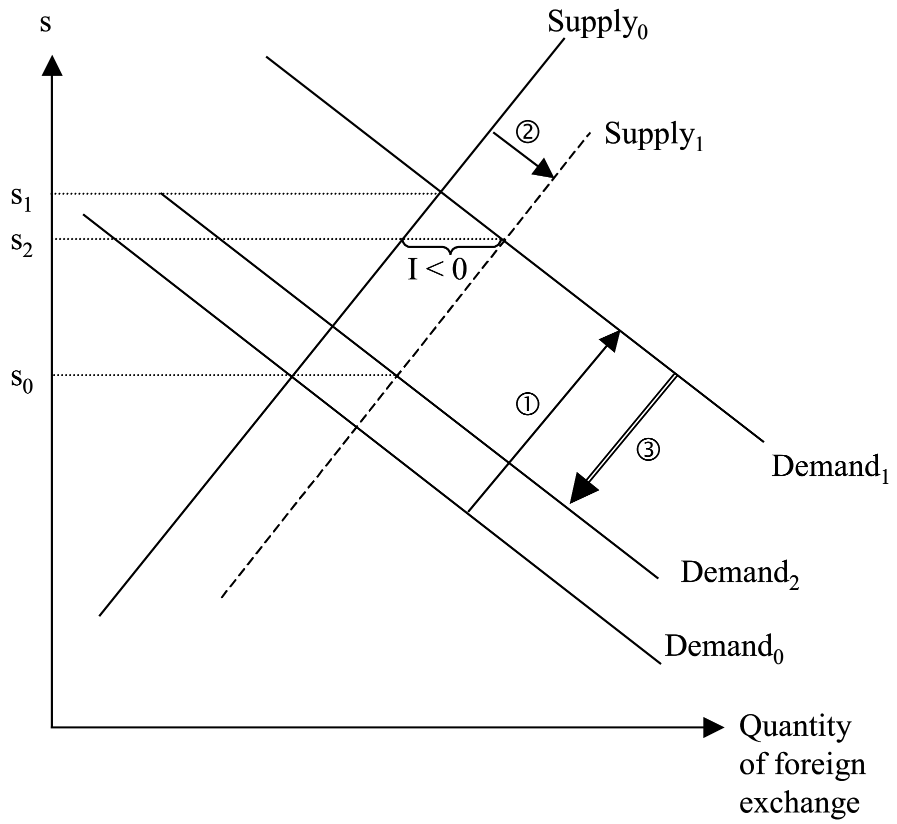
In the discussion of the macroeconomic portfolio balance channel and the signalling channel we criticised the weak empirical results in favour of these two channels for the underlying exchange rate models which are based on the efficient markets hypothesis and which are widely rejected in the empirical literature. In both channels, interventions were assumed to influence the course of the exchange rate by altering a fundamental determinant of the exchange rate (either the risk premium in the case of the portfolio balance channel, or the expected future interest rate in the case of the signalling channel). If, however, fundamental determinants are weakly related to exchange rate movements, an alternative intervention channel should be discussed which is based on an exchange rate model that does not rely upon the hypothesis of an efficient foreign exchange market, but that incorporates the sources of inefficiencies, such as noise trading and chartism.

The so-called ‘noise trading’ channel of sterilised foreign exchange market interventions which was developed by Hung (1997) (based on two earlier working papers: Hung, 1991a, 1991b) provides central banks with a means of exploiting the behaviour of short run technical-oriented traders who dominate especially the worlds most liquid currency markets (see Chapter III): “The hypothesis maintains that (...) central banks can use well-designed intervention strategies to induce noise traders to buy or sell a currency in such a way that the otherwise temporary effect of sterilized intervention is longer-lasting” (Hung, 1997, p. 782). In particular, it provides an explanation for the secrecy puzzle and the volatility puzzle which emerged from the signalling channel of sterilised foreign exchange market interventions. Hung (1997, p. 780) states: “In cases where intervention is intended to reverse the direction of the exchange rate moving with strong momentum, authorities may use volatility-enhancing intervention to manage the exchange rate level, although normally they may prefer to reduce exchange rate volatility.” The higher volatility is viewed to be a reflection of the market's increased uncertainty about the sustainability of the prevailing trend. Hung assumes that the more ambiguous the signals that are spread by the central bank's intervention (secrecy of the intervention), the higher the uncertainty of the market participants (volatility of the exchange rate) who may think that the market momentum is changing of its own accord.

Another way of interpreting sterilised interventions in this context is through their role of remedying the coordination failure of the foreign exchange market when it is subject to irrational speculative bubbles brought on by non-economic factors such as chartism or technical analysis. This so-called 'coordination' channel has already been discussed implicitly in Dominguez and Frankel (1993b). In their analogy for foreign exchange market interventions, they liken the role of intervention to the role played by herd dogs among cattle. "On those rare occasions when a stampede gets under way because each panicked steer is following its neighbors, the herd can potentially wander quite far from the proper course. The dogs can be useful in heading off a stampede: if a few of them succeed in turning around a few key steers in a highly visible manner, the rest of the herd may turn to follow" (Dominguez and Frankel, 1993b, p. 139). In a related study Dominguez and Frankel (1993c, p. 343) come to the following conclusion: "Our own inclination is to believe that expectations only tend to be extrapolative in occasional periods: speculative bubble environments, when the foreign exchange market loses its moorings and forecasters forget about fundamentals. Of course, these are precisely the periods in which central bankers might be most interested in using the tool of intervention."

Figure V.6 graphically illustrates the noise trading / coordination channel. Suppose that for technical reasons (chartism) the demand for foreign exchange steadily rises (①) so that the domestic currency depreciates from s_0 to s_1. Suppose further that if the spot rate reached s_2, it would break a technically important point recommending the noise trader to sell foreign exchange from that time on. From this clearly follows the strategy of the central bank: Through intervention it has to create a temporary increase in the supply of foreign exchange (②) which causes an appreciation to s_2 (this re-allocates an important role to the balance of payments flow channel which was criticised in Section V.1.2.2 because of its temporary nature). If chartists perceive that the prevailing trend has been broken and that a trend reversal has been formed, noise traders may unwind their positions and take on new positions, betting on the intervention-inspired reversal. Such shifts in noise traders' positions will tend to perpetuate the effect of the initial intervention operation and contribute to the reversal in trend desired by the monetary authorities (③).

Figure V.6: The noise trading channel of sterilised foreign exchange market intervention



The theoretical background for a chartist-fundamentalist foreign exchange market was presented in Chapter III. A main result was that deviations from fundamental values can persist for a considerable length of time as it is individually rational in such circumstances for each market participant not to bet against the market. In the following, we will extend the chartist-fundamentalist model by introducing a central bank as an additional player in the foreign exchange market. Without central bank interventions, we showed that the exchange rate evolves according to

(V.21) $$s_{t+1} = s_t + \upsilon\theta^f\left(s_t^{fund} - s_t\right) + \left(1-\upsilon\right)\theta^c\left(s_t - \frac{1}{n+1}\sum_{i=0}^{n} s_{t-i}\right) + \varepsilon_{t+1}$$

which is similar to equation (III.41). With interventions, (V.21) becomes

(V.22) $$s_{t+1} = s_t + \upsilon\theta^f\left(s_t^{fund} - s_t\right) + (1-\upsilon)\theta^c\left(s_t - \frac{1}{n+1}\sum_{i=0}^{n} s_{t-i}\right) + I_t + \varepsilon_{t+1}$$

where I_t reflects the effect of the intervention in time t on the exchange rate in time $t+1$. We specifically modelled an intervention rule according to which the central bank only buys foreign exchange when the value of its currency is below its fundamental value (overvaluation) and it only sells foreign currency when the value of its currency is above its fundamental value (undervaluation). The single intervention is assumed to temporarily move the exchange rate by five per cent.[87] In summary, the intervention variable is defined by

(V.23) $$I_t = \begin{cases} +0.05 s_t, \text{ if } s_t < s_t^{fund} \\ -0.05 s_t, \text{ if } s_t > s_t^{fund}. \end{cases}$$

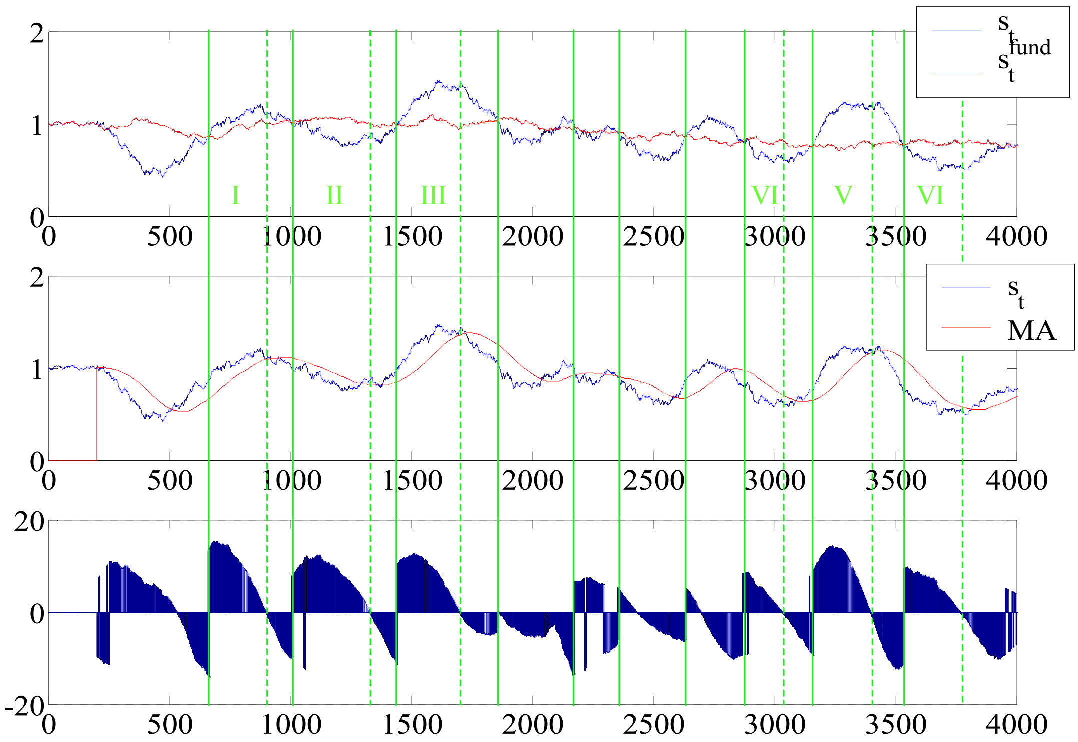
In fact, a sterilised intervention through the noise trading / coordination channel implicitly increases the weight υ of the fundamentalists in equation (V.21) which was defined as the percentage of private market participants with stabilising rational expectations. Thus, central banks can overcome the collective action problem by using sterilised foreign exchange market interventions to support the private fundamentalists and to accelerate the trend reversal.

The results of the simulation are shown in Figure V.7. The upper two panels are identical with Figure III.2 in Section III.3.2.1.2 (see here also for the calibration of the model). The lower panel shows the effectiveness curve of interventions in the chartist-fundamentalist model which depicts the effects of a single intervention in time t. The effect is measured by the reduction in the misalignment from t to $t+1000$ (in comparison with the situation without intervention) in per cent. The solid green vertical lines mark the period in which the actual exchange rate breaks the red fundamental line (see the upper panel). Interventions that take place shortly before these points are clearly destabilising as they accelerate an already existing trend of the currency, thereby creating some kind of overshooting. By contrast, interventions that take place after these points are very successful in reducing the degree of misalignment. The dashed green vertical

[87] For those who believe that this effect is too high, just think back to the intervention to support the yen on June 17, 1998. Within a few hours the currency moved from around 144 to 136 yen per US-$ which corresponds to a dollar depreciation of more than five per cent. This intervention was coordinated between the Japanese authorities and the US Federal Reserve, with a sale of US-$ by the Japanese authorities amounting to 1670 millions of US-$ (i.e. ⅔ of the total), and a sale of US-$ by the Federal Reserve amounting to 833 millions of US-$ (i.e. ⅓ of the total) (see also Figure V.9 below for the Japanese interventions).

lines mark the period in which the effect of the interventions turns from positive to negative. They roughly coincide with the periods in which the actual exchange rate breaks the red moving average line (see the middle panel). The maxima of the blue effectiveness curve coincide with the maximum distance of the actual exchange rate from its moving average.

Figure V.7: Interventions in the chartist-fundamentalist model



To sum up, interventions in the chartist-fundamentalist model appear to be successful if

- the exchange rate trend (misalignment) is sufficiently large (in the middle of our simulation period between $t \approx 1700$ and $t \approx 2300$ where s_t is relatively close to both, s_t^{fund} and MA, the pattern of the effectiveness curve is very unstable),
- the current spot exchange rate is either above both, the fundamental value of the currency and its moving average, or the current spot exchange rate is below both, the fundamental value of the currency and its moving average (see the areas in Figure V.7 marked by roman numerals),
- the distance of the current spot exchange rate from its moving average reaches a maximum.

The coordination view of interventions recalls strongly the old discussion that a central bank acts as a stabilising speculator. If a central bank intervenes in the foreign exchange market, Friedman (1953) suggests that it should measure the success of its intervention by its profitability, as a private speculator would. According to Friedman, speculation in foreign exchange markets is generally stabilising (see Chapter I) as long as speculators buy when the price is low and sell when the price is high. Figure V.6 shows that the central bank creates additional supply of foreign exchange by buying its own currency which is relatively cheap (s is high). If the intervention is successful the relative price of the domestic currency rises (s falls). In the end, the central banks makes a profit as it sold the assets (the foreign assets) which it expected to fall in price.

Thus, one way to get some (though not conclusive[88]) evidence on the effectiveness of intervention according to the coordination channel is to calculate the profitability of a central bank's interventions. Recent research on this topic, however, has discovered two seemingly contradictory empirical facts. On the one hand, a number of studies have found that central bank interventions are profitable – or at least, do not make systematic losses (Leahy, 1995, Sjöö and Sweeney, 2001, Sweeney, 1997). On the other hand, there is striking evidence that technical trading rules can earn economically significant excess returns in the foreign exchange market, in particular on days when central banks intervene (LeBaron, 1999, Szakmary and Mathur, 1997). Neely (1998) reconciles the technical trading results with the profit calculations for central banks by showing that profits from intervention occur over a longer time horizon than profits from technical trading rules. In a similar vein, Saacke (2002) estimated the profitability of Fed and Bundesbank interventions for the period from 1979 to 1994. He concluded that the "seeming contradiction turned out to be due to (a) intervention profits and trading rule profitability being measured over different horizons and (b) after interventions, exchange rates moving contrary to central banks' intentions in the short run, but in agreement with their intentions in the long run" (Saacke, 2002, p. 474). Thus, in the short-run, intervention often generates losses and technical traders profit against the central bank, but in the longer-run the central bank will make profits, indicating a long-run effectiveness of sterilised foreign exchange market interventions.

[88] In the early years after Friedman published his influential article, authors like Baumol (1957) and Johnson (1967) produced theoretical examples of profitable speculation that is destabilising. It is clear that a central bank that behaves similar to a chartist would both, contribute to a further destabilisation, and make profits in the short-run. In the longer-run, however, the central bank would lose on average (see Section 3.2.1 of Chapter III for the discussion of divergent time horizons in the noise trader literature). As in our view central banks are not primarily

Another indication of the importance of the coordination channel was presented by Bofinger and Schmidt (2002). Drawing upon the results of the purely descriptive study of Catte et al. (1994), they determined the long trends of the DM/US-$ and yen/US-$ exchange rate by estimating a Markov-Switching model. They then took a closer look at the turning points of the exchange rate time series and the foreign exchange market interventions of the three central banks. They come to the result that “a comparison of the intervention activities with the evaluated turning points indicates that no major turning point in both exchange rate time series was attained without any central bank interventions” (Bofinger and Schmidt, 2002, p. 37). Thus, central banks appear to act as an important trend setter in the foreign exchange market, with interventions being an important means to determine the timing of the turning points (see also Figure V.9 and Figure V.10 below for a graphical presentation of the Japanese case).

V.1.3 A summary of the intervention channels

V.1.3.1 The intervention-response function

In Chapter IV we set up a fairly general model of an open economy (see equations (IV.1) to (IV.4) of the baseline model) which can be applied to systems of floating exchange rates as well as to systems of absolutely fixed exchange rates. While Section IV.1.2 shortly described the mechanics of a central bank’s intervention in the domestic money market in order to control short-term interest rates, the purpose of this Section was to show how foreign exchange market interventions can be implemented as monetary policy instrument in this model. In particular, we showed that the UIP condition serves as core relationship for the explanation of persistent effects of foreign exchange market interventions on the exchange rate. Table V.1 summarises the channels through which interventions are assumed to influence the spot exchange rate.

The direction of intervention is prescribed by deviations of the exchange rate from UIP. It may be of use to recall here that a UIP compatible path makes international investors indifferent between domestic and foreign investments and thus prevents them from speculation, provided that their expectations are compatible with the targeted exchange rate of the central bank. In Chapter III we presented a UIP condition that took into account non-rational behaviour of

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interested in maximising its profit, but in stabilising its final targets, the possibility that a central bank deliberately destabilises the value of its currency by interventions can be excluded.

foreign exchange market participants (see equation (III.36)). We extend this condition by the risk premium explanation of the UIP puzzle (see equation (III.29)) so that the overall UIP becomes

(V.24) $$\upsilon E_t \Delta s_{t+1} + (1-\upsilon)\mathcal{E}_t \Delta s_{t+1} + u_t^s = i_t - i_t^f .$$

Table V.1: Summary of the intervention channels

	direct influence on	indirect influence on	sterilised	remark
monetary channel	i_t	s_t	no	based on EMH
balance of payments flow channel	s_t	-	yes	based on b.o.p., temporary (asset market disequilibrium)
portfolio balance channel	$u_t^s = \rho_s u_{t-1}^s + \varepsilon_t^s$	s_t	yes	based on EMH
signalling / expectations channel	$E_t s_{t+1}$ or i_{t+j} with $j > 0$	s_t	yes	based on EMH
noise trading / coordination channel	$\mathcal{E}_t s_{t+1}$	s_t	yes	based on noise and chartism (EMH fails)

Let us assume that at time t, the central bank targets an exchange rate path $\Delta s_{t+1}^T = \left(s_{t+1}^T - s_t^T\right)$ that equals the current interest rate differential $\left(i_t - i_t^f\right)$ so that ex post in $t+1$ there should have been no opportunity to realise excess returns. The volume of intervention in the foreign exchange market which is needed to achieve Δs_{t+1}^T is characterised by the following intervention response function:

(V.25) $$I_t = \Delta NFA_t = f_2\left(\Delta s_{t+1}^T - \upsilon E_t \Delta s_{t+1} - (1-\upsilon)\mathcal{E}_t \Delta s_{t+1} - u_t^s\right)$$

where $f_2(0)$ is equal to zero and where the first derivative $f_2^{'}$ is always positive.[89] Theoretically, I_t can adopt values ranging from a critical negative value ($NFA_t^c - NFA_{t-1}$) to infinity (we will

[89] For simplicity, we assume that the mean of the risk premium is zero. This is equal to saying that investors are risk neutral over the long-term. In the case of a non-zero mean (which is certainly the case for most emerging market economies) the central bank targets an exchange rate path that equals the current interest rate differential minus

come back to this important asymmetry in the case of foreign exchange sales below in Section V.1.4). Under the assumption that the central bank targets the rationally expected and therefore fundamentally correct exchange rate path ($\Delta s_{t+1}^{T} = E_t \Delta s_{t+1}$) equation (V.25) simplifies to

$$\text{(V.26)} \qquad I_t = \Delta NFA_t = f_2\left(\left(1-\upsilon\right)\left(\Delta s_{t+1}^{T} - \mathcal{E}_t \Delta s_{t+1}\right) - u_t^s\right).$$

In principle, the central bank may be confronted with three situations. First, if the central bank's targeted exchange rate path equals the private sector's expected exchange rate change plus the actual risk premium, there is no need for the central bank to intervene in the foreign exchange market.

In the second case, private investors expect to make a profit from an investment in the domestic currency which leads to *capital inflows*. The sum of the private sector's expectations about the future exchange rate path and the required risk premium are more than compensated by the given actual interest differential and the given actual spot rate:

$$\text{(V.27)} \qquad i_t - i_t^f = \Delta s_{t+1}^{T} > \upsilon E_t \Delta s_{t+1} + \left(1-\upsilon\right) \mathcal{E}_t \Delta s_{t+1} + u_t^s .$$

In a world of direct managed floating the central bank intervenes in the foreign exchange market in order to absorb the excess supply of foreign exchange ($I_t > 0$). This guarantees that the central bank achieves the desired exchange rate path Δs_{t+1}^{T}. At the same time, it is able to keep the interest rate at its level i_t because of the immediate sterilisation of the accumulated foreign reserves.

The third case is characterised by *capital outflows* which can be described as follows:

$$\text{(V.28)} \qquad i_t - i_t^f = \Delta s_{t+1}^{T} < \mu \cdot E_t \Delta s_{t+1} + \left(1-\mu\right) \cdot \mathcal{E}_t \Delta s_{t+1} + u_t^s .$$

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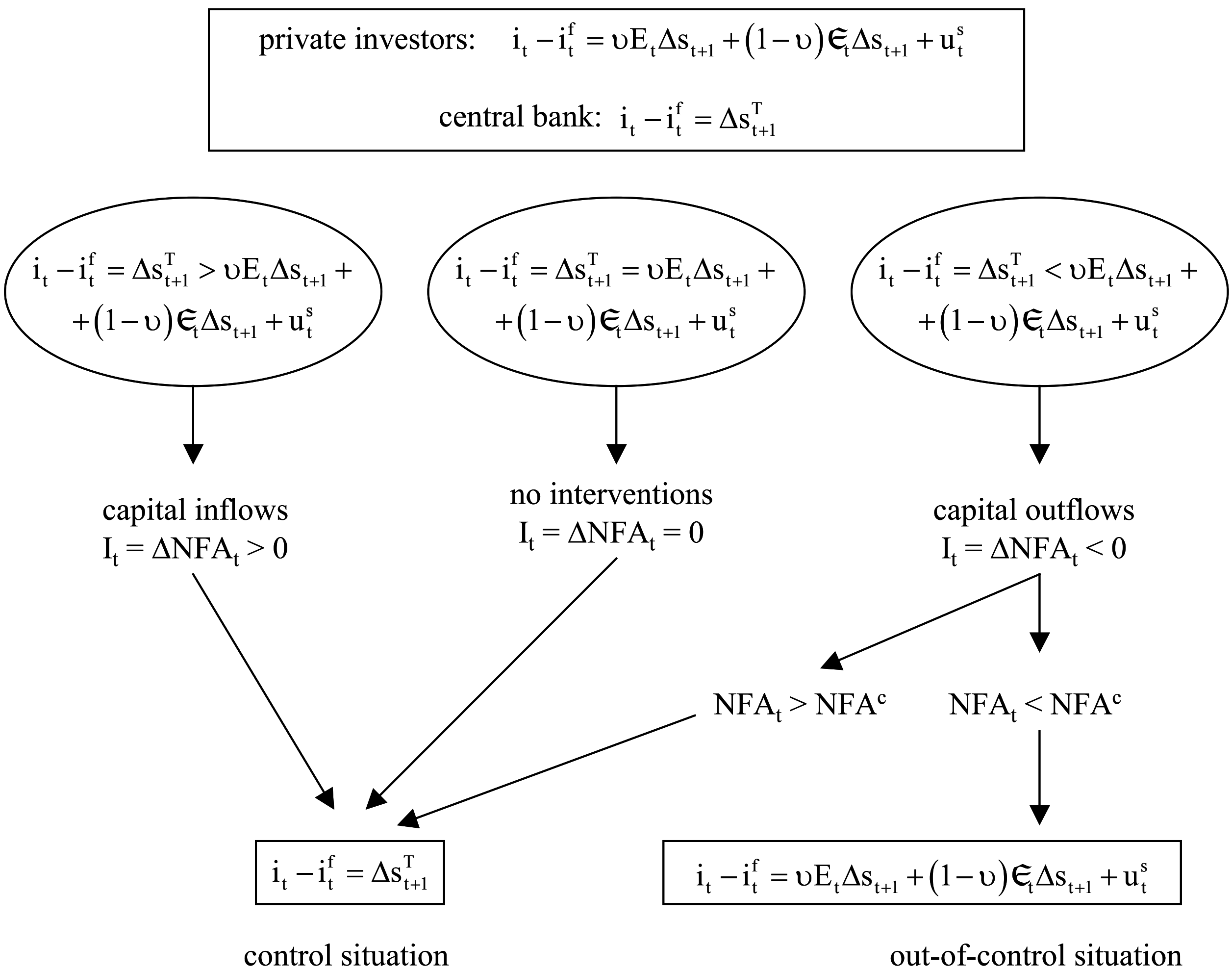
the mean of the risk premium that is required by private investors. Interventions then only occur when the risk premium deviates from its mean (and, of course, still in the case of collective non-rationality). We will come back to the problems related with permanent non-zero risk premia in Section V.1.4.2.

The actual interest rate differential does not compensate for the expected exchange rate change and the required risk premium, and hence, international investors prefer the foreign investment. As the central bank's objective is to realise Δs^T_{t+1}, it has to sell foreign assets in order to satisfy the excess demand for foreign exchange ($I_t < 0$).

Under normal conditions the central bank is able to realise its target path for the exchange rate which equals the path of the rational and forward-looking investor, in all three cases. Thus, the UIP condition becomes:

$$\text{(V.29)} \qquad i_t - i^f_t = \Delta s^T_{t+1} = E_t \Delta s_{t+1}.$$

Figure V.8: The central bank's intervention response function f_2



We call this the 'control situation'. There is only one, but a very important situation – as we will see below in the next Section – in which the central bank loses control over its operating targets:

the capital outflow case with foreign reserves falling below a critical threshold NFA^{c}. In this situation which we call ‘out-of-control situation’, the central bank is no longer able to target the exchange rate through sterilised sales of foreign exchange since it runs out of sufficient reserves. It rather has to adjust its interest rates in order to stop the capital outflow. This adjustment can be achieved by either reducing the domestic part of the monetary base, or by non-sterilised foreign exchange market interventions (if there are still foreign reserves left) which lower the foreign part of the monetary base. Independently of how domestic interest rates are raised, the UIP condition in the out-of-control situation becomes

$$\text{(V.30)} \qquad i_t - i_t^f = \upsilon E_t \Delta s_{t+1} + \left(1-\upsilon\right) \epsilon_t \Delta s_{t+1} + u_t^s .$$

Figure V.8 summarises again the major relationships underlying the external equilibrium of our strategy.

V.1.3.2 On the relevance of the five intervention channels

Which of the five channels through which interventions are modelled to affect the exchange rate are finally relevant for a strategy of direct managed floating? According to equation (V.25) interventions are carried out each time the aggregate net order flow of private market participants deviates from the order flow that is needed to realise the spot exchange rate that is in line with the targeted path. The targeted path is consistent with the fundamental path of the exchange rate. By fundamental path we mean the exchange rate path that would result from an efficient foreign exchange market with a stable degree of risk aversion of the private sector, and hence, from UIP with a constant (for simplicity zero; see footnote 89 on page 227) risk premium. Possible reasons for deviations from the underlying UIP are noisy expectations on the part of the market participants and/or shocks to their propensity to bear risk. The relevant intervention channels are therefore the *balance of payments flow channel*, the *noise trading / coordination channel* and the *portfolio balance channel*. The monetary channel and – in our view as well – the signalling channel do not provide the central bank with an independent monetary policy tool as interventions are – though possibly with some lag – closely related with interest rate changes. Thus, in the following they will not be discussed anymore in the context of a strategy of direct managed floating.

Even though the balance of payments flow channel only exerts a temporary effect on the exchange rate, we already mentioned in Section V.1.2.5 that for the noise trading / coordination channel of sterilised interventions to be triggered (and with it, a sustainable impact of the intervention on the exchange rate) only a temporary shift in the level of the exchange rate is needed. The balance of payments flow channel and the noise trading / coordination channel are therefore closely interrelated.

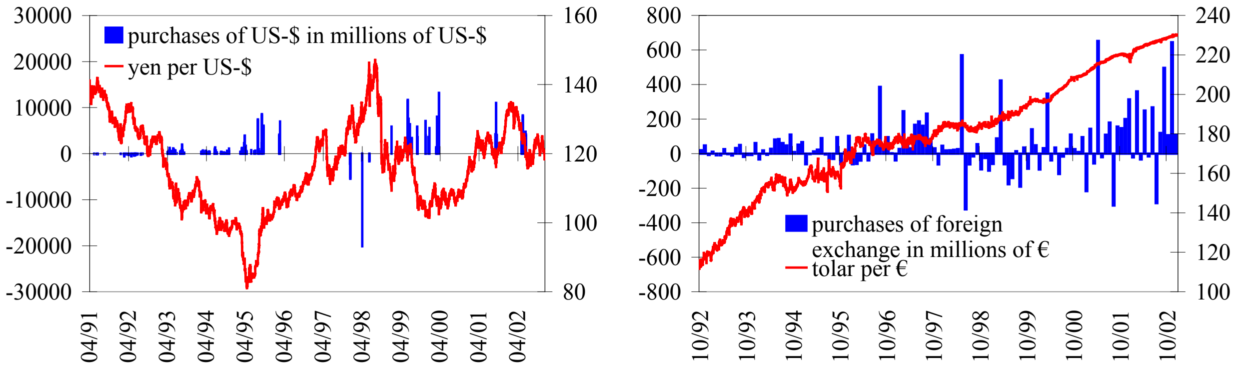
An important difference between the portfolio balance channel and the noise trading / coordination channel is that according to the latter significant deviations from the fundamental value of the currency have to occur before interventions become efficient. By contrast, the former is already effective immediately after the exchange rate leaves the fundamental path due to disturbances of the risk premium. In the following, we will illustrate this difference with two country studies.

On the one hand, there are very liquid foreign exchange markets like that of the Japanese yen. The central bank (or to be more precise, the Japanese Ministry of Finance) only intervenes infrequently and in clusters. A particular feature of the Japanese exchange rate policy is that interventions take place when the exchange rate remarkably deviates from PPP and UIP – thereby fulfilling a basic prerequisite of interventions through the noise trading / coordination channel (see the left panels of Figure V.9, Figure V.10 and Figure V.11 for the Japanese case).

On the other hand, there are very thin foreign exchange markets like that of the Slovenian tolar, in which central banks basically target the exchange rate through portfolio shifts effects. The Bank of Slovenia is continuously engaged in the foreign exchange market and it tightly manages the course of the tolar. Thus, the occurrence of misalignments (large swings in the REER) or inefficiencies (pronounced excess returns) is prevented from the outset (see the right panels of Figure V.9, Figure V.10 and Figure V.11 for the Slovenian case).[90]

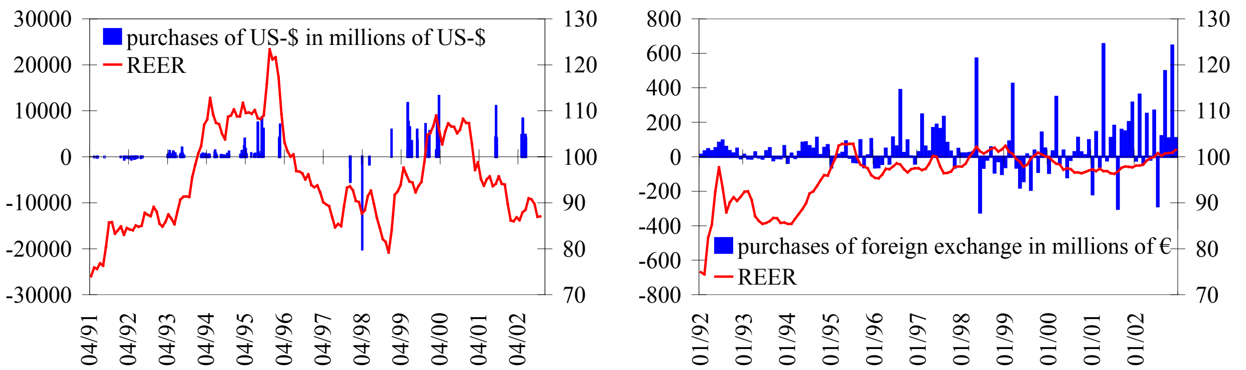
[90] Note that in the early years of economic transition (1992-1994) significant deviations from PPP and UIP also occurred in Slovenia which was mainly due to instabilities arising from the problems related to the separation process from former Yugoslavia.

Figure V.9: Foreign exchange market interventions and the targeted exchange rate



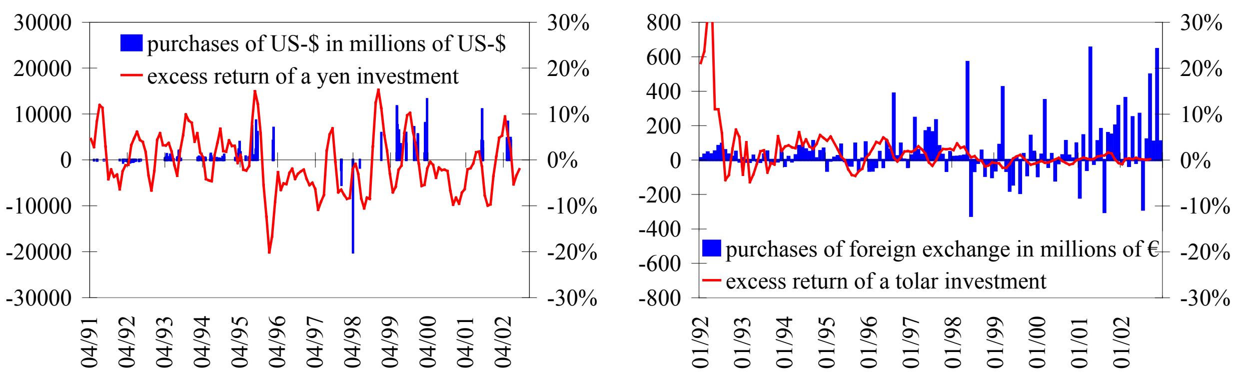
Note: The interventions are depicted on the left scale. Japanese official intervention data is published on the website of the Japanese Ministry of Finance. The Slovenian interventions are proxied by monthly changes in foreign reserves minus gold which are published by the IMF in its International Financial Statistics. Daily yen/US-$ exchange rates are published by the Federal Reserve. Daily tolar/€ exchange rates are taken from databases of Datastream and the Deutsche Bundesbank. Euro exchange rates prior to 1999 have been converted from DM/tolar rates.

Figure V.10: Foreign exchange market interventions and deviations from PPP



Note: The REER which is depicted on the right scale is an index of the real effective exchange rate on the basis of relative consumer prices. An increase in the REER is a real appreciation. The Japanese data is calculated and published by the IMF in its International Financial Statistics. The Slovenian data is taken from the Monthly Bulletin of the Bank of Slovenia.

Figure V.11: Foreign exchange market interventions and deviations from UIP



Note: The excess return is depicted on the right scale. It measures ex post deviations from UIP with a time horizon of 3 months. The interest rates used to calculate the excess return are 3-month deposit rates which are published in the International Financial Statistics of the IMF.

Having mentioned the liquidity of the underlying foreign exchange market, another important difference between the intervention channels emerges. While the balance of payments flow channel and the portfolio balance channel (as well as the monetary channel) are often classified as direct channels through which interventions may have an immediate effect on exchange rates, the noise trading / coordination channel (and also the signalling channel) is an indirect channel. Rosenberg (1996, p. 294) explains as follows: "The direct channels stress the importance of the volume and intensity of the intervention operations themselves, while the indirect channels stress the importance of market responses to the intervention operations and how private investor expectations and positions may be altered."[91]

The volume of the intervention, however, can not be assessed in isolation from the liquidity of the underlying foreign exchange market: the larger and the more liquid the market, the smaller the direct effect of a given amount of foreign exchange used for the intervention. In Bofinger and Wollmershäuser (2001) we proposed a summary measure to proxy the relative intervention activity of a country. We calculated the sum of absolute changes (S^{abs}) in the central banks level of foreign reserves (Res) over the last $n = 12$ months as a fraction of the country's degree of openness which is defined as the arithmetic mean of imports (Im) and exports (Ex):

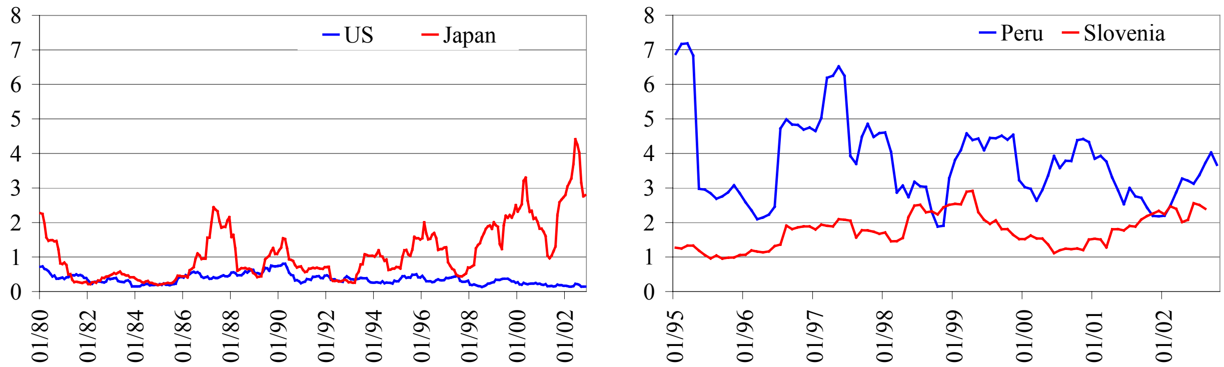
$$\text{(V.31)} \qquad S^{abs}(n)_t = \sum_{i=0}^{n} \left| \frac{Res_{t-i}}{\frac{Ex_{t-i} + Im_{t-i}}{2}} - \frac{Res_{t-i-1}}{\frac{Ex_{t-i-1} + Im_{t-i-1}}{2}} \right| .$$

By taking absolute values, our focus was on the question whether a central bank intervenes or not. Thus, we did not discriminate between sales and purchases of foreign exchange reserves. Figure V.12 shows the intervention activity of two large industrialised economies (the US and Japan) and two small open emerging market economies (Peru and Slovenia). While the US intervention activity is relatively low throughout the whole period 1975-2002, the Japanese

[91] Within the framework of the signalling channel, the question whether the amount of the sale or the purchase of foreign currency matters for the effects on the exchange rate, cannot be answered unambiguously. On the one hand, it is argued that only the information that is transmitted by the central bank is relevant. On the other hand, as it was expressed by Mussa (1981), the central bank's operation aims at buying credibility and thus the investors' confidence that the signal is true. In this case, one can argue that the more a central bank spends, the more it can buy (which is equal to say the higher the potential costs of lost reputation) and the more successful the intervention will be.

intervention measure reveals again the infrequent and clustered activity of the Japanese authorities. By contrast, the two emerging market economies show a permanently higher intervention activity.

Figure V.12: Intervention activity



Note: The two charts depict S^{abs} on the basis of data that was taken from the International Financial Statistics of the IMF.

With the normalisation of the reserve changes to the size of the countries' external sector we take into account the differences in the countries' total economic size, and hence in the size of the foreign exchange markets. Of course, a better way to measure the size and the liquidity of the foreign exchange market would be to directly look at the turnover of the market under consideration. The relevance of this flow figure directly follows from the microstructure approach of the portfolio balance channel and the balance of payments flow channel. Unfortunately, as the data on foreign exchange market turnover which is collected by the Bank for International Settlements is only available every three years, an informative indicator of relative intervention activity cannot be calculated. As an alternative, we could have normalised the changes in reserves by the amount of publicly held domestic government securities. The relevance of this stock figure directly follows from the macro level of the portfolio balance channel. Here again, the data which is also collected by the Bank for International Settlements is available at a quarterly frequency only since 1994.

Nevertheless, we take a short look at the two alternatives to the size of the external sector (see Table V.2, Table V.3 and Table V.4). The figures in the Tables show that the size of the external sector significantly overestimates the size and the liquidity of the foreign exchange market (irrespective of whether proxied by foreign exchange market turnover or by the amount of publicly held domestic government securities) of the small open emerging market economies compared to that of the US or Japan. Thus, the relative intervention activity is even more pronounced in Slovenia and Peru than revealed by Figure V.12.

Table V.2: Size of the external sector (Ex+Im)/2: 04/2001

	Japan	US	Peru	Slovenia
in billions of US dollars	32.30	80.80	0.56	0.79
in percent of US	39.98	100.00	0.70	0.98

Source: International Financial Statistics

Table V.3: Foreign exchange turnover of local currency net of local inter-dealer double-counting (daily averages): 04/2001

	Japan	US	Peru	Slovenia
in billions of US dollars	109.71	236.44	0.22	0.09
in percent of US	46.40	100.00	0.09	0.04

Source: Bank for International Settlement (2002), Table E.7

Table V.4: Domestic government debt securities (amounts outstanding): 03/2001

	Japan	US	Peru	Slovenia
in billions of US dollars	3753.40	4248.40	1.70	0.02
in percent of US	88.35	100.00	0.04	0.00

Source: BIS Quarterly Review (International Banking and Financial Market Developments), Table 16A; Slovenian data: Bulletin of Government Finance, Ministry of Finance, Republic of Slovenia

To sum up, the average intervention activity in small open economies like Peru and Slovenia is remarkably higher and more continuous compared with the intervention activity of the US and Japan. At the same time, the turnover of the Peruvian and Slovenian currencies as well as the stock of domestic bonds is only a tiny fraction of the respective figures of the US and Japan. From this it follows that in Peru and Slovenia (standing for small open emerging market economies in general) portfolio shifts effects seem to be the dominant channel for sterilised interventions, whereas market sentiment considerations play the dominant role for the intervention policy of the Japanese and the US authorities. Note, however, that this does not mean that portfolio effects do not play any role in the Japanese case. A look at Table V.5 shows that in contrast to the US, the frequency and the average volume of Japanese interventions is much higher. Thus, direct effects also seem to have played a non-negligible role for Japanese interventions.[92]

Table V.5: Summary statistics on official intervention data

intervening central bank	market of intervention	period	number of days with interventions	average intervention volume in billions of US dollars
Federal Reserve	mark/dollar	1980-1990	423	0.1
Federal Reserve	mark/dollar	1991-1998	31	0.3
Federal Reserve	euro/dollar	1999-2002	1	1.3
Federal Reserve	yen/dollar	1991-2002	22	0.4
Bank of Japan	yen dollar	1991-2002	215	1.4

Source: Central bank websites

V.1.4 The limits of foreign exchange market interventions

V.1.4.1 Quantitative limits

The last Section has already shown that targeting the nominal exchange rate by foreign exchange market interventions may be subject to an important limitation. Theoretically, a central bank's sterilised purchases of foreign exchange are not restricted by any quantitative limits. It buys foreign assets from a broker or a market maker in exchange for net domestic assets. In contrast to this, sales of foreign exchange are clearly limited by the central bank's stock of foreign currency denominated assets. As long as its reserves exceed a critical threshold, NFA^c, the central bank can credibly achieve the desired path through sterilised sales. But as soon as the current stock of foreign reserves is perceived as too low by the market, foresighted investors anticipate the upcoming exhaustion of reserves and the consequent depreciation of the currency, and hence sell domestic currency. Thus, capital outflows will accelerate and the central bank finally looses its intervention instrument. This idea of a hard budget constraint on the control of the exchange rate is quite similar in spirit to the theory of currency crisis under fixed exchange rates developed by Krugman (1979). However, it should be stressed again that this constraint is asymmetric and that

[92] The volume of intervention of the Federal Reserve on September 22, 2000 to support the euro is exceptional in the US intervention history. Neither the US interventions in the yen/dollar market, nor those in the mark/dollar market have ever reached this amount.

it only applies to prolonged capital outflow episodes. Capital inflows, and thereby appreciating pressure on the domestic currency can be fully absorbed by the central bank. Thus, even if one does not believe in any of the discussed asset market approaches to the effectiveness of sterilised foreign exchange market interventions, the required 'brute force' policy in the framework of the balance of payments flow channel can be indefinitely realised – at least – in times of an appreciating domestic currency.

Besides the possible limitations concerning the stock of foreign assets in the central bank's balance sheet one might be further tempted to argue that in the case of capital inflows there is also an important quantitative limit set by the stock of domestic assets. Recall that in order to sterilise the purchase of foreign assets the central bank has to withdraw liquidity from the banking system. This can either be done by reducing the stock of domestic assets (i.e. the central bank's lending to the domestic banking system) or by expanding the central bank's liabilities to the banking system (i.e. by allowing the commercial banks to deposit interest bearing excessive funds at central bank) (see Figure V.2 in Section V.1.2.1 for a stylised central bank balance sheet). While the reduction of the central bank's claims against the banking system is obviously limited by stocks of domestic assets, there is no such boundary on the liability side of the balance sheet. Thus, theoretically, the central bank's liabilities to the domestic banking system can be increased infinitely, provided that commercial banks have access to an unlimited deposit facility. And indeed, many central banks in small open emerging market economies which are engaged in sterilised foreign exchange market interventions have balance sheets with extensive negative NDA positions.

V.1.4.2 Limits due to budgetary costs

A second aspect which might impose a constraint on the control of the exchange rate is the costs resulting from the sterilisation of changes in the net foreign assets. In order to explain the origin of these so-called sterilisation costs (C_t^S) it is helpful to imagine the composition of the balance sheet of a central bank as a portfolio consisting of interest-bearing assets and liabilities in domestic and foreign currency. The act of sterilisation therefore represents nothing else than a change from foreign interest-bearing assets to domestic interest-bearing assets (in the case of a constant balance sheet total) or from foreign interest-bearing assets to domestic liabilities which are remunerated at a domestic interest rate (in the case of a varying balance sheet total). In this Section we will show exemplarily for the case of an appreciating currency and the related central bank's purchase of foreign currency under which conditions sterilisation costs may occur. The opposite can be derived in an analogous manner.

The sterilisation costs that are supposed to occur in period t (defined per unit of domestic currency that is supplied in interventions in period $t-1$) are made up of two components: the interest rate costs (or earnings) (C_t^i) and the valuation losses (or returns) from foreign exchange reserves (C_t^V):

(V.32) $$C_t^S = C_t^i + C_t^V .$$

The interest rate component of sterilisation is determined by the difference between the foreign and the domestic interest rate:

(V.33) $$C_t^i = i_{t-1} - i_{t-1}^f .$$

This is due to the fact that a sterilised intervention that tries to prevent an appreciation leads to an increase in foreign assets and a decrease in domestic assets; in the case of a deposit facility or the issuance of notes, domestic liabilities increase. Thus, the central bank loses income from domestic assets (or has to pay interest on domestic liabilities) while it receives additional income from a higher amount of foreign assets. It is obvious that sterilised interventions are associated with interest costs (returns) if the domestic interest rate is higher (lower) than the foreign interest rate.

The valuation costs (returns) per unit of sterilisation depend on the percentage change of the exchange rate which we express by the difference of the log of the nominal exchange rate:

(V.34) $$C_t^V = -(s_t - s_{t-1}) = -\Delta s_t .$$

If the domestic currency depreciates, the value of foreign exchange reserves in terms of the domestic currency increases. The central bank makes a profit from sterilised intervention.

Both cost components can be combined in order to define conditions under which sterilised interventions are free of charge:

(V.35) $$C_t^S = 0 \overset{!}{=} i_{t-1} - i_{t-1}^f - (s_t - s_{t-1}),$$

which leads to the ex post formulation of the interest parity condition:

(V.36) $$(s_t - s_{t-1}) = i_{t-1} - i_{t-1}^f .$$

In other words, the costs of sterilised intervention are zero if a central bank targets the exchange rate along a path that is determined by the interest rate differential. This guarantees at the same time that there are no profit opportunities for short-term oriented investors whom invest in the domestic currency. If the domestic interest rate is higher than the foreign interest rate the advantage is fully compensated by a depreciation of the domestic currency. Thus the condition of zero costs for sterilised interventions is the mirror image of the condition that the mix of exchange rate and interest policy should not provide profit opportunities for short-term oriented investors. In fact, the profits of these investors are to a large extent nothing else but the sterilisation costs paid by the central bank.[93]

The situation is somewhat more complicated if there is a permanent risk premium (u_t^s) that is different from zero. Thus, the UIP equation becomes:

(V.37) $$(s_t - s_{t-1}) + u_{t-1}^s = i_{t-1} - i_{t-1}^f .$$

In this case the total costs of sterilisation are:

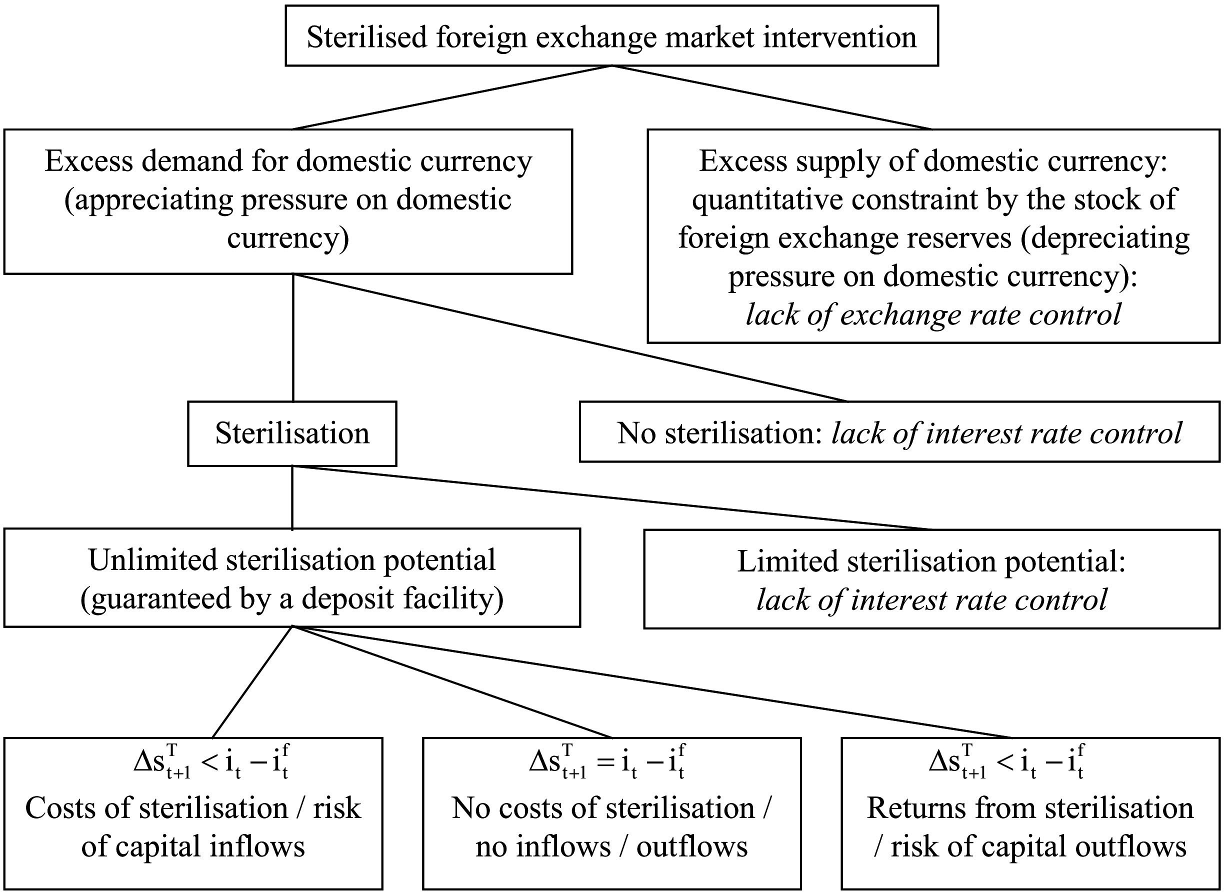
(V.38) $$C_t^S = u_{t-1}^s .$$

Thus, exchange rate targeting becomes more difficult, if the exchange rate path that is chosen is associated with a high risk premium.

[93] As far as domestic commercial banks receive deposits denominated in the domestic currency and grant credits in the foreign currency, they also pay for the profits of short-term oriented investors.

Figure V.13 summarises the critical issues that are related with sterilised foreign exchange market interventions.

Figure V.13: Scope and limits of sterilised foreign exchange market interventions



V.1.5 Some concluding remarks on the effectiveness of sterilised interventions

A central requirement for the successful implementation of a strategy of direct managed floating is the effectiveness of foreign exchange market interventions that leave the interest rate instrument unchanged. However, the empirical literature on sterilised interventions is anything but conclusive about this issue. Having already criticised many of these studies in Sections V.1.2.2 to V.1.2.5 for various reasons, two of the most important points are worth repeating.

The first criticism concerns the studied foreign exchange market. Most of the empirical studies (investigating in particular the portfolio balance channel and the signalling channel) were conducted on the basis of official US interventions in the mark/dollar market. As has been shown in Section V.1.3.2, researchers thereby selected the central bank which is least active in the foreign exchange market (interventions on rare occasions and with relatively small amounts) and the foreign exchange market which is by far the most liquid in the world (measured by daily turnover and the size of the bonds market). On the basis of these results, they often conclude that sterilised foreign exchange market interventions do not provide central banks in general with an efficient policy tool.

The second criticism concerns the efficient market hypothesis. Most econometric tests of intervention channels (monetary, portfolio balance, signalling) are based on a joint hypothesis of efficient foreign exchange markets and effective sterilised foreign exchange interventions. While exchange rate economists regularly come to the result that models of exchange rate determination based on the former are not able to predict the movements in the exchange rate, one should not be surprised that the attempts to explain the effectiveness of interventions on the basis of the same models are not very satisfying. Most economist, however, treat the assumption of efficient foreign exchange markets as axiomatic and conclude on the basis of the mixed empirical results from the intervention studies that they are not very supportive of the effectiveness of sterilised interventions.

Apart from these two, in our opinion, important and rarely mentioned types of criticism a final remark is devoted to the sterilisation issue. It should be stressed again that sterilised interventions are not aimed at creating a disequilibrium on the international financial markets. In many papers dealing with fixed exchange rate systems under internationally mobile capital sterilisation was primarily discussed as a means to maintain artificially high yields. Calvo et al. (1996, p. 134), for example, argue as follows: “Presumably, funds are being attracted into the country by the promise of higher expected interest rates. But if the capital inflow is sterilised, this will prevent the interest rate differential from narrowing, and may thus induce further capital inflows.” This perpetuation of policy-induced capital inflows and the related increase in the volume of sterilisation led most economists to argue that the sterilisation instrument is ineffective under perfect capital mobility. Additionally, it entails an import risk for the monetary policy maker. Since the interest rate differential is artificially kept above what the market would perceive as an equilibrium under constant exchange rates (i.e. $i_t > i_t^f + u_t^s$), sterilisation costs incur. These costs are often regarded as quasi-fiscal costs of the government that are supposed to constitute an upper boundary for a central bank’s ability to control the fixed exchange rate (see Calvo et al.

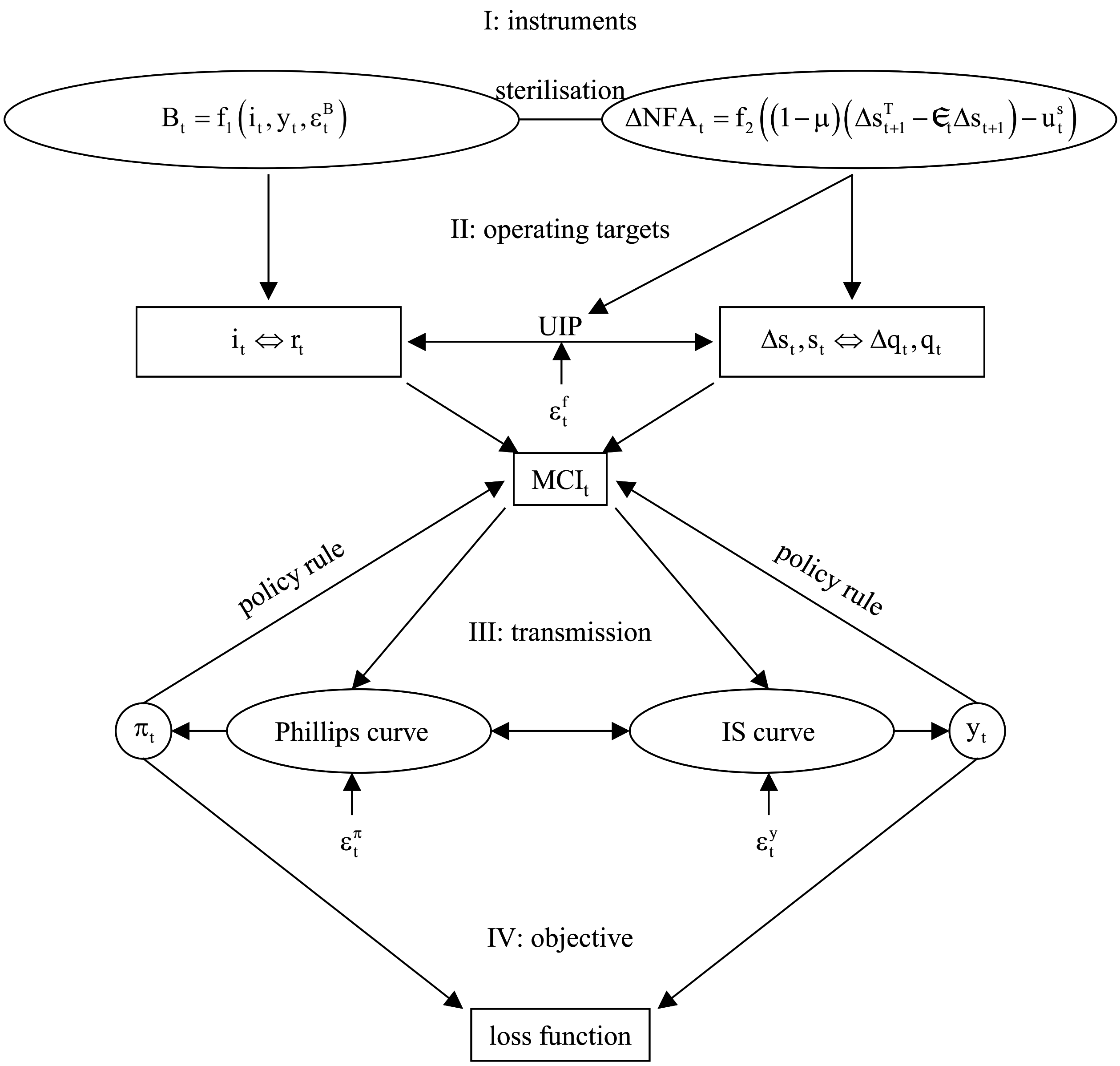
(1993) for estimates of magnitudes of such quasi-fiscal costs under fixed exchange rates; see Grilli (1986) for a model of currency crisis that is in the spirit of Krugman (1979) with a private sector anticipating the limited capacity or willingness of the government to bear the costs). Thus, in our opinion, sterilisation of foreign exchange market interventions is a policy tool that is non-compliant with systems of fixed exchange rates. Since the domestic interest rate is fully determined by the interest rate of the anchor country, in credible fixed rate systems the sole instrument is non-sterilised interventions (see the discussion of the monetary channel of interventions and its application to currency board arrangements in Section V.1.1). With regard to systems of direct managed floating exchange rates this critique however does not apply provided that sterilised interventions are used in the way described above.

Thus, we fully agree with Mayer (1982, p. 12) who argues as follows: “As regards the potential rôle of official intervention in the exchange markets, it is clear that there would be very little room for such intervention in the ideal scenario of nearly perfect foresight on the part of exchange market participants. Since, under these conditions, any diversion of the spot and forward exchange rates from their ‘optimal response pattern’ [the UIP path, T.W.] would give rise to practically unlimited speculative capital flows, efforts by the authorities to prevent the spot rate from accommodating the change in interest rate differentials would entail reserve losses (or gains) on a scale that would soon force them to abandon such policy.” In a similar vein, Dominguez and Frankel (1993b, p. 139) again use the analogy between interventions and herd dogs: “It is clear that a few dogs, who after all are smaller in size and fewer in numbers than the steers, probably could not sustain overall control of the herd for long without the sense of direction provided by the cowhands and would have little idea what to do with such control if they had it. This makes the point that intervention operations – which, after all, are small compared with the private market – probably could not sustain control of the foreign exchange market for long without the sense of direction provided by monetary policy and might be used to pursue inconsistent policy goals even if such control could be sustained.”

V.2 Monetary policy under direct managed floating

In the last Section we have shown that central banks are able to independently control two operating targets, a short-term interest rate and the exchange rate. For the reasons outlined the UIP condition serves as an important guideline for the paths of the two operating targets. However, it should be clear that theoretically the number of combinations is unlimited. For each level of domestic interest rates (given the foreign interest rate) a different target path of the exchange rate follows. Thus, in this Section we develop a second restriction for the setting of the central bank's two operating targets by defining a policy rule according to which the operating targets have to be adjusted in response to a small set of macroeconomic information variables.

Figure V.14: Monetary policy under direct managed floating



In principle, the proceeding is quite similar to that of a central bank that pursues a strategy with a single interest rate operating target as for example presented in Chapter IV. We first showed that under normal circumstances a central bank is able to perfectly control each level of the short-term nominal interest rate. We then developed a policy rule that tells the monetary policy maker which interest rate level he should target. Unlike in the case of interest rate policy rules, however, the policy framework for direct managed floating has to based on the simultaneous use of the exchange rate and the interest rate as independent operating targets of monetary policy. Figure V.14 gives an overview of the basic relationships of the strategy.[94]

While levels I and II of the strategy (instruments and operating targets) have already been discussed in Section V.1 the focus of this Section is on levels III and IV. In the first step we will summarise the two operating targets by a comprehensive measure that we call a monetary conditions index (MCI). We will concentrate our analysis on two possible formulations of the MCI: a real MCI which is defined as

$$\text{(V.39)} \qquad MCI_t = r_t - \psi q_t$$

and a nominal MCI which is given by

$$\text{(V.40)} \qquad MCI_t = i_t - \psi \Delta s_t$$

where ψ reflects the relative importance of the exchange rate term for measuring monetary conditions.

The advantage of the nominal MCI is straightforward as it directly measures the observable setting of the monetary policy instruments i_t and s_t. Including the lagged nominal exchange rate instead of its level stems from the non-stationary properties of the level of s_t. If a stationary variable and a non-stationary variable are linearly combined to an index, the variable with the higher order of integration will tend to dominate fluctuations in the MCI and hence will lead to a biased information content of the index (Eika et al., 1996). For this reason McCallum (2000) refers to (V.40) as a dimensionally coherent definition of an MCI. The problem with different orders of integration vanishes if the MCI is defined in real terms. Since both r_t and q_t are non-stationary variables, the MCI is non-stationary as well. A problem with the real MCI may however emerge if one doubts that the real interest rate and the real exchange rate can be viewed as operating targets. In Section IV.1.2 and Section V.1 we have shown that their nominal

[94] In Figure V.24 below (see Section V.3) we present a similar diagram for monetary policy with a single operating target under market determined exchange rates.

counterparts are directly controllable through interventions in the domestic money market and in the foreign exchange market. Also, for the real variables to be directly controllable we have to make some further assumptions. According to the Fisher relationship the real interest rate which enters the aggregate demand equation (see equation (V.45) below) as a basic determinant is usually defined as

$$r_t = i_t - E_t \pi_{t+1} . \tag{V.41}$$

Expectations about the future inflation rate are determined by the Phillips curve. Under the assumption of a purely backward-looking Phillips curve Ellingsen and Söderström (2001) have shown that it is consistent to express aggregate demand as a function of the ex post real interest rate which is given by[95]

$$r_t = i_t - \pi_t . \tag{V.42}$$

Thus, in period t, the real interest rate is fully determined by the operating target i_t and the observable rate of inflation π_t. In a similar vein, the real exchange rate is solely defined by variables that are known by the actors of our open economy model. From equation (V.47) (see below) q_t is given by

$$q_t = s_t - s_{t-1} + q_{t-1} + \pi_t^f - \pi_t . \tag{V.43}$$

To sum up, targeting the nominal interest rate and the nominal exchange rate implies control over the real interest rate and the real exchange rate. Thus, both the nominal MCI and the real MCI can be regarded as operating targets of a direct managed floating central bank.

In the second step, we will derive a policy rule in terms of the MCI that minimises the central bank's loss function by taking into account the economy's basic transmission channels of monetary impulses to the goal variables. As in Chapter IV the model of the economy is given by the following equations:

(V.44) $\pi_{t+1} = \pi_t + \gamma_y y_t + \gamma_q (q_t - q_{t-1}) + \varepsilon^{\pi}_{t+1}$

(V.45) $y_{t+1} = \beta_y y_t - \beta_i (i_t - \pi_t) + \beta_q q_t + \varepsilon^{y}_{t+1}$

(V.46) $i_t = i^f_t + E_t s_{t+1} - s_t + u^s_t$

(V.47) $s_t - s_{t-1} \equiv q_t - q_{t-1} - \pi^f_t + \pi_t$.

Again π^f_t is set to zero so that $i^f_t = r^f_t = \rho_f r^f_{t-1} + \varepsilon^f_t$. Compared with a single interest rate operating target framework, however, under a direct managed float the UIP equation (V.46) enters the model with a modified shock term to reflect the effects of sterilised foreign exchange market interventions. While in Chapter IV one way to capture the purely market determined outcome of unexpected exchange rate movements was to model an autoregressive UIP disturbance according to $u^s_t = \rho_s u^s_t + \varepsilon^s_t$, in Section V.1.3 of this Chapter we summarised the situation in which a central bank that follows the intervention rule (V.25) has control of the exchange rate by equation (V.29), i.e. a perfectly holding UIP condition. Thus, the open economy model given by equations (V.44) to (V.47) has to be adjusted by assuming that

- there are no persistent deviations from UIP, i.e. ρ_s is equal to zero;
- $\mathrm{Var}\left[\varepsilon^s_t\right]$ is small in comparison with the values it takes under purely market determined exchange rates.

Below we will show that the results obtained from the analysis of the direct managed floating strategy are quite robust against variations of the variance of the UIP disturbance – provided that the values of the variance are kept small. Thus, for the sake of simplicity, we will set the variance to zero. Nevertheless it is worth mentioning that the practical relevance of non-zero variances even for central banks practicing a direct managed float should not be underestimated. In this case the central bank is assumed not to be concerned about some (day-to-day) volatility in the movement of the exchange rate. If the exchange rate is determined by UIP, we have already shown (see Chapter II) that the exchange rate path that is expected by the privates (and eventually targeted by the central bank) in time $t-1$ may be subject to unanticipated changes in time t for the following three reasons:

[95] We therefore refrained from explicitly formulating aggregate demand in terms of the expected real interest rate in all our open economy models in Chapter IV and in this Chapter. This is common practice in all purely backward-

- unanticipated changes of the central bank's interest rate instrument (i_t)
- shocks stemming from the foreign country (as summarised by i_t^f)
- disturbances to UIP (ε_t^s which is under the control of the direct managed floating central bank).

While the first two reasons alone would make the exchange rate path quite foreseeable due to central banks' practice of interest rate smoothing (i.e. central banks alter interest rates only in small steps and try to avoid frequent sign changes when altering the interest rate; see also Chapter IV), the accepted degree of temporary disturbances to UIP contributes towards maintaining some uncertainty on the part of foreign investors. The problem related to perfectly foreseeable exchange rate path is that it can easily lead market participants to underestimate the degree of foreign exchange risk and encourage one-way bets. Thus, it is often recommended that a central bank should not "attempt to even out all short-term volatility in the exchange rate, because such volatility serves to sharpen participants' awareness of risk" (Goldstein, 2002, p. 43).

It should finally be noted that in accordance with Chapter IV the economics of controlling the operating targets do not explicitly enter the model. Thus, it is assumed that a central bank is able to fully control i_t and s_t with its instruments.[96]

V.2.1 The role of MCIs in monetary policy

Generally an MCI is defined as the weighted sum of variables P_ω directly affected by monetary policy actions (Mayes and Virén, 2000):

$$\text{(V.48)} \qquad MCI_t = \sum_{\omega} \psi_\omega \left(P_{\omega,t} - P_{\omega,0} \right).$$

The degree of restriction of variable P_ω in period t is measured as percent deviation from its neutral value which was realised, by assumption, in some base period $t = 0$.[97] The weights ψ_ω

looking models (see e.g. Rudebusch and Svensson, 1999).

96 For an approach to integrate the instruments of monetary policy into a standard open economy macro model, see Coenen and Wieland (2002b). Note however that in this paper only non-sterilised interventions in the foreign exchange market are considered as an alternative to interventions in the domestic money market.

used for constructing MCIs represent the relative impact of the variables P_ω on the final targets of the monetary policy authority and thus, they are normally derived on the basis of a macroeconomic model. We will come back to the issue of calculating the appropriate weights below in Section V.2.2. In most applications the variables entering the MCI are a short-term interest rate and some measure of the exchange rate. Since the MCI is an index it is quite common to normalise the weight of one variable (usually that of the interest rate) to unity so that the weight of the other variable becomes a relative weight ($\psi = \psi_q / \psi_r$ and $\psi = \psi_{\Delta s} / \psi_i$ in the case of the MCIs presented in equation (V.39) and (V.40) above).

During the 1990s several central banks (e.g. Canada, New Zealand, Sweden and Norway; see Eika et al., 1996, Freedman, 1994, Nadal-De Simone et al., 1996) and international institutions (e.g. the IMF) constructed such an index and regularly reported on its evolution. Because the interest rate and the exchange rate have an important impact on a central bank's final targets in an open economy and since both are assumed to be tightly interlinked on the international financial markets the appeal of the MCI is understandable. In the following we will briefly summarise the use of the MCI by two of its formerly leading advocates, the Bank of Canada and the Reserve Bank of New Zealand. We will show that in a monetary policy environment in which the exchange rate is purely determined by the market the MCI mixes up two variables that are situated on two fundamentally different stages of the transmission process. The related problems mainly contributed to the loss of the MCI's attractiveness in recent years.

In Canada the MCI was officially used as an operating target since the early 1990s (Freedman, 1994). However, unlike in the definition of an operating target given in Chapter I (operating targets are variables that the central bank influences directly by its monetary policy instruments) the Canadian authorities did not directly control both the interest rate and the exchange rate, but only the interest rate. Thus, when the central bank needs to change monetary conditions directly, it adjusts its interest rates, which in turn is assumed to affect the exchange rate in some systematic way – usually via uncovered interest parity. Freedman (1994, p. 467) gives the following example: "If short-term interest rates rose by 1 percentage point and the increase was expected to last one quarter, and if the expected exchange rate remained unchanged, the

[97] Note that in the case of our MCIs presented in equations (V.39) and (V.40) the neutral values are zero. This is due to the fact that in the definition of the initial conditions of the dynamic system we set all variables – somewhat arbitrarily – to zero (see in contrast to this the analysis of the zero lower bound on nominal interest rates in Chapter IV). Moreover, all the variables defining the MCI are mean stationary.

exchange rate would appreciate by 0.25 percent." The overall restriction exerted by the tightening of interest rates is measured by the weighted sum of both the increase in the interest rate and the appreciation of the exchange rate. Thus, when the MCI is employed under market determined exchange rates (independently or indirect managed floating) its characterisation as an operating target of monetary policy may be misleading. Stevens (1998, p. 36) puts this as follows: "An MCI is a sort of hybrid of the policy *instrument*, and one (important) part of, what economists call, the *transmission* mechanism for policy. Monetary policy does not control the exchange rate directly; the exchange rate is a result of changes in the instrument (among a host of other factors)."[98] In a similar vein the European Central Bank writes: "MCIs mix variables which are not of the same nature. Aggregating the nominal short-term interest rate, which is controlled by the central bank, and the exchange rate which may respond to many influences other than monetary policy decisions, does not result in a meaningful indicator of the monetary policy stance of the ECB" (ECB, 2002, p. 25).

If the exchange rate and the interest rate were indeed tightly linked by UIP, the hybrid nature of the MCI would not be a cause for concern. However, given the topic of the present study, it is clear that UIP does not describe the behaviour of financial market participants and that the link between interest rates and exchange rates is subject to a high degree of uncertainty under market-determined exchange rates. The problems related to a non-stable relationship between the interest rate and the exchange rate can be exemplified by the experiences of the Reserve Bank of New Zealand which introduced the use of the MCI in June 1997. The practice of the Reserve Bank of New Zealand had probably taken the concept the furthest, adopting a practice of announcing a 'desired' level of the MCI and its future path within a narrow indicative band, conditional on the information available at the time, which they judge as most likely to be consistent with the achievement of their inflation target over time. But soon the limits of this strategy were revealed: "Such narrow bands did not adequately allow for the short-term 'noise' in the exchange rate, and we also greatly underestimated the extent of the quarter-to-quarter shifts in desired monetary conditions that were likely to be required. Use of these tight indicative bands around the MCI intra-quarter greatly increased the day-to-day and week-to-week responsiveness of interest rates to day-to-day exchange rate movements. It also led to interest rates rising quite sharply intra-quarter, as the exchange rate began to trend sharply downwards"

[98] Note that many economists (as the one just cited) do not distinguish between operating targets and instruments as operating targets are supposed to be perfectly controllable with the central bank's instruments. Strictly speaking, what they call an instrument is an operating target.

(Reserve Bank of New Zealand, 2000, item 36). The experience portrayed in this quotation confirms our results obtained in Chapter IV where we have shown that in the case of an alternative modelling of financial market behaviour there is a high probability that interest rates become very volatile.

On the academic level, the idea to use an MCI as an operating target for monetary policy under market-determined exchange rates was in particular promoted by Ball (1999b). Instead of the UIP condition he uses a rather simple structure for the international linkages of an open economy by simply assuming a negative relationship between the real exchange rate and the domestic real interest rate which can be disturbed by random shocks (see also Chapter IV):

(V.49) $$q_t = -\alpha_i \left(i_t - \pi_t\right) + \varepsilon_t^q .$$

Using equation (V.44) and (V.45) as Phillips curve and aggregate demand curve and assuming a traditional intertemporal loss function he derives an optimum monetary policy rule for a central bank in an open economy which he expressed in terms of an MCI as 'policy instrument'.[99] He correctly states that "the rationale for using an MCI is that it measures the overall stance of policy, including the stimulus through both r and e [the real interest rate and the real exchange rate in his notation; T.W.]. Policy makers shift the MCI when they want to ease or tighten" (Ball, 1999b, p. 131). But subsequently he specifies his policy rule as follows: "When there are shifts in the e/r relation – shocks in equation (3) [our equation (V.49); T.W.] – r is adjusted to keep the MCI at the desired level." In other words, even though he accepts the central role of the exchange rate for monetary policy in an open economy, he grounds his theory on an exchange rate system with purely market-determined exchange rates in which the only instrument of monetary policy is the interest rate. Thus, the way he (as well as the Bank of Canada and the Reserve Bank of New Zealand) uses the MCI is in principle identical with an indirect managed floating policy rule (see Chapter IV) where the operating target i_t reacts to movements of a range of endogenous variables, including some measure of the exchange rate.

To sum up, at the end of the 1990s the concept of the MCI lost a great part of its initial attractiveness. The Reserve Bank of New Zealand abandoned publishing an MCI in March 1999

[99] See again footnote 98 on the distinction between operating targets and instruments in the monetary policy literature.

and concentrated its policy statements on a short-term interest rate. While the Bank of Canada continues to publish an MCI, its role in taking monetary policy decisions was reduced to that of many other indicators in recent years. It should be stressed again that the way we use the MCI in this Chapter fundamentally differs from that just described. Under direct managed floating both the interest rate and the exchange rate serve as operating targets. Thus, combining both to an aggregate measure again yields an operating target that can be perfectly controlled (within the limits mentioned in Section IV.1.2 and Section V.1.4) by the central bank.

V.2.2 The MCI as composite operating target under direct managed floating

Before deriving the central bank's policy rule the objective of the policymaker has to be defined. As in Chapter IV the problem of the monetary policy authority is to minimise in each period τ an intertemporal loss function J_τ

(V.50) $$J_\tau = E_t\left[\sum_{t=0}^{\infty}\delta^t L_{\tau+t}\right]$$

with a period loss function given by

(V.51) $$L_t = \lambda_\pi \pi_t^2 + \lambda_y y_t^2 .$$

The preferences of the central bank with respect to the target variables λ_π and λ_y are assumed to take equal values ($\lambda_\pi = \lambda_y = 1$). One major difference to the analysis presented in Chapter IV is the introduction of a composite operating target. While under market determined exchange rates the policy rule is formulated in terms of a short-term interest rate, under direct managed floating the policy rule has to be defined in terms of an MCI. Thus, we have to transform the constraint under which (V.50) will be minimised into a constraint in which the MCI serves as a control variable.

V.2.2.1 Introducing the MCI as control variable[100]

Recall that the problem under market determined exchange rates was to find an interest rate path that minimises the intertemporal loss subject to the structure and the state of the economy given by

(V.52) $$x_{t+1} = Ax_t + Bi_t + \varepsilon_{t+1}$$

or – somewhat more detailed – by

(V.53) $$\begin{pmatrix} r^f_{t+1} \\ u^s_{t+1} \\ \pi_{t+1} \\ y_{t+1} \\ q_t \\ i_t \\ E_t q_{t+1} \end{pmatrix} = \begin{pmatrix} \rho_f & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \rho_s & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & \gamma_y & -\gamma_q & 0 & \gamma_q \\ 0 & 0 & \beta_i & \beta_y & 0 & 0 & \beta_q \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & -1 & -1 & -\gamma_y & \gamma_q & 0 & 1-\gamma_q \end{pmatrix} \begin{pmatrix} r^f_t \\ u^s_t \\ \pi_t \\ y_t \\ q_{t-1} \\ i_{t-1} \\ q_t \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \\ 0 \\ -\beta_i \\ 0 \\ 1 \\ 1 \end{pmatrix} i_t + \begin{pmatrix} \varepsilon^f_{t+1} \\ \varepsilon^s_{t+1} \\ \varepsilon^\pi_{t+1} \\ \varepsilon^y_{t+1} \\ 0 \\ 0 \\ 0 \end{pmatrix}.$$

A and B are matrices containing the structural coefficients and x_t is the vector of state variables (see Appendix IV.A.a). The interest rate i_t which has been served so far as a control variable was isolated from the other system variables. If the purpose is to introduce a new control variable, we have to replace the old control variable i_t with an expression containing the new control variable. In this Section we present the concrete proceedings only for the real MCI. The transformation of the state-space representation for the nominal MCI as operating target is shown in Appendix V.A.

In the first step we take the definition of the real MCI (given by (V.39)) and we replace the real interest rate with i_t and $E_t\pi_{t+1}$ according to the Fisher equation:

(V.54) $$\begin{aligned} MCI_t &= r_t - \psi q_t = \\ &= i_t - E_t\pi_{t+1} - \psi q_t. \end{aligned}$$

[100] The transformation of the system into a system with the MCI as a control variable draws on appendix F of the

Then, the expected future inflation rate can be expressed as a function of the state variables x_t and the interest rate i_t:[101]

(V.55)
$$\begin{aligned} E_t\pi_{t+1} &= \pi_{t+1} - \varepsilon^{\pi}_{t+1} = \\ &= A_3 x_t + B_3 i_t. \end{aligned}$$

A_i is a $1 \times n$ row vector (where $n = n_1 + n_2 = 6 + 1 = 7$) containing the elements of the i-th row of matrix A. B_i is a scalar taking the value of the i-th row of the column vector B. Note that in our case B_3 is equal to zero so that $E_t\pi_{t+1} = A_3 x_t$. In a similar vein, the real exchange rate can be expressed as

(V.56)
$$q_t = A_5 x_t + B_5 i_t$$

where again B_5 is equal to zero so that $q_t = A_5 x_t$. Solving (V.54) for i_t and inserting (V.55) and (V.56) into the resulting equation yields the following expression:

(V.57)
$$i_t = MCI_t + \left(A_3 + \psi A_5\right) x_t.$$

We can now rewrite the state-space representation of our economy by substituting i_t in (V.52) for (V.57):

(V.58)
$$\begin{aligned} x_{t+1} &= Ax_t + B\left[MCI_t + \left(A_3 + \psi A_5\right)x_t\right] + \varepsilon_{t+1} = \\ &= \underbrace{\left[A + B\left(A_3 + \psi A_5\right)\right]}_{A^{MCI}} x_t + B\,MCI_t + \varepsilon_{t+1}. \end{aligned}$$

This finally gives a state-space form of the model's equations with an MCI as control variable:

(V.59)
$$x_{t+1} = A^{MCI} x_t + B\,MCI_t + \varepsilon_{t+1}.$$

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working paper version of Svensson (2000).

Similarly, we can derive a modified equation for the vector of target variables z_t. Recall that with i_t as control variable z_t was given by

(V.60) $$z_t = C_x x_t + C_i i_t .$$

Inserting (V.57) into (V.60) and rearranging it yields

(V.61) $$z_t = \underbrace{\left[C_x + C_i\left(A_3 + \psi A_5\right)\right]}_{C_x^{MCI}} x_t + C_i MCI_t .$$

V.2.2.2 Numerical determination of the coefficients of the policy rule

The central bank's problem is solved by assuming the central bank follows a simple policy rule in terms of the MCI:

(V.62) $$MCI_t = f_\pi \pi_t + f_y y_t$$

Similar to the proceeding in Chapter IV the operating target is adjusted in response to a small set of observable variables, namely the actual inflation rate and the actual output gap. In order to determine the response coefficients in the policy rule we performed a constrained optimisation for both the real MCI (given by (V.39)) and the nominal MCI (given by (V.40)). In any case, searching for an optimal simple policy rule involves three unknown values: the optimum weighting of the exchange rate term in the MCI (ψ) and the optimum response coefficients (f_π and f_y). Since analytical solutions of the central bank's problem may be very complex and in many cases even not computable we approached the problem by numerical simulation.[102] Therefore we have to calibrate the model (see Table V.6). The parameters of the Phillips curve and the IS (aggregate demand) equation are identical to those in Chapter IV. In contrast to the simulations of Chapter IV however the foreign interest rate is modelled as an autoregressive

[101] Equation (V.55) shows again that in period t the expected future rate of inflation $E_t\pi_{t+1}$ is fully pre-determined. We implicitly used this fact in the introduction to Section V.2 (see equations (V.41) and (V.42)).

[102] The mathematics for calculating the optimised coefficients, the related variances and the loss is identical with the case of an interest rate as operating target, and hence already described in Appendix IV.B.c.

process with a positive and non-zero persistence parameter ρ_f. For simplicity the variance of the i.i.d. shocks ε_t^{π}, ε_t^{y} and ε_t^{f} is normalised to unity.

Table V.6: Calibration of the model

Phillips curve		IS equation			UIP equation	
γ_y	γ_q	β_y	β_i	β_q	ρ_f	ρ_s
0.4	0.2	0.8	0.6	0.2	0.3	0

When determining the optimal simple policy rule it is important to bear in mind that its derivation cannot be based on the certainty-equivalence principle (see Section IV.2.1). Thus, the weight ψ and the coefficients f_{π} and f_y depend – among other things – on the variances of the shock terms. While the real shocks ($\varepsilon_t^{\pi}, \varepsilon_t^{y}$) as well as the shocks from abroad (ε_t^{f}) are assumed to be policy-independent, the UIP shocks are not. According to our 'technical' definition of direct managed floating at the beginning of Section V.2 sterilised foreign exchange market interventions enter the model by avoiding any persistent deviation from UIP (i.e. $\rho_s = 0$) and by eventually allowing for some stochastic white noise shock (i.e. some short term volatility in the exchange rate). Thus, in order to find out whether the degree to which the spot exchange rate is managed, has an influence on the structure of the optimal simple rule we calculated the weight ψ and the coefficients f_{π} and f_y for both MCI rules (the real MCI rule, $MCI_t = r_t - \psi q_t$, and the nominal MCI rule, $MCI_t = i_t - \psi \Delta s_t$) for values of the variance of the UIP shock ranging from zero to one (see Table V.7 and Table V.8).

Accordingly, the optimised coefficients of the real MCI rule are independent of the variance of the UIP shock (al least within $0 \le \mathrm{Var}\left[\varepsilon_t^{s}\right] \le 1$). The real exchange rate enters the MCI with a weight of 0.14 implying that a one percentage point increase in the real interest rate exerts the same degree of monetary restriction as an appreciation of the real exchange rate by $1/0.14 = 7.14$ per cent. Given the response coefficients the MCI has to rise in the case of an increase in inflation and/or output. The results are somewhat different for the nominal MCI rule. For variances of the UIP shock exceeding 0.6 the weighting of the exchange rate in the MCI increases from 0.26 to 0.27. At the same threshold value of $\mathrm{Var}\left[\varepsilon_t^{s}\right]$ the reaction coefficient for the output gap rises to 1.71. Since we assume that the central banks accommodates the majority of UIP disturbances we decided for a nominal MCI rule with the parameters $\psi = 0.26$, $f_\pi = 1.91$ and $f_y = 1.69$.

Table V.7: Optimised coefficients, variances and loss of the real MCI rule

$Var\left[\varepsilon_t^s\right]$	ψ	f_π	f_y	$Var\left[\pi_t\right]$	$Var\left[y_t\right]$	loss	relative loss
0.0	0.14	1.27	1.34	2.62	2.31	4.93	100.33
0.1	0.14	1.27	1.34	2.63	2.31	4.93	100.33
0.2	0.14	1.27	1.34	2.63	2.31	4.94	100.33
0.3	0.14	1.27	1.34	2.63	2.31	4.94	100.33
0.4	0.14	1.27	1.34	2.63	2.31	4.94	100.33
0.5	0.14	1.27	1.34	2.64	2.31	4.94	100.33
0.6	0.14	1.27	1.34	2.64	2.31	4.95	100.33
0.7	0.14	1.27	1.34	2.64	2.31	4.95	100.33
0.8	0.14	1.27	1.34	2.64	2.31	4.95	100.33
0.9	0.14	1.27	1.34	2.65	2.31	4.95	100.34
1.0	0.14	1.27	1.34	2.65	2.31	4.96	100.34

Note: The relative loss refers to the loss from optimal unrestricted policy under commitment.

Table V.8: Optimised coefficients, variances and loss of the nominal MCI rule

$Var\left[\varepsilon_t^s\right]$	ψ	f_π	f_y	$Var\left[\pi_t\right]$	$Var\left[y_t\right]$	loss	relative loss
0.0	0.26	1.91	1.69	2.60	2.33	4.94	100.48
0.1	0.26	1.91	1.69	2.61	2.33	4.94	100.48
0.2	0.26	1.91	1.69	2.61	2.33	4.94	100.49
0.3	0.26	1.91	1.69	2.61	2.33	4.95	100.49
0.4	0.26	1.91	1.69	2.61	2.34	4.95	100.50
0.5	0.26	1.91	1.69	2.62	2.34	4.95	100.50
0.6	0.26	1.91	1.69	2.62	2.34	4.96	100.51
0.7	0.27	1.91	1.71	2.62	2.34	4.96	100.51
0.8	0.27	1.91	1.71	2.63	2.34	4.96	100.52
0.9	0.27	1.91	1.71	2.63	2.34	4.96	100.52
1.0	0.27	1.91	1.71	2.63	2.34	4.97	100.52

Note: The relative loss refers to the loss from optimal unrestricted policy under commitment.

V.2.2.3 A note on the optimum weighting of the exchange rate term in the MCI

In contrast to our model consistent approach for the calculation of ψ economists and central banks often propose to weight the exchange rate term in the MCI according to the relative elasticities of the exchange rate and the interest rate in the IS curve, i.e. $\psi = \beta_q / \beta_i$ (see Dennis, 1997, Dornbusch et al., 1998, Freedman, 1994). The idea behind this one-dimensional view is that real output (or the output gap) constitutes the sole target variable of the central bank. If inflation is added as an additional monetary policy target, this way of calculating ψ remains correct as long as the only determinant of inflation is output (in our case: $\gamma_q = 0$, see calculations below; for the calculations of an MCI in the case of an inflation equation without exchange rate pass-through see Gerlach and Smets (2000) and Detken and Gaspar (2003)). Otherwise, the information on the monetary policy stance contained in the MCI may be flawed. Gerlach and Smets (2000, p. 1679) state: “In accordance with central bank practice, our model suggests that the optimal weight on the exchange rate depends on the elasticities of aggregate demand.(…) However, this model may be deficient in a number of ways. First, monetary policy may affect inflation through other transmission channels than the output gap, for instance through the direct effect of exchange rate changes on import prices. If so, the attractive result that the weight on the exchange rate depends solely on the elasticities of aggregate demand may no longer hold true.”

One way to cope with this problem is to define an MCI with respect to each of the central bank’s final targets (Eika et al., 1996, Nadal-De Simone et al., 1996). Suppose that the target variables are summarised by a vector z_t (see equation (V.60)). Thus, the relative exchange rate weight of the real MCI on target variable $z_{i,t}$ is defined as the quotient of the two partial derivatives of the target variable $z_{i,t}$ with respect to the exchange rate and the interest rate:

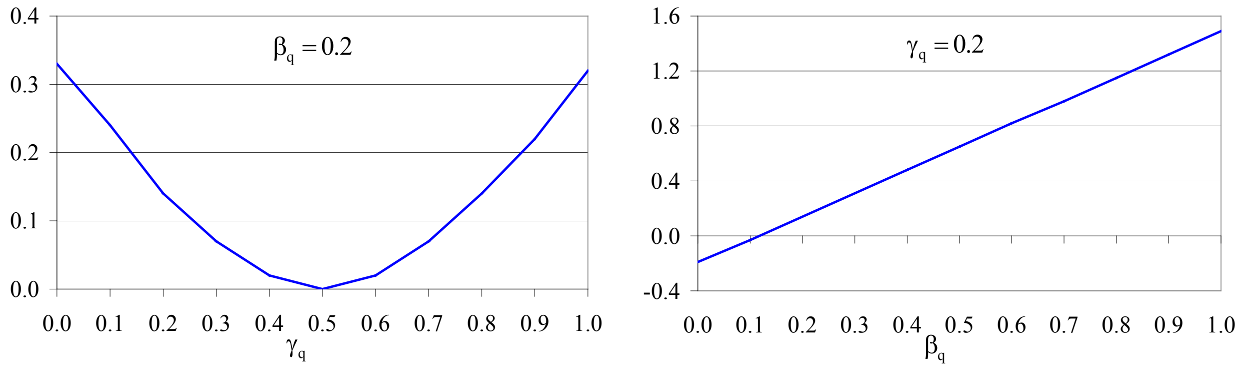
$$\text{(V.63)} \qquad \psi_{zi} = \frac{\partial z_{i,t} / \partial q_t}{\partial z_{i,t} / \partial r_t}.$$

The same proceeding applies in the case of a nominal MCI. In our view, however, this approach certainly does not contribute to the basic requirement of every monetary policy strategy to be transparent and communicable. Given the two final targets π_t and y_t the central bank would have to publish two MCIs and situations producing contradictory results cannot be excluded.

For this reason we adopted an alternative approach in which we derived a single but fully model-consistent MCI. The weight on the real exchange rate depends on the effects of both operating targets on both of the central bank's target variables as summarised by the intertemporal loss function as well as on the policymaker's preferences (see Ball, 1999b, and Guender, 2001 for a similar approach).

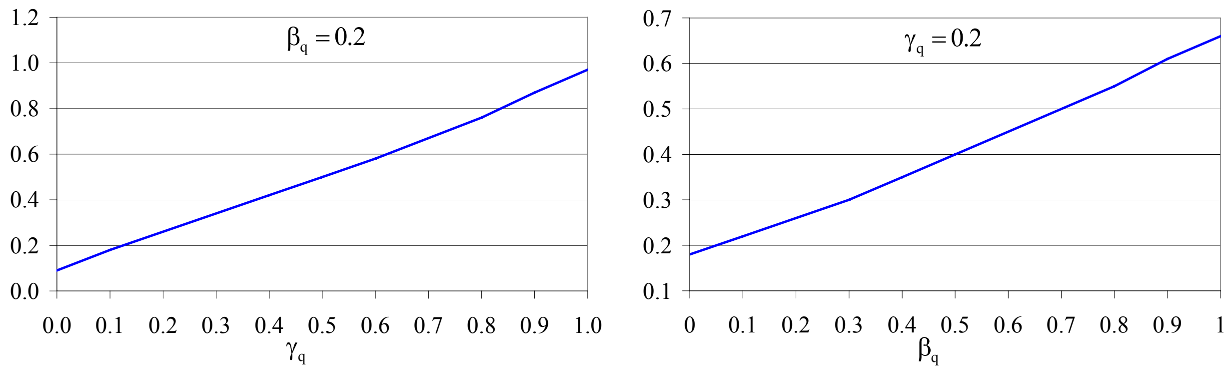
In the following, we will show how the optimum exchange rate weight ψ varies with the degree of openness of the economy and with the preference parameters in the intertemporal loss function. We first take a look at the weight of the exchange rate in the real MCI. For a given exchange rate elasticity of aggregate demand ($\beta_q = 0.2$) the optimum weight ψ only reaches $\beta_q / \beta_i = 0.33$ if there is no additional exchange rate channel in the model (i.e. for $\gamma_q = 0$). However, as the left panel of Figure V.15 shows the direct impact of exchange rate changes on inflation is an important determinant of ψ. For a growing γ_q the weight initially falls until it reaches its minimum ($\psi = 0$) for $\gamma_q = 0.5$ and then increases again. If, on the other hand, γ_q is held constant ψ grows linearly with the exchange rate elasticity of aggregate demand (see the right panel of Figure V.15).

Figure V.15: Optimum MCI weights for a varying degree of openness (real MCI)



Under a nominal MCI rule ψ depends linearly on both, the exchange rate elasticity in the Phillips curve and the exchange rate elasticity of aggregate demand (see Figure V.16). However, when γ_q goes to zero the MCI weight does not become $\beta_q / \beta_i = 0.33$ (but 0.09). This is due to the fact that in contrast to the real MCI now the lag structure of the MCI is different compared with the lag structure of aggregate demand (see also Stevens (1998) on this point who argues that for more realistic models with a more detailed lag structure the simple rule thumb $\psi = \beta_q / \beta_i$ in the case of a Phillips curve without exchange rate term does not apply anymore).

Figure V.16: Optimum MCI weights for a varying degree of openness (nominal MCI)



Even though it seems to be important to take into account all the relevant transmission channels of the exchange rate when calculating the exchange rate weight in the MCI the additional loss that occurs if one simply assumes ψ to take a value of $\beta_q / \beta_i = 0.33$ is rather limited. The variances of the goal variables and the losses shown in Table V.9 are expressed in relation to the outcome resulting from an unrestricted MCI weight (see Table V.7 and Table V.8). We calculated these values by setting ψ to 0.33 and by optimising over the response coefficients f_π and f_y.

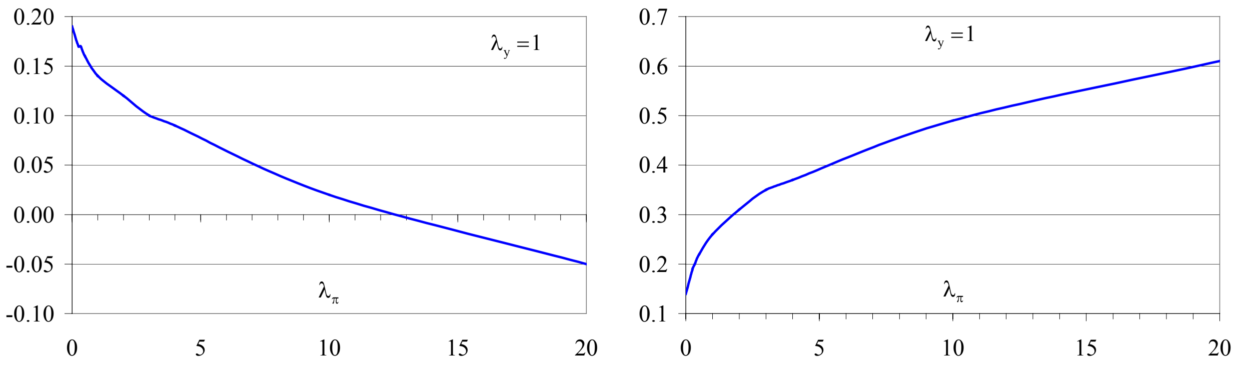
Table V.9: Loss if ψ is set to β_q / β_i

	f_π	f_y	$\mathrm{Var}[\pi_t]$	$\mathrm{Var}[y_t]$	loss
real MCI	1.51	1.57	100.16	100.59	100.36
nominal MCI	1.91	1.80	99.44	100.96	100.16

Besides the exchange rate elasticities of output and inflation, an additional determinant of ψ is the relative preferences of the central bank towards its final targets. For a given preference λ_y Figure V.17 depicts ψ for values of λ_π ranging from zero ('output junkie') to twenty ('inflation nutter'). In the case of a real MCI (left panel) the exchange rate weight in the MCI steadily falls and even becomes negative for a strict inflation targeting central bank. This result is quite similar to the analytically solved MCI problem of Guender (2001). In the case of a nominal MCI (right panel) the exchange rate weight in the MCI steadily grows with the degree of strict inflation targeting. Thus the more the central bank is concerned about the variance of inflation the more the rate of nominal depreciation impacts on the restriction of monetary policy.

Figure V.17: Optimum MCI weights for varying preferences of the central bank

real MCI: $MCI_t = r_t - \psi q_t$ nominal MCI: $MCI_t = i_t - \psi \Delta s_t$



V.2.3 Direct managed floating in action

The setting of the two operating targets within the direct managed floating framework can be demonstrated if we analyse the dynamics following the occurrence of each of the three possible shocks that may hit the economy: a positive demand shock, an inflationary supply shock and a shock in the form of an increase of the foreign real interest rate. The following Figures depict the impulse-response of the variables of interest over 20 periods. The shocks are assumed to hit the economy in period 1. In each case the size of the shock is one standard deviation. To demonstrate the necessity of a policy reaction the upper left panel of Figure V.18, Figure V.20 and Figure V.22 depict the development of inflation and output under the assumption that there is no policy reaction. For simplicity the absence of monetary policy is simulated by a constant real interest rate. The three charts show that in such a scenario the shocks would cause large and persistent oscillations in inflation and output, and hence significant costs in terms of the loss function.

Figure V.18 shows that in the case of a real MCI rule a positive demand shock calls for a restrictive MCI in period 1. In an open economy framework this is mainly achieved by an increase of the domestic real and nominal interest rate. Since the foreign real interest rate has remained unchanged, UIP requires that the domestic currency follows a depreciation path beginning in period 1. This is realised by an immediate real and nominal appreciation of the domestic currency which exerts an additional degree of monetary restriction in period 1 (see the lower charts in Figure V.18 for the path of the operating targets). From period 2 on the overall degree of restriction more or less returns to zero. The nominal interest rates gradually return to its neutral level while the nominal exchange rate converges to a new equilibrium level. The effects of both the nominal depreciation and the decrease in nominal interest rates tend to be neutralised by the positive but declining domestic rate of inflation so that their real counterparts q_t and r_t quickly return to zero. The policy response of a central bank following a nominal MCI rule is almost identical (see Figure V.19).

Figure V.18: Demand shock (real MCI)

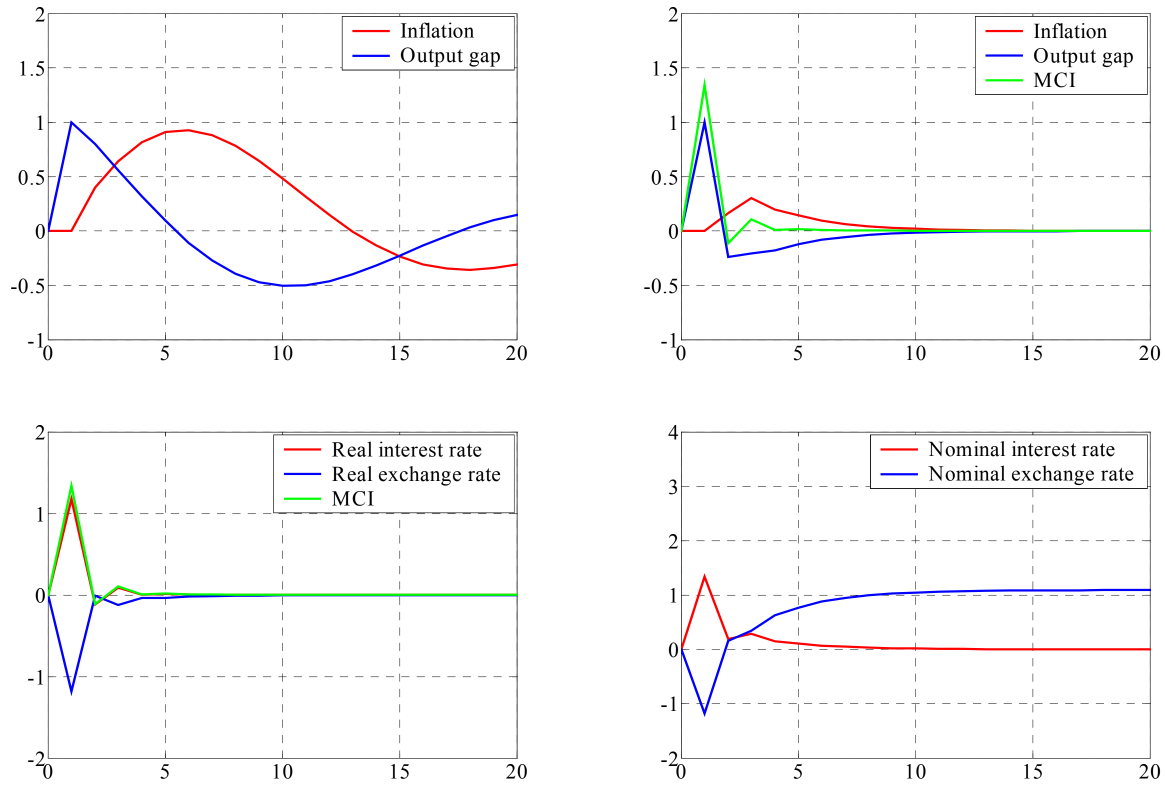
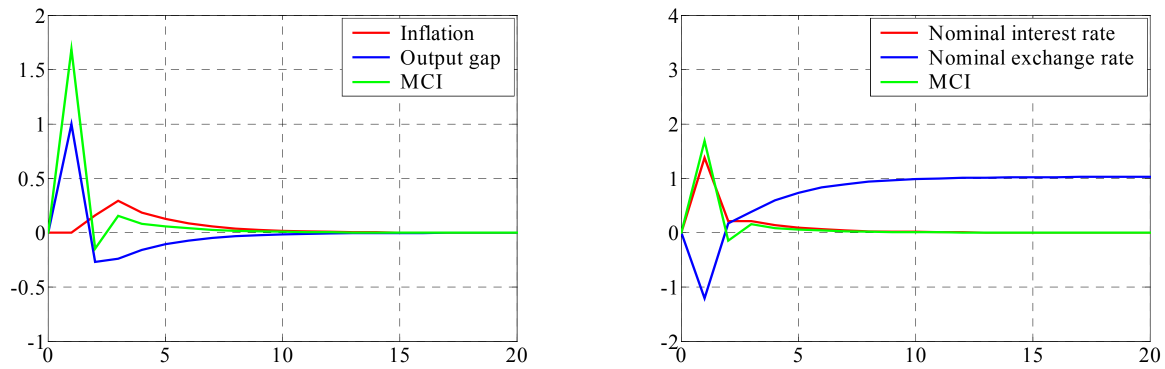


Figure V.19: Demand shock (nominal MCI)



In the situation of an inflationary supply shock the model shows that an almost similar tightening of monetary conditions is required – at least in the case of a real MCI rule (see Figure V.20). Unlike in the event of a positive demand shock however the nominal interest rate hike is more pronounced and comes along with a much smaller initial nominal appreciation. Nonetheless the UIP condition is perfectly met since the expected depreciation is much higher. Again the real interest rate and the real exchange rate quickly return to zero. Thus, the more pronounced movements in the nominal operating targets are neutralised by a much higher and in particular more persistent rise in the rate of inflation. Similar to the well-known result for closed economy models (see e.g. Clarida et al., 1998) the positive supply shock faces the central bank with an important short run trade-off between output and inflation. Instead of almost perfectly offsetting the effects of the demand shock the central bank now creates a significant negative output gap in order to bring down inflation. Since the negative output gap persists over several periods the inflation rate is reduced almost automatically, albeit slowly, without any significant additional monetary restriction. In the case of a nominal MCI rule the initial increase in the MCI is somewhat more pronounced (see Figure V.21). The rest of the dynamics is again quite similar to those of the real MCI rule.

Figure V.20: Supply shock (real MCI)

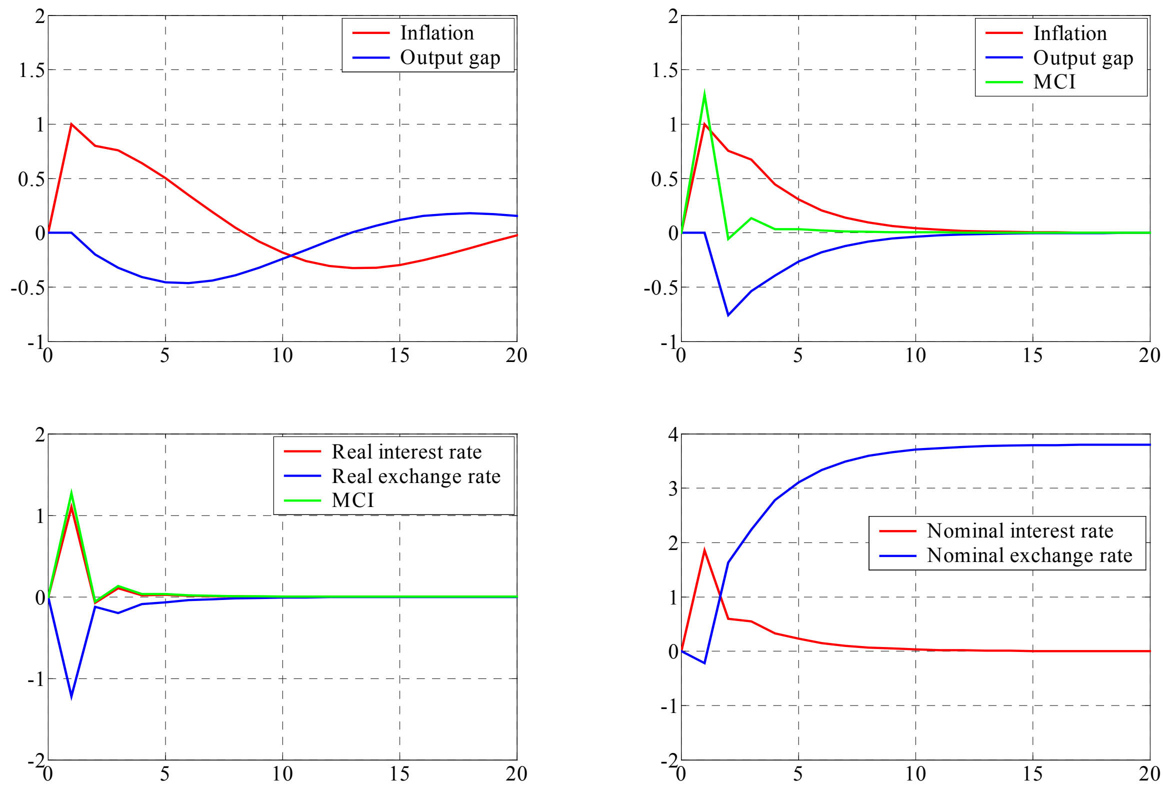
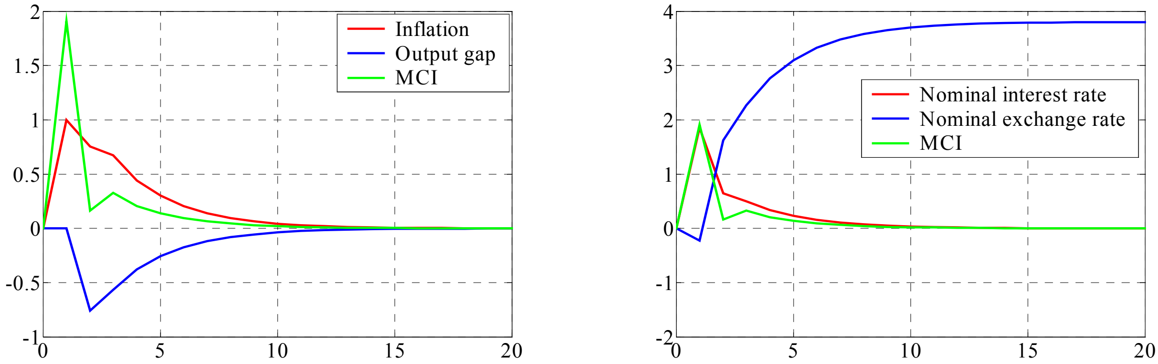


Figure V.21: Supply shock (nominal MCI)



In an open economy changes in the foreign interest rate can be also treated as a shock. Here we assume that the foreign interest rate is increased by one standard deviation. Initially the shock induces the central bank to adjust its policy mix – i.e. the combination of the two operating targets – without changing the overall monetary conditions in period 1 (see Figure V.22 for the real MCI rule and Figure V.23 for the nominal MCI rule).

Figure V.22: Foreign interest rate shock (real MCI)

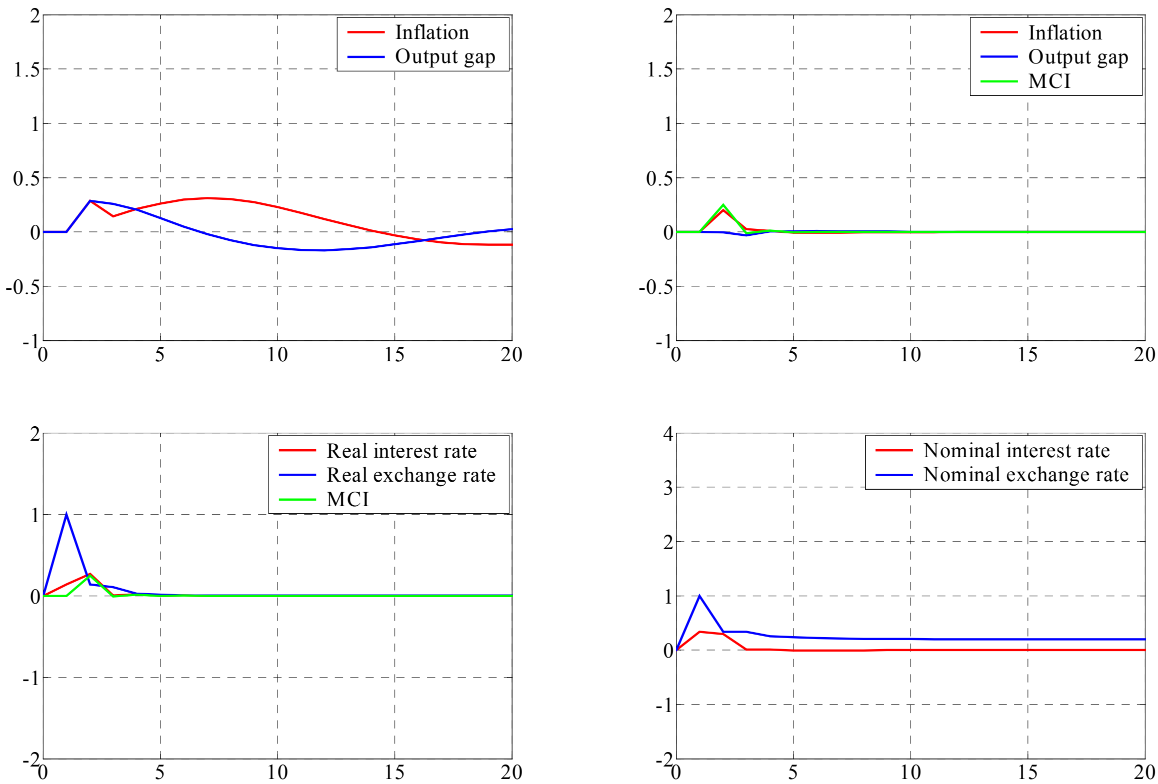
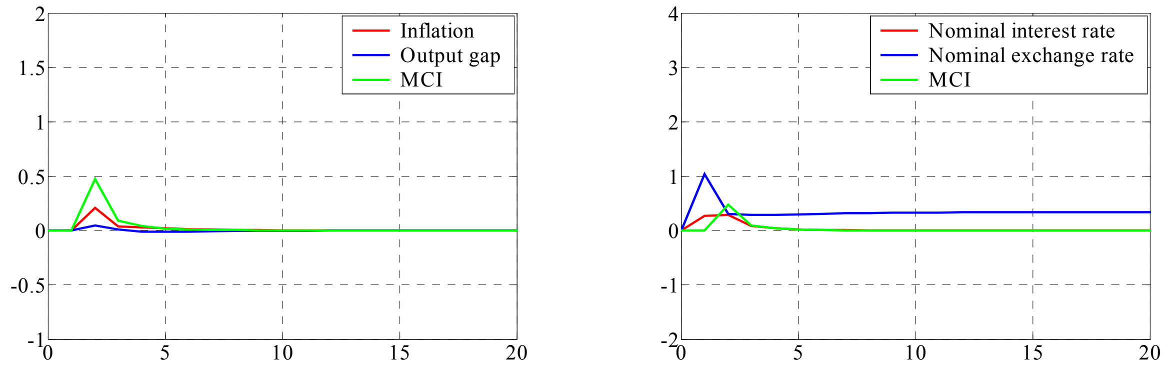


Figure V.23: Foreign interest rate shock (nominal MCI)

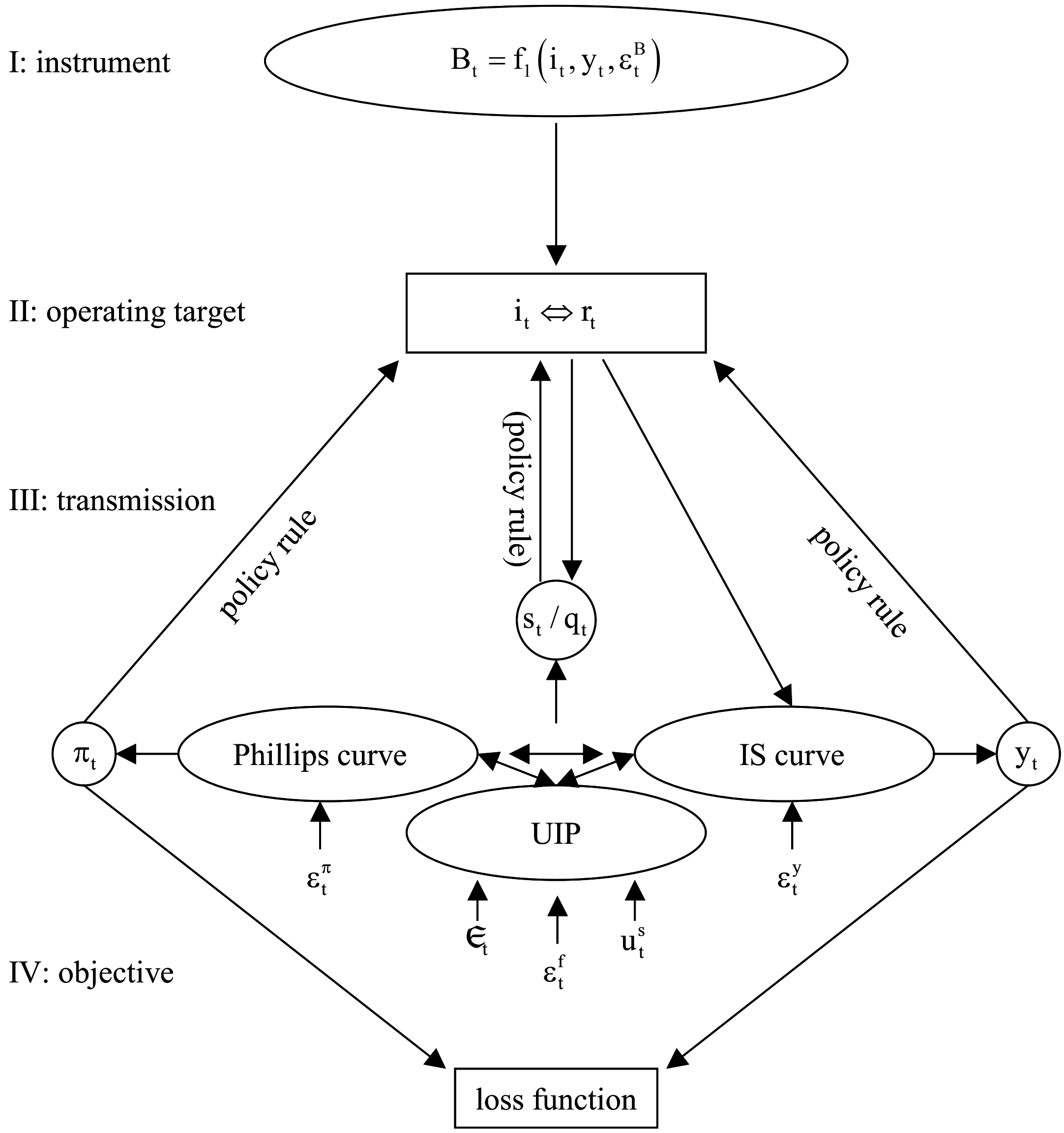


This can be reconciled with UIP if the domestic real interest rate is increased, but less than the foreign rate and if at the same time the exchange rate is depreciated. While the two components of this change of the policy mix nearly offset each other with respect to their effect on output, the real depreciation (caused by a nominal depreciation) directly leads to an increase in inflation in period 2. From this it follows that the MCI rises in period 2 in order to counteract the inflationary pressure. However this contraction in monetary policy has again almost no feedback on output, so it can be concluded that the consequences of foreign interest rate shocks can be compensated relatively well with the policy rules just described.

V.3 Direct managed floating in comparison with independently and indirect managed floating

In the last Section we developed the theoretical framework for a strategy of direct managed floating. The crucial difference to strategies of independently floating and indirect managed floating exchange rates was the way in which the exchange rate is determined. While under independently floating and indirect managed floating the exchange rate is purely market determined, a direct managed floating central bank additionally makes use of a second policy instrument, namely sterilised foreign exchange market interventions, in order to target the path of the nominal exchange rate. Instead of being the guideline for the central bank's simultaneous targeting of the interest rate and the exchange rate (see Section V.1.3), the UIP condition becomes a basic element of the transmission process if the central bank leaves the exchange rate to the market. In Figure V.24 we summarise the basic structure of a monetary policy strategy under market determined exchange rates. The interest rate which serves as a single operating target responds to inflation and output and eventually – under indirect managed floating – to an exchange rate term. As has been shown in Chapters III and IV, the UIP condition introduces a high degree of uncertainty for the policy maker which we modelled by expectational anomalies ϵ_t and risk premium shocks u_t^s.

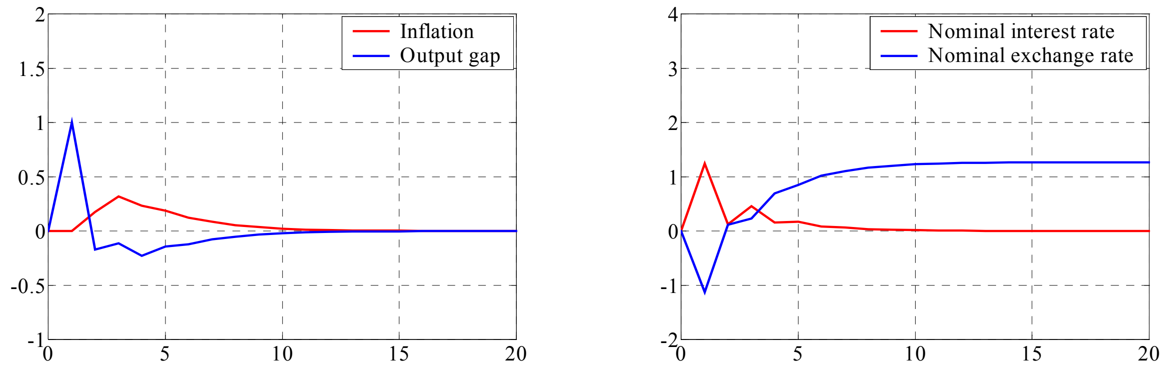
Figure V.24: Monetary policy under market determined exchange rates



V.3.1 A comparison of the consequences of shocks under independently/indirect managed floating and direct managed floating

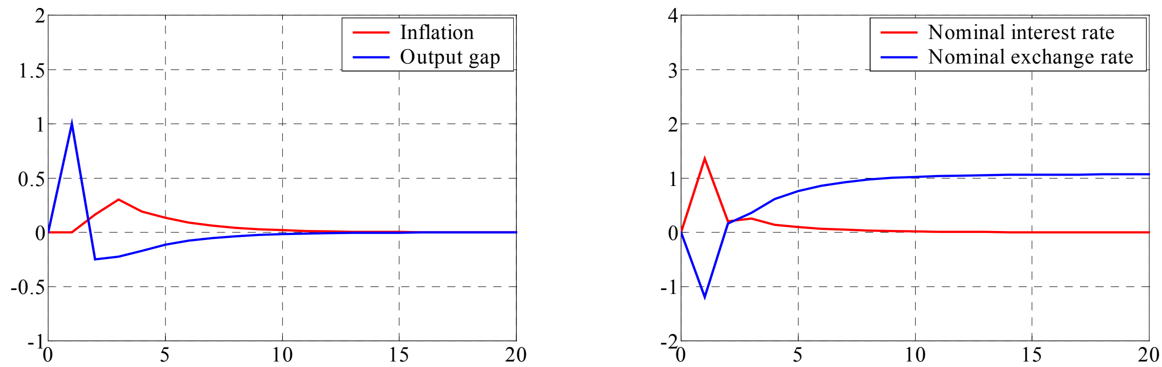
One might be tempted to ask the difference of the monetary policy response under independently floating and indirect managed floating on the one hand and direct managed floating on the other hand. The answer crucially depends on the nature of the shocks hitting the economy. In the case of domestic demand, domestic supply and foreign interest rate shocks the dynamics of the economy following the policy intervention are quite similar. This is shown in Figure V.25 to Figure V.30 which depict the impulse responses for an independently floating and an indirect managed floating central bank. The response coefficients were calculated on the basis of a constrained optimisation as described in Chapter IV. As usual, the central bank is assumed to have equal preferences towards output and inflation. Note that the coefficients of the policy rule for an independently floating central bank slightly differ from those of policy rule R1 in Chapter IV which is due to the additional foreign interest rate shock that has been set to zero in Chapter IV. By contrast, the optimal coefficients of the indirect managed floating policy rule (the structure of which corresponds to that of the robust policy rule R6) are unaffected by the inclusion of this additional shock.

Figure V.25: Demand shock under independently floating



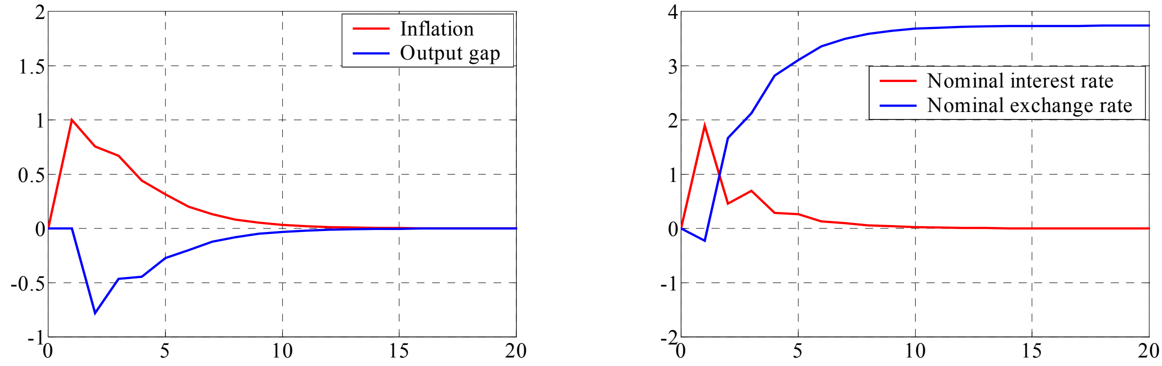
Note: The optimal independently floating policy rule is $i_t = 1.89\pi_t + 1.24y_t$.

Figure V.26: Demand shock under indirect managed floating



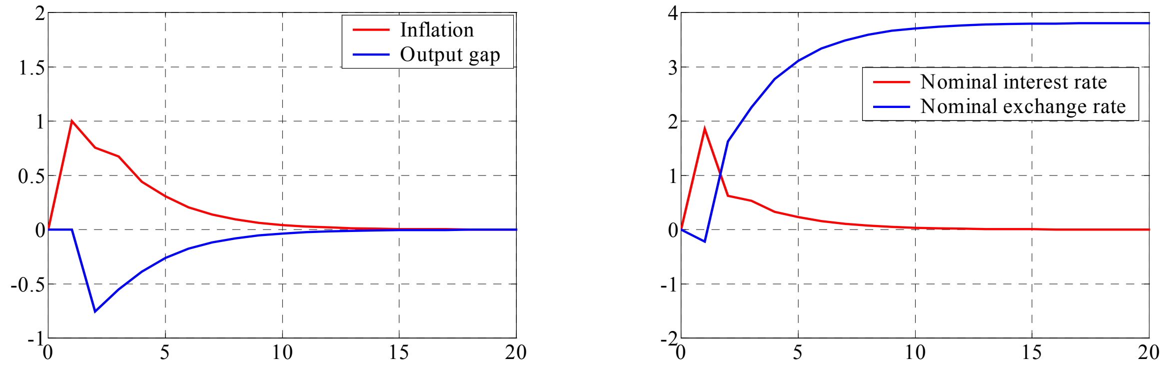
Note: The optimal indirect managed floating policy rule is $i_t = 2.29\pi_t + 1.78y_t + 0.36q_t - 0.23q_{t-1}$.

Figure V.27: Supply shock under independently floating



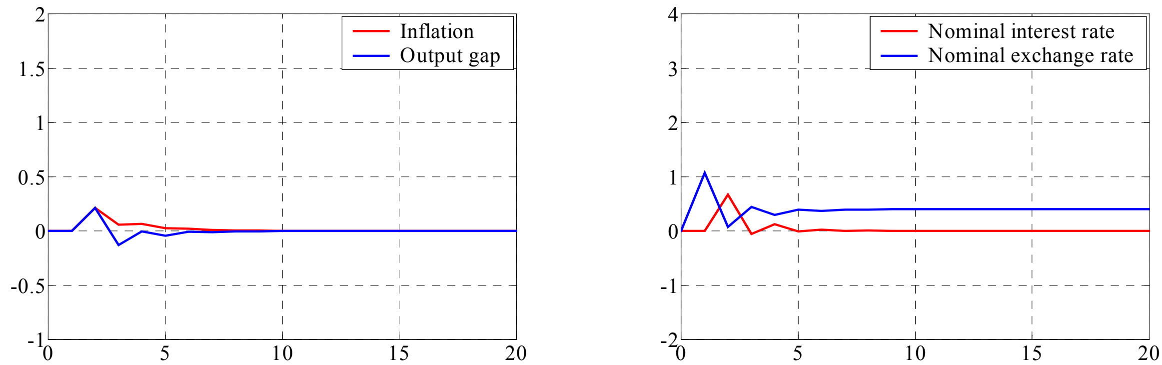
Note: The optimal independently floating policy rule is $i_t = 1.89\pi_t + 1.24y_t$.

Figure V.28: Supply shock under indirect managed floating



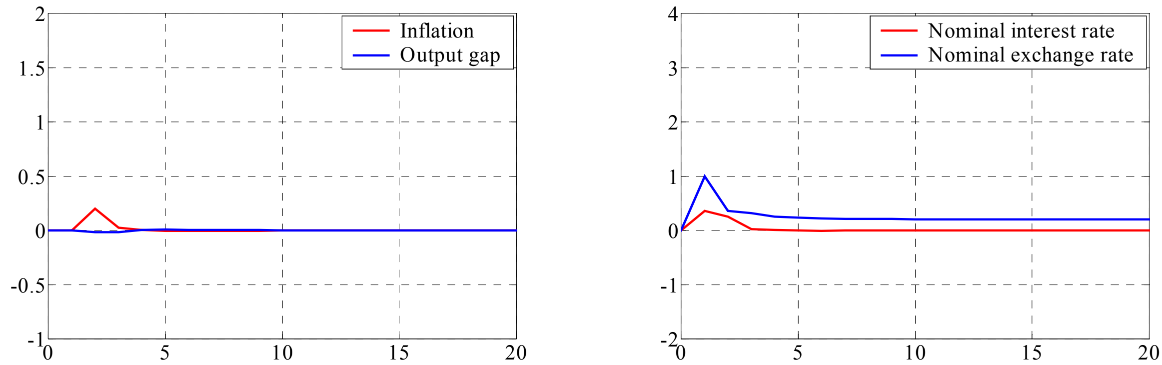
Note: The optimal indirect managed floating policy rule is $i_t = 2.29\pi_t + 1.78y_t + 0.36q_t - 0.23q_{t-1}$.

Figure V.29: Foreign interest rate shock under independently floating



Note: The optimal independently floating policy rule is $i_t = 1.89\pi_t + 1.24y_t$.

Figure V.30: Foreign interest rate shock under indirect managed floating



Note: The optimal indirect managed floating policy rule is $i_t = 2.29\pi_t + 1.78y_t + 0.36q_t - 0.23q_{t-1}$.

Since ε_t^y, ε_t^π and ε_t^f are independently distributed, the interest rate path and the nominal exchange rate path perfectly fulfil the UIP condition. If there are no unexpected exchange rate movements in the form of disturbances to UIP, then the direct managed floating central bank sees no need for sterilised foreign exchange market interventions. The intervention response function given by equation (V.25) takes a value of zero. Thus, the exchange rate can be viewed as being purely market determined. From this it follows that the central bank's policy rule could be equally expressed as

(V.64) $$r_t = 1.27\pi_t + 1.34y_t + 0.14q_t$$

or

(V.65) $$i_t = 1.91\pi_t + 1.69y_t + 0.26\Delta s_t$$

which results from solving the real/nominal MCI policy rule given by equation (V.62) for the interest rate. It is obvious that these two policy rules are quite similar in their structure to the indirect managed floating policy rules R2 and R5 in Chapter IV.

The difference between direct managed floating and independently/indirect managed floating basically appears in the case of UIP shocks. While the direct managed floating central bank absorbs these shocks with its foreign exchange market policy instruments, the independently/ indirect managed floating central bank implicitly/explicitly reacts to the resulting exchange rate movements with its interest rates. From Chapter IV we know that not only the fact that UIP disturbances may occur, but particularly the high degree of uncertainty that surrounds these shocks poses a problem for the central bank. In contrast, however, to our analysis in Chapter IV we keep the analysis simple by only considering uncertainty about the persistence of the shocks to the risk premium.

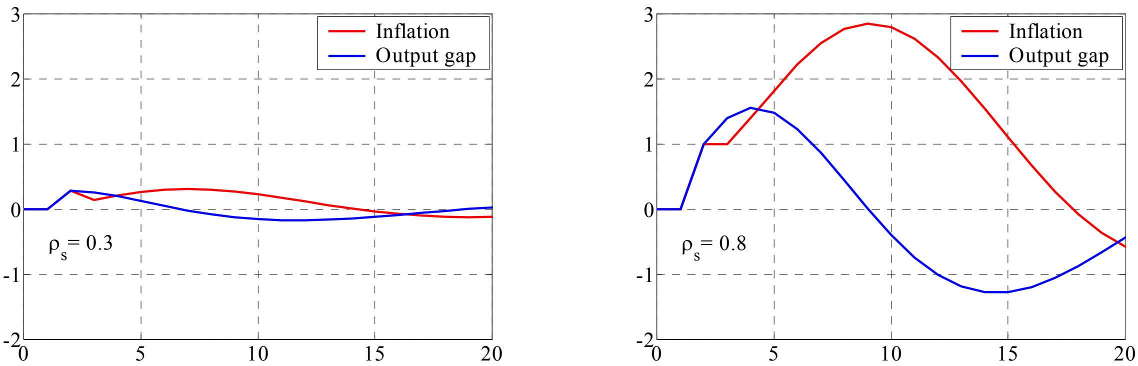
Again we assume that the central banks deems a value of ρ_s equal to 0.3 to be most likely. Thus it follows a policy rule that was optimised on the basis of this information. Uncertainty is modelled as an unexpected increase in the risk premium to 0.8. Since the direct managed floating central bank is assumed to perfectly absorb all kinds of disturbances to UIP we set the variance and the persistence of the UIP shock to zero (see Table V.10 for the parameters).

Table V.10: UIP shock parameters under different strategies

	direct managed floating	independently floating		indirect managed floating	
		certain	uncertain	certain	uncertain
$\mathrm{Var}\left[\varepsilon_t^s\right]$	0	1	1	1	1
ρ_s	0	0.3	0.8	0.3	0.8

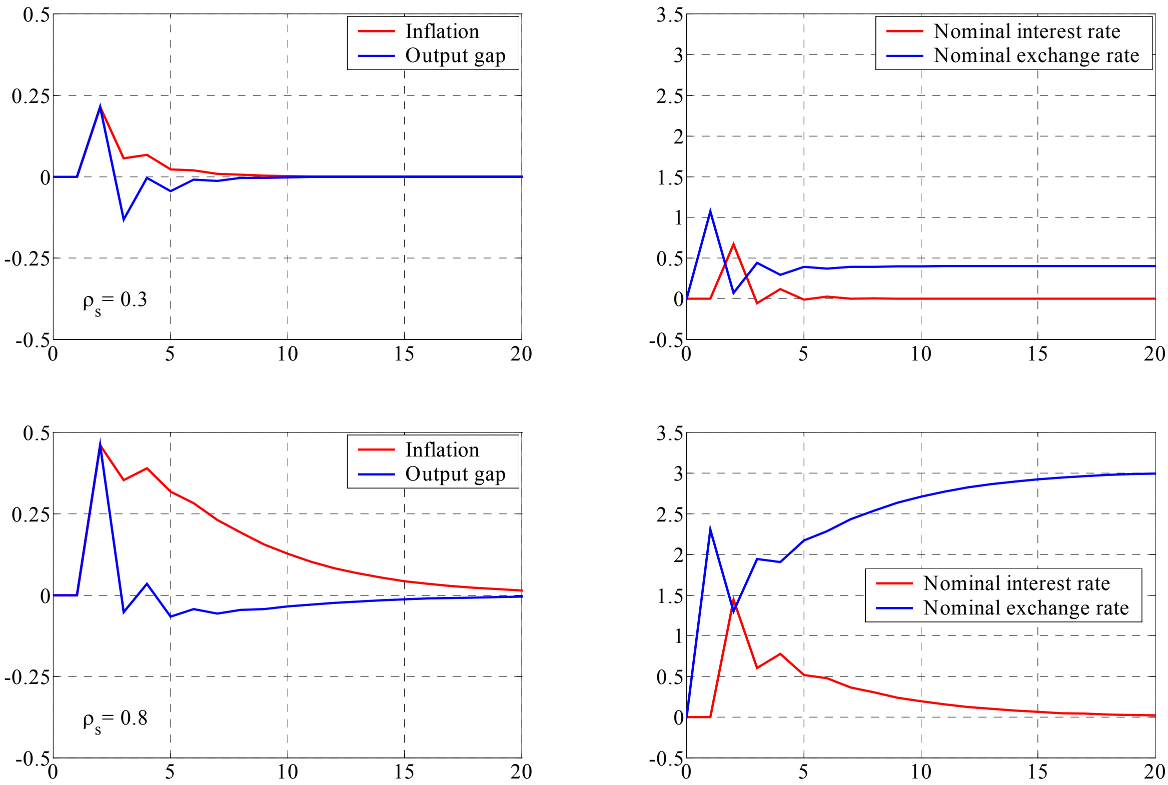
In a first step Figure V.31 illustrates the impact of a unit UIP shock with $\rho_s = 0.3$ (left panel) and $\rho_s = 0.8$ (right panel) on output and inflation under the assumption that the real interest rate remains unchanged (i.e. in the absence of any policy reaction). A positive UIP shock causes the domestic currency to depreciate, and by this stimulates output and accelerates inflation. With an increase in the risk premium the oscillations of the target variables become more pronounced.

Figure V.31: Impact of persistent UIP shocks in the absence of monetary policy



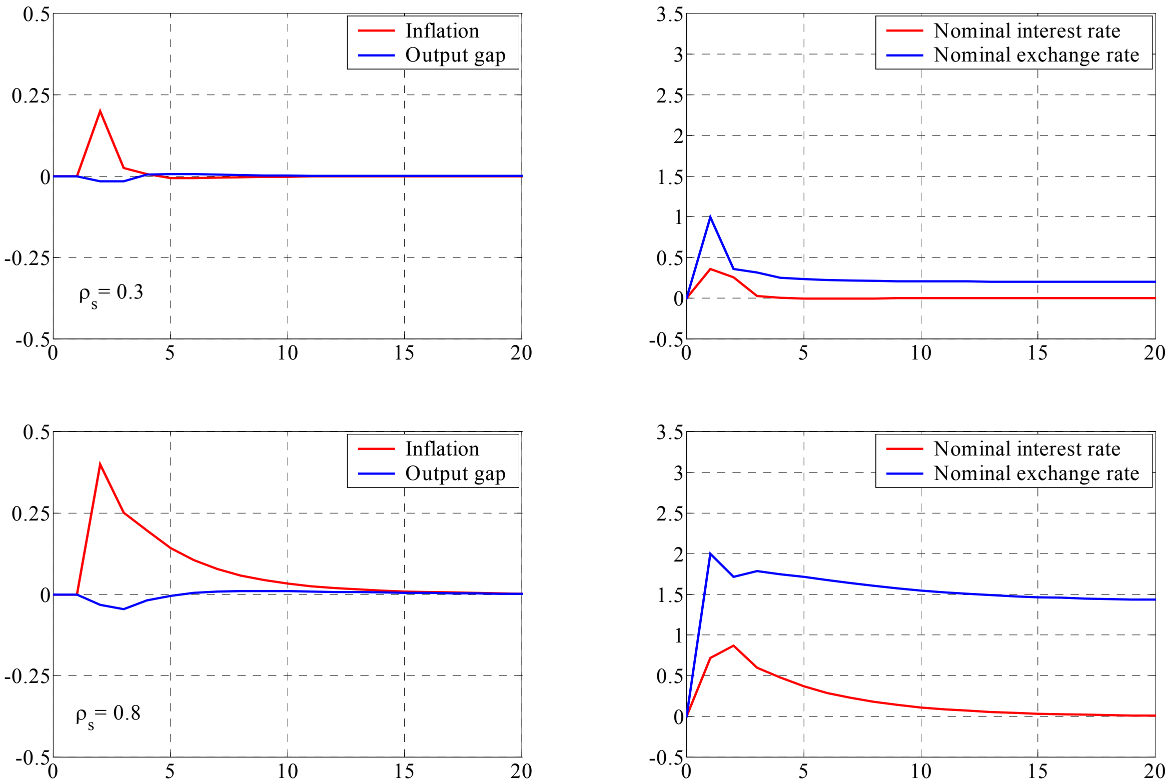
An independently floating central bank reacts to this shock by raising nominal interest rates to counteract the expansionary effects of the depreciation (see Figure V.32). The output gap is sharply reduced to negative levels which helps to bring back inflation to its target level. The cost resulting from this shock stem primarily from a persistent deviation of inflation from its target level. The interest rate response of the indirect managed floating central bank is much less pronounced (see Figure V.33). In the case of a highly persistent UIP shock the advantage of this rule is revealed: due to the specific structure of the interest rate rule the central bank already adjusts its interest rates in period 1. Consequently, the interest rate path is more gradual (see the discussion on the relationship between interest rate smoothing and indirect managed floating in Section IV.1.4.3) and losses in terms of the output gap can be avoided almost altogether. While inflation still exceeds its target for several periods, it returns much faster compared with the situation shown in Figure V.32.

Figure V.32: Persistent UIP shocks under independently floating



Note: The optimal independently floating policy rule is $i_t = 1.89\pi_t + 1.24y_t$.

Figure V.33:Persistent UIP shocks under indirect managed floating



Note: The optimal indirect managed floating policy rule is $i_t = 2.29\pi_t + 1.78y_t + 0.36q_t - 0.23q_{t-1}$.

V.3.2 A welfare comparison of independently/indirect managed floating with direct managed floating

In the discussion of the preceding Figures an important point was made concerning the trade-off between inflation and output. While economists today widely agree upon the fact that there is no such trade-off in the long-term (see e.g. Taylor, 1998, for a recent paper), this conclusion is no more apparent in the short-term. A short look back to our Phillips curve in equation (V.44) gives a straightforward explanation: it is perfectly accelerationist. In other words there is no possibility that output can be raised permanently above its trend growth rate without accelerating rates of inflation. Thus, in the long-term the Phillips curve is vertical, though in the short-term an important trade-off exists between the variances of inflation and output leading to a 'second order' Phillips curve which is not vertical anymore but convex to the origin (Taylor, 1979a). In order to bring back, say, a positive inflation to its target level after a shock the central bank temporarily dampens economic activity by raising interest rates (such a situation is best illustrated in the case of a supply shock; see Figure V.20, Figure V.21, Figure V.27 and Figure V.28). Thus, it deliberately accepts an increase in the variance of the output gap in order to reduce the variance of inflation. The central bank's concrete decision about the desired combination of inflation variance and output variance crucially depends on the relative weight the policymakers put on inflation versus output stabilisation in their intertemporal loss function. Varying the preferences from one end of the spectrum (full inflation stabilisation) to the other end (full output stabilisation) and calculating for each preference type the set of efficient combinations of inflation variance and output variance defines the so-called policy frontier.

The term policy frontier already indicates that the attainable combinations are a function of the policy rule chosen by the central bank. Thus, in order to compare the performance of several classes of policy rules, we computed the policy frontier for each policy rule by tracing out the minimum weighted unconditional variances at different relative preferences for inflation versus output gap variance. Technically speaking, for each of the simple policy rules we performed the following optimisation

(V.66) $$\min_{\langle F^s \rangle} J_0 = \min_{\langle F^s \rangle} \left\{ \lambda_\pi \mathrm{Var}\left[\pi_t\right] + \lambda_y \mathrm{Var}\left[y_t\right] \right\}$$

with $\lambda_\pi / \lambda_y \in \{1/4, 1/3, 1/2, 1, 2, 3, 4\}$. F^s is the vector containing the coefficients of the policy rules for the real and the nominal MCI. The optimised parameters of the two policy rules are summarised in Table V.11. The red line in Figure V.34/Figure V.35 shows the trade-off between the variance of inflation and output resulting from the real/nominal MCI policy rule. By construction, at points on the policy frontier, it is not possible to reduce the variance of inflation without increasing the variance of the output gap. Thus, for a given structure of the policy rule the frontier represents an efficiency locus. The blue line represents the unrestricted optimal policy frontier calculated on the basis of an optimisation under commitment over a grid for λ_π / λ_y from 0.2 to 5 in increments of 0.1. By definition the policymakers cannot attain any combination that is closer to the origin than the blue line. The proximity of the red direct managed floating frontiers to the blue baseline frontier confirms the results shown in the last column of Table V.7 and Table V.8 according to which the loss produced by the MCI rules only slightly exceeds the loss resulting from optimal unrestricted policy under commitment. Moreover, the Figures show that the nominal MCI rule seems to be preferable in the case of a high preference for inflation stability whereas the opposite applies to the real MCI rule. The improvement, however, is rather small.

Table V.11: MCI policy rules

λ_π / λ_y	real MCI			nominal MCI		
	ψ	f_π	f_y	ψ	f_π	f_y
4	0.09	2.01	1.46	0.37	2.77	2.06
3	0.10	1.84	1.43	0.35	2.56	1.98
2	0.12	1.62	1.40	0.31	2.29	1.85
1	0.14	1.27	1.34	0.26	1.91	1.69
1/2	0.16	0.98	1.30	0.22	1.61	1.56
1/3	0.17	0.83	1.27	0.20	1.47	1.49
1/4	0.17	0.73	1.24	0.19	1.39	1.46

Figure V.34: Policy frontiers under direct managed floating (real MCI)

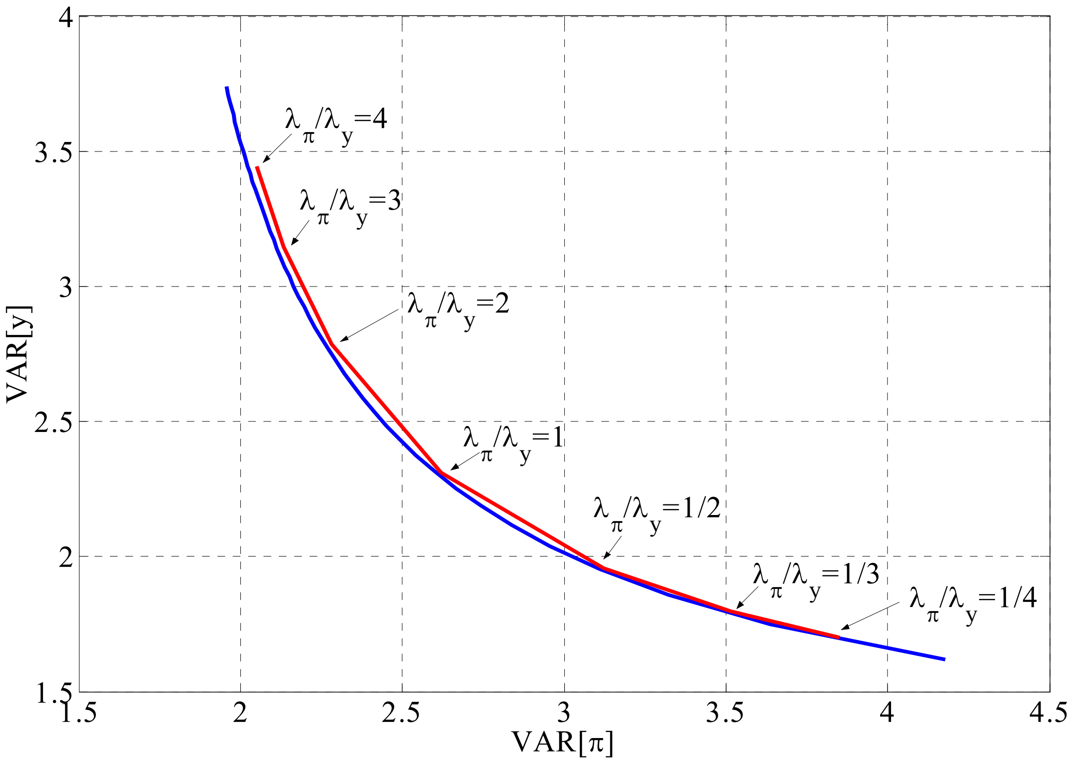
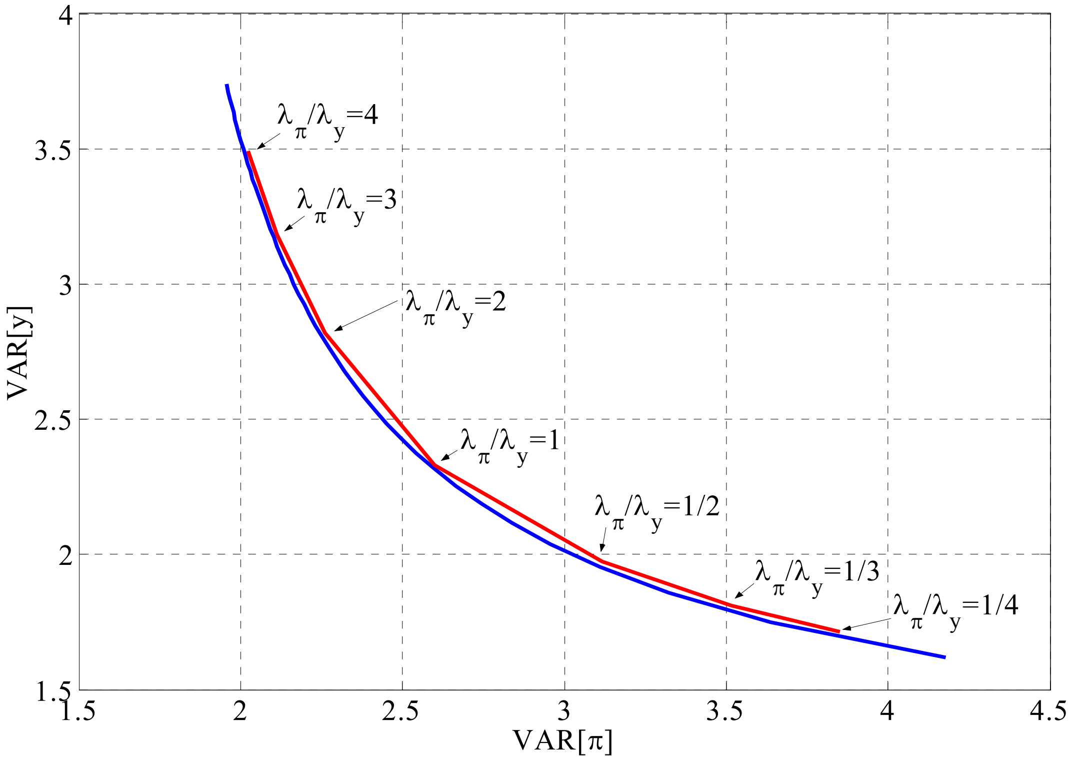


Figure V.35: Policy frontiers under direct managed floating (nominal MCI)



To make a comparison with the attainable trade-off under independently/indirect managed floating exchange rates we optimised the interest rate rules for different pairs of preference parameters under the assumption that the policymakers are certain about the statistical properties of UIP shocks (i.e. for $\rho_s = 0.3$). The resulting coefficients for the policy rules are shown in Table V.12. We then traced out the policy frontiers of the independently floating central bank (see Figure V.36) and the indirect managed floating central bank (see Figure V.37) for both the certainty and the uncertainty case. The blue line represents the frontier under direct managed floating. In accordance with the results obtained in Chapter IV the independently floating central bank that follows an exclusively domestically oriented policy rule clearly performs worse than the indirect managed floating central bank in an environment with uncertain exchange rate movements.[103] Compared to the strategy of direct managed floating both independently floating and indirect managed floating result in a higher variance of the goal variables – irrespective of

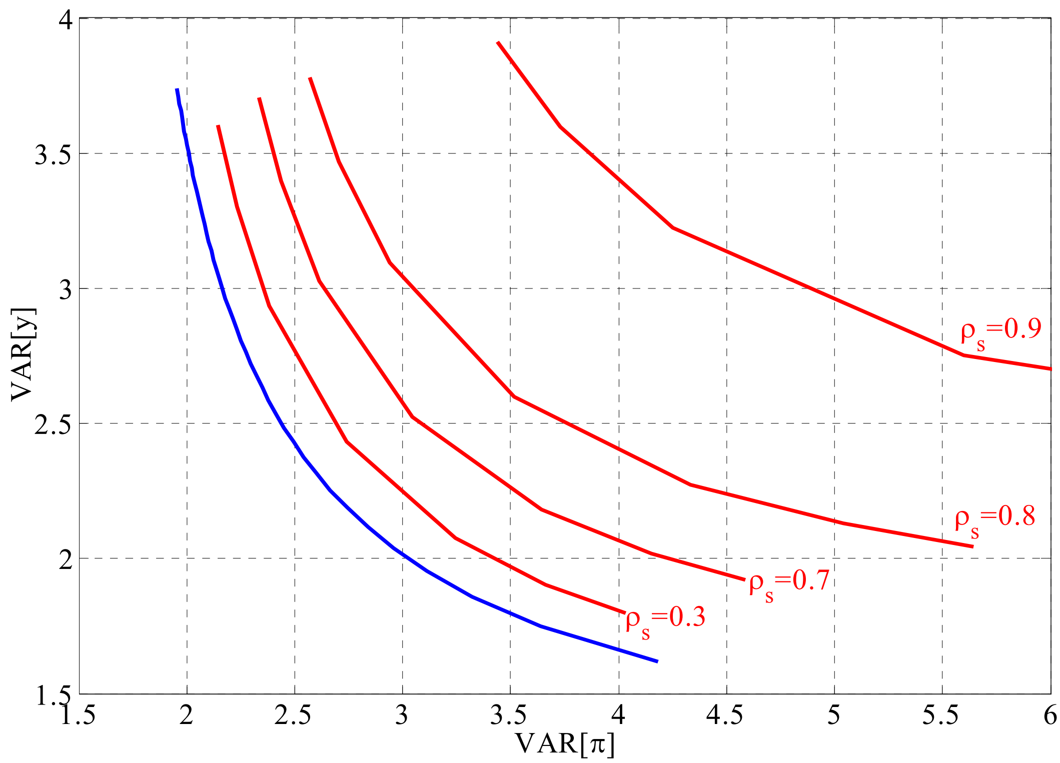
[103] If ρ_s takes a value of 0.9 under an independently floating central bank the variance of inflation rises up to 11.3 for $\lambda_\pi / \lambda_y = 1/4$ while the variance of the output gap slightly falls to 2.4. We don't show that part of the policy frontier to make the results more comparable with the other strategies shown in Figure V.34, Figure V.35 and Figure V.37.

the central bank's relative preferences. It is interesting to see however that for a central bank putting a high weight on output stabilisation the benefit from intervening in the foreign exchange market decreases considerably for a indirect managed floating central bank – even in the case of a high degree of exchange rate uncertainty.

Table V.12: Policy rules under independently floating and indirect managed floating

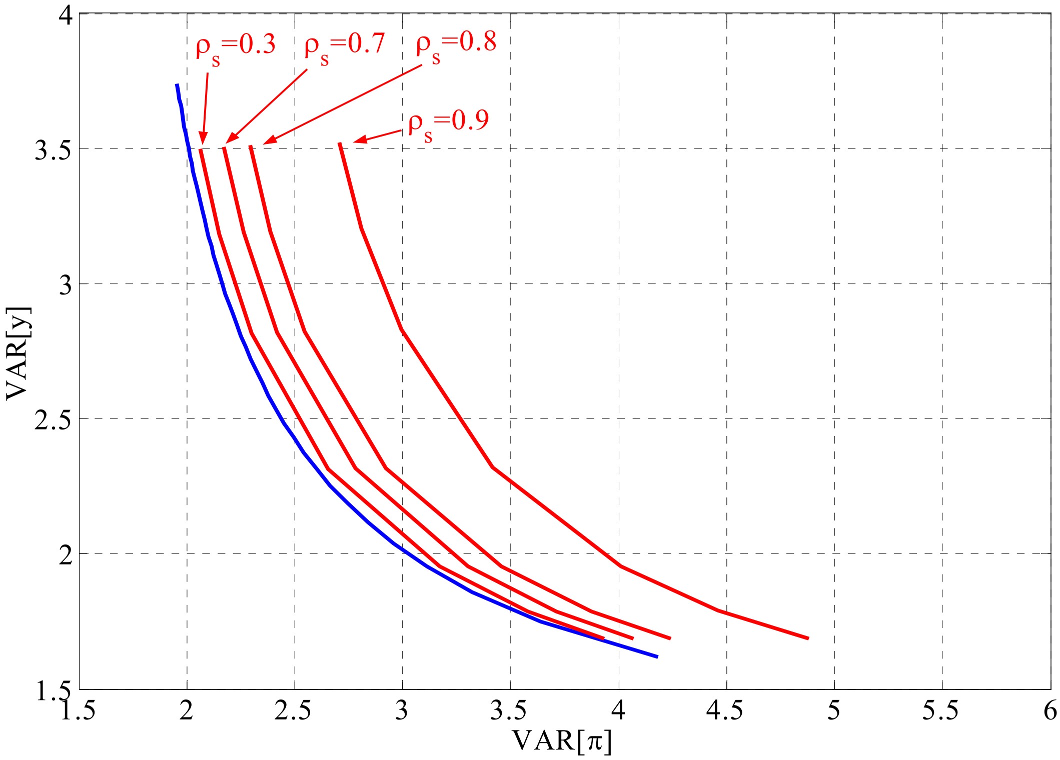
λ_π / λ_y	$i_t = f_\pi \pi_t + f_y y_t$		$i_t = f_\pi \pi_t + f_y y_t + f_q q_t + f_{q(-1)} q_{t-1}$			
	f_π	f_y	f_π	f_y	f_q	$f_{q(-1)}$
4	2.54	1.36	3.19	2.11	0.4	-0.38
3	2.39	1.33	2.97	2.02	0.39	-0.34
2	2.19	1.29	2.70	1.93	0.38	-0.30
1	1.89	1.24	2.29	1.78	0.36	-0.23
1/2	1.66	1.21	1.97	1.67	0.35	-0.18
1/3	1.54	1.19	1.82	1.63	0.35	-0.16
1/4	1.47	1.19	1.72	1.59	0.34	-0.14

Figure V.36: Policy frontiers under independently floating with consideration of exchange rate uncertainty



The costs of market determined exchange rates (either in independently floating or in indirect managed floating systems) consist in the social loss – expressed in terms of output and inflation volatility – that is caused by the unpredictability of the true relationship between interest rates and exchange rates on the international financial markets. Direct managed floating clearly provides a better outcome than purely market determined exchange rates. Of course this result only holds if foreign exchange market interventions do not cause any additional costs. But as long as the central bank implements its direct managed floating strategy according to the rules presented in Section V.1 of this Chapter (in particular the zero-cost-condition derived in Section V.1.4.2) the benefit provided by this strategy is indeed a 'free lunch'.

Figure V.37: Policy frontiers under indirect managed floating with consideration of exchange rate uncertainty



Appendix to Chapter V

V.A State-space representation of the model with a nominal MCI as control variable

In Section V.2 we defined the nominal MCI as

(V.67) $$MCI_t = i_t - \psi \Delta s_t .$$

Using the definition of the real exchange rate (see equation (V.47)) we can rewrite the MCI as follows:

(V.68) $$MCI_t = i_t - \psi\left(q_t - q_{t-1} + \pi_t\right).$$

Solving (V.68) for i_t

(V.69) $$i_t = MCI_t + \psi\left(q_t - q_{t-1} + \pi_t\right)$$

gives an expression containing variables (namely q_{t-1} and π_t) that are not part of the original vector x_{t+1}:

(V.70) $$x_{t+1} = Ax_t + Bi_t + \varepsilon_{t+1}$$

(V.71) $$\begin{pmatrix} r^f_{t+1} \\ u^s_{t+1} \\ \pi_{t+1} \\ y_{t+1} \\ q_t \\ i_t \\ E_t q_{t+1} \end{pmatrix} = \begin{pmatrix} \rho_f & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \rho_s & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & \gamma_y & -\gamma_q & 0 & \gamma_q \\ 0 & 0 & \beta_i & \beta_y & 0 & 0 & \beta_q \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & -1 & -1 & -\gamma_y & \gamma_q & 0 & 1-\gamma_q \end{pmatrix} \begin{pmatrix} r^f_t \\ u^s_t \\ \pi_t \\ y_t \\ q_{t-1} \\ i_{t-1} \\ q_t \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \\ 0 \\ -\beta_i \\ 0 \\ 1 \\ 1 \end{pmatrix} i_t + \begin{pmatrix} \varepsilon^f_{t+1} \\ \varepsilon^s_{t+1} \\ \varepsilon^\pi_{t+1} \\ \varepsilon^y_{t+1} \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

Thus, we extend the system by two identities (the italicised variables and coefficients show the modification compared to (V.71)) to

$$\text{(V.72)}\qquad \begin{pmatrix} r^f_{t+1} \\ u^s_{t+1} \\ \pi_{t+1} \\ y_{t+1} \\ q_t \\ i_t \\ \pi_t \\ q_{t-1} \\ E_t q_{t+1} \end{pmatrix} = \begin{pmatrix} \rho_f & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \rho_s & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & \gamma_y & -\gamma_q & 0 & 0 & 0 & \gamma_q \\ 0 & 0 & \beta_i & \beta_y & 0 & 0 & 0 & 0 & \beta_q \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & -1 & -1 & -\gamma_y & \gamma_q & 0 & 0 & 0 & 1-\gamma_q \end{pmatrix} \begin{pmatrix} r^f_t \\ u^s_t \\ \pi_t \\ y_t \\ q_{t-1} \\ i_{t-1} \\ \pi_{t-1} \\ q_{t-2} \\ q_t \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \\ 0 \\ -\beta_i \\ 0 \\ 1 \\ 0 \\ 0 \\ 1 \end{pmatrix} i_t + \begin{pmatrix} \varepsilon^f_{t+1} \\ \varepsilon^s_{t+1} \\ \varepsilon^\pi_{t+1} \\ \varepsilon^y_{t+1} \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

that can be summarised by

$$\text{(V.73)}\qquad \tilde{x}_{t+1} = \tilde{A}\tilde{x}_t + \tilde{B}i_t + \tilde{\varepsilon}_{t+1}\,.$$

Expressing the endogenous variables in (V.69) as a function of the state vector x_t then gives

$$\text{(V.74)}\qquad i_t = MCI_t + \psi\left(\tilde{A}_5\tilde{x}_t - \tilde{A}_8\tilde{x}_t + \tilde{A}_7\tilde{x}_t\right) = MCI_t + \psi\left(\tilde{A}_5 - \tilde{A}_8 + \tilde{A}_7\right)\tilde{x}_t$$

where $\tilde{A}_i$ is a $1\times n$ row vector containing the elements of the i-th row of matrix $\tilde{A}$. We can now rewrite the state-space representation of our economy by substituting i_t in (V.72) for (V.74):

$$\text{(V.75)}\qquad \begin{aligned} \tilde{x}_{t+1} &= \tilde{A}\tilde{x}_t + \tilde{B}\left[MCI_t + \psi\left(\tilde{A}_5 - \tilde{A}_8 + \tilde{A}_7\right)\tilde{x}_t\right] + \tilde{\varepsilon}_{t+1} = \\ &= \left[\tilde{A} + \psi\tilde{B}\left(\tilde{A}_5 - \tilde{A}_8 + \tilde{A}_7\right)\right]\tilde{x}_t + \tilde{B}\,MCI_t + \tilde{\varepsilon}_{t+1} = \\ &= \tilde{A}^{MCI}\tilde{x}_t + \tilde{B}\,MCI_t + \tilde{\varepsilon}_{t+1}. \end{aligned}$$

The vector of target variables which is originally given by

$$\text{(V.76)}\qquad \tilde{z}_t = \tilde{C}_x\tilde{x}_t + C_i i_t$$

becomes

(V.77) $$z_t = \left[\tilde{C}_x + \psi C_i \left(\tilde{A}_5 - \tilde{A}_8 + \tilde{A}_7\right)\right]\tilde{x}_t + C_i i_t$$

after inserting (V.74) into (V.76). Note that due to the extension of the state vector from x_t to $\tilde{x}_t$ the matrix $\tilde{C}_x$ has the following form:

(V.78) $$\tilde{C}_x = \begin{pmatrix} 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 \end{pmatrix}.$$