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Theories on the Scope for Foreign Exchange Market Intervention

By Geert J. Almekinders*, Tilburg

I. Introduction

During the period 1985 - 1990 the world's foreign exchange markets experienced recurrent strains. The central banks of the main industrialized countries reacted by intervening in the foreign exchange markets on a scale not seen since the demise of the Bretton Woods system of fixed exchange rates in 1973. This has led to a renewed interest in studying the scope for central bank foreign exchange market intervention. Recent empirical investigations into the objectives and effectiveness of foreign currency operations by central banks are surveyed in *Almekinders* and *Eijffinger* (1991) and *Edison* (1993). This article traces out recent developments in modeling foreign exchange market interventions. It does not address the question of whether central bank intervention is desirable (cf. *Pilbeam* 1991, ch. 1). Instead it starts from the assumption that central bank intervention is a given feature of foreign exchange markets. The central question is whether and how intervention is able to influence the course of the exchange rate. As a consequence, no attention is paid to exchange rate management as an instrument of (domestic income) stabilization policy (*Marston* 1985, *Pilbeam* 1991, ch. 2 and *Alogoskoufis* 1994).

The remainder of this article is organized as follows. Section II provides a definition of exchange market intervention and introduces the concept of sterilization. Section III and IV set out the channels of influence of unsterilized and sterilized intervention in the well-established models of exchange rate determination depicted in the left-hand column of Table 1.[1] Furthermore, the mechanics of foreign exchange market

* Parts of this paper appear in *Almekinders* (1995). I wish to thank *Sylvester Eijffinger* and *Jacques Sijben* for helpful comments on an earlier draft. My appreciation does not implicate them for errors either of omission or commission that remain in this paper.

[1] For detailed surveys of exchange rate theories see *Visser* (1991, ch. 7 and ch. 8), *MacDonald* and *Taylor* (1992), *Baltensperger* (1992) and *Pentecost* (1993).

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intervention in the studies shown in the two right-hand columns of Table 1 are analysed. Section V discusses some alternative approaches to the study of foreign exchange intervention. Section VI concludes.

Table 1

Representative Exchange Rate Models and Some Selected "Intervention" Studies

Exchange rate model	Non-sterilized intervention	Sterilized intervention
Purchasing Power Parity		
Mundell-Fleming Model	Black (1985)	Black (1985)
Flex-price Monetary Model		
Sticky-price Monetary Model	Djajic & Bazzoni (1992)	Natividad & Stone (1990)
Portfolio Balance Model	Moreno & Yin (1992)	Masson & Blundell-Wignall (1985)
Stock-Flow Portfolio Model		

II. Intervention and Sterilization: The Basics

I define an exchange market intervention as a sale or a purchase of foreign currency by the domestic monetary authorities aimed at changing the exchange rate of the domestic currency *vis-à-vis* one or more foreign currencies. An important distinction is to be made between unsterilized or 'monetary' interventions and sterilized or 'pure' interventions. The effect of both types of intervention will be illustrated by pointing to the changes in the balance sheet of the central bank and the private sector each brings about.

A stylized balance sheet of the domestic central bank reflects that the monetary base of the domestic country (*MB*), which consists of total domestic currency in circulation and the reserves of the private banking system, is equal to the sum of net foreign assets (*NFA*) and domestic assets (*DA*) in the hands of the domestic central bank.

Balance sheet of the domestic central bank

Assets	Liabilities
Net foreign Assets (*NFA*)	**Monetary Base** (*MB*)
Gold	Total currency in circulation
Foreign currency	Reserves of the private banking system
SDR	
Net position in IMF	
Domestic Assets (*DA*)	
Government securities	
Loans to commercial banks	

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A purchase (sale) of foreign currency by the domestic central bank from the domestic private sector leads to a direct increase (decrease) in the domestic money supply. In terms of changes in the above balance sheet's entries: $\Delta MB = \Delta NFA$.[2]

Nowadays, the main industrialized countries implement monetary policy based on the control of some monetary aggregate. The monetary authorities of these countries do not want exchange rate policy to interfere with monetary policy. Thus, the domestic central bank may attempt to adhere to a preannounced target for the growth rate of some monetary aggregate. To do so, it can sterilize the effect of the initial exchange market intervention by selling long-term domestic assets denominated in domestic currency, say government bonds, from its openmarket portfolio to the domestic private sector leaving the domestic monetary base, *ceteris paribus,* unchanged in spite of the initial purchase of foreign currency. The effect of the exchange market intervention on the monetary base is completely neutralized when $\Delta DA = -\Delta NFA$ in the balance sheet of the domestic central bank.

Obviously, in the end, there is no difference between domestic monetary policy on the one hand and unsterilized intervention on the other hand.[3] For that reason, it is often argued that unsterilized intervention amounts to using the foreign exchange market to conduct monetary policy in lieu of the domestic financial market. I opt for a more positive approach of unsterilized intervention. While in general the effect of central bank intervention on the reserve position of domestic commercial banks is sterilized routinely, more emphasis on limiting exchange rate volatility in the formulation of monetary policy will most likely be reflected in a lower degree of sterilization. Therefore, I find it useful to

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2 The exact implications of an operation in foreign currency by the domestic central bank depend on who is the counterpart in the transaction. For instance, a distinction can be made between the domestic commercial banking system and the domestic non-bank private sector. Obviously, in theoretical models without a fractional reserve private banking system this distinction is not relevant. The present paper does not elaborate on the international implications of interventions undertaken by the domestic central bank. According to most standard expositions on foreign exchange intervention official transactions only affect the balance sheets of the domestic central bank and those of the domestic private sector. As clearly put forward by *Weber* (1986), *Belongia* (1992) and *Humpage* (1994) intervention conducted by the domestic central bank almost necessarily involves the actions of the foreign central bank.

3 Domestic monetary policy typically involves the same change in the domestic monetary base brought about by the central bank via an open market purchase or sale of domestic government securities ($\Delta MB = \Delta DA$).

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review the possibilities and limitations of unsterilized intervention working through what *Humpage* (1986) calls the *monetary channel.*

When the monetary authorities take action to neutralize the money market effect of the initial purchase of foreign currency this monetary channel is ruled out. However, changes in the domestic central bank's balance sheet imply that sterilized or 'pure' intervention involves an exchange of foreign currency denominated securities in return for government bonds denominated in domestic currency. In a closed financial system, the domestic private sector experiences the reverse swap of assets in its portfolio. Thus, the currency composition of the domestic private sector's portfolio of investments changes. Below it will be analysed whether and how this forced change in the currency composition of private investors' portfolios has repercussions on the course of the exchange rate through a *portfolio channel.*

III. The Flow Approach to Exchange Rate Determination

1. Purchasing power parity

Since long it has been recognized that purchasing power parity (PPP) and hence the relative price of national outputs provides the international financial system with a long term anchor for exchange rate movements. The absolute version of purchasing power parity relates the exchange rate of the foreign currency in terms of domestic currency to overall price levels in the domestic and foreign country. It is an extension of the well-known Law of One Price to general price levels. Accordingly, goods arbitrage equalizes the market exchange rate to the purchasing power parity rate given by equation (1). Relative purchasing power parity is simply the concept of absolute PPP expressed in growth rates. It asserts that the value of foreign currency in terms of domestic currency tends to rise at a rate equal to the difference between domestic and foreign inflation (equation (2)).[4]

[4] In general, the short-run validity of purchasing power parity is rejected in empirical tests (for a recent survey, see *Giovannetti* (1992)). This is because in practice short-term capital flows swamp the trade balance of the balance of payments. Thus, short-term exchange rates are set in financial markets rather than in goods markets. Currency prices fluctuate minute by minute. Price levels, in contrast, are sticky and adjust slowly. With exchange rates moving more quickly than goods prices, deviations from PPP will arise. Therefore, exchange rates can persistently deviate from their purchasing power parity-implied values.

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Purchasing power parity as a theory of exchange rate determination

(1)	$S_t = P_t / P_t^*$	absolute purchasing power parity
(2)	$\dot{S}_t = \dot{P}_t - \dot{P}_t^*$	relative purchasing power parity
(3)	$M_t^{(*)} V_t^{(*)} = P_t^{(*)} Y_t^{(*)}$	quantity theory of money
(4)	$\dot{S}_t = (\dot{M} - \dot{M}^*)_t + (\dot{V} - \dot{V}^*)_t - (\dot{Y} - \dot{Y}^*)_t$	solution for the exchange rate

where S, P, M, V and Y are the exchange rate (measured as domestic currency units per unit of foreign currency), the price level, the quantity of money supplied, the income velocity of money and real income, respectively. Subscript t denotes time. An asterisk $(^*)$ indicates that the variable refers to the same variable in the foreign country. A dot over a variable denotes a percentage change.

A further expression for the percentage change in the domestic currency value of foreign exchange can be obtained by combining the PPP approach with the Quantity Theory of Money for both the home and the foreign country (equation (3)). With the income velocity of money and the level of real income unchanged, an increase in the domestic money supply will be reflected in higher domestic prices. Hence, the depreciation of the domestic currency (rise in S_t) implied by equation (4). As a direct consequence it follows that an unsterilized intervention will in the long run, *ceteris paribus,* influence the level of the exchange rate. By contrast, a pure intervention which, by definition, lacks a money market effect leaves the exchange rate unaffected.

2. The Mundell-Fleming model

a) The standard Mundell-Fleming model and intervention

Particularly since the collapse of the Bretton Woods system of fixed but adjustable exchange rates a lot of efforts have been devoted to investigate the determinants of short-term fluctuations in the exchange value of foreign currencies. Initially, most of these investigations were carried out along the lines of the Mundell-Fleming model. *Mundell* (1963) and *Fleming* (1962) are seminal articles exploring the possibilities and effects of monetary and fiscal policy under fixed and flexible exchange rates. They were written at a time when the Bretton Woods fixed exchange rate system was still operative. The theoretical framework underlying the analysis in the two studies has become known as the Mundell-Fleming model. Although it is not the primary aim of this model to explain

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exchange rate movements, it represents an authoritative formulation of the flow approach to exchange rate determination.[5]

Central to the Mundell-Fleming model when looked at as a theory of exchange rate determination is the balance of payments equilibrium condition. It states that with freely floating exchange rates the net volume of foreign currency flowing through the current account and the capital account sums up to zero. The basic model assumes static expectations. With the expected exchange rate depreciation equal to zero, a return differential between domestic and foreign bonds and hence net international capital flows can only arise through a difference between the domestic rate of interest and the given world interest rate.

Imagine the domestic economy is initially in equilibrium. In section II it was established that an unsterilized purchase of foreign currency from the domestic private sector conducted by the domestic central bank increases the domestic money supply. Although the domestic interest rate is *de facto* fixed at the foreign level due to the assumed perfect international capital mobility, this can be thought of as causing an incipient decline in the domestic interest rate which in turn leads to a capital outflow and a lower value of the domestic currency.

In section II it was established that a pure intervention results in a change in the currency composition of the private sector's nominal financial wealth but not in its volume. As bonds denominated in different currencies are perfect substitutes in the Mundell-Fleming model the altered currency composition does not have any effect on the exchange rate.

b) (Un)sterilized intervention in Black's (1985) flow model

Not every author surrenders to the apparent ineffectiveness of sterilized intervention in flow models of the exchange rate. With the benefit of hindsight *Black* (1985) combines some selected building blocks of the various models of exchange rate determination which survived in empirical testing. Black argues that, in general, empirical evidence is not supportive of short-run PPP (see also footnote 4) and perfect substitutability of assets denominated in different currencies. He assumes imperfect substitutability and rational expectations under imperfect information. The author starts out by deriving a short-run stock equilibrium condition for foreign assets. Within a mean-variance framework he arrives at an

[5] For a solid representation of the Mundell-Fleming model, see *Pentecost* (1993, ch. 5).

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expression for the net stock of bonds denominated in foreign currency f_t private investors are willing to hold:

$$(0) \qquad f_t = \beta[(E_t s_{t+1} - s_t) + (i_t^* - i_t)] \qquad \text{with } \beta = \frac{1}{\rho \sigma_{s,1}^2}$$

Accordingly, the willingness of speculators to hold foreign assets depends positively on the expected depreciation of domestic currency $(E_t s_{t+1} - s_t)$ and the excess of the foreign over the domestic interest rate $(i_t^* - i_t)$. It is inversely related to the variability of the exchange rate $\sigma_{s,1}^2$ and the investors' degree of risk aversion ρ. Obviously, the Mundell-Fleming model is concerned with the equilibration of flow-demand and supply for foreign exchange. The first difference of the stock of foreign assets held by speculators in consecutive periods is taken to imply the out*flow* of private capital Δf_t (equation (1)). Equation (2) is the trade balance measured in foreign currency. Equation (3) accounts for changes in central bank reserves. Accordingly, the central bank intervention reaction function consists of a two parts. Firstly, the "leaning against the wind" component $(-\xi_1 (s_t - s_{t-1}))$ reflects that the central bank buys foreign currency (positive value of Δr_t) when the current exchange rate is lower than the exchange rate in the previous period. Secondly, a component capturing intervention aimed at driving the exchange rate closer to the target level $s^T (-\xi_2 (s_t - s^T))$ reflects that the central bank buys foreign currency (positive value of Δr_t) when the current exchange rate is lower than this target level. Equation (4) is the balance of payments equation.

Nonsterilized purchases of foreign currency increase the domestic monetary base and lower the domestic interest rate. In Black's model this leads to additional private purchases of foreign bonds and, hence, to a strenghtening of the initial effect of the central bank's purchases on the balance of supply and demand in the foreign exchange market. However, in Black's view the monetary channel of intervention is not the most interesting one.

The analysis of the effectiveness of sterilized intervention is far from casual. *Black* adheres to the (perhaps heroic) assumption that private speculators have a stabilizing influence on the course of the exchange rate. Therefore, for the purpose of his study it is not the *direct* influence of intervention on the exchange rate that counts. The crucial issue is whether the monetary authorities are able to induce private investors to assume a larger position in foreign currency. Thus, Black is in search of an *indirect* effect of sterilized intervention. As investors are assumed to

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The Mundell-Fleming model amended as in Black (1985)

(1)	$\Delta f_t = \beta [(E_t s_{t+1} - s_t) - (E_{t-1} s_t + s_{t-1}) + \Delta i_t^* - \Delta i_t] + \Delta v_t$	net flow of private capital
(2)	$t_t = \tau (s_t + p_t^* - p_t) + \varepsilon_t$	trade balance
(3)	$\Delta r_t = -\xi_1 (s_t - s_{t-1}) - \xi_2 (s_t - s^T)$	intervention reaction funct.
(4)	$\Delta r_t + t_t + \Delta f_t = 0$	balance of payments

where f_t and r_t are the stock of net foreign assets held by the private sector and the central bank, respectively. Δv_t and ε_t are uncorrelated random disturbance terms with mean zero, constant variance and zero autocorrelation; τ, ξ_1 and ξ_2 are positive constants; lowercase letters refer to natural logarithms of variables; Δ is the first-difference operator with $\Delta x_t = x_t - x_{t-1}$; E_t represents the expectations operator conditional on information available at time t;

be rational they know the equilibrium value of the exchange rate. Thus sterilized interventions are effective if they reduce uncertainty among investors (measured by $\sigma^2_{s,1}$) so as to mobilize stabilizing speculative capital flows.

Based on the model described by the equations (1) - (4), which is quite similar to the one analysed in *Neumann* (1984), *Black* derives certain expressions for the willingness of speculators to bear risk β. It should be noted that the author assumes the foreign interest rate to be constant and, more importantly, that sterilized interventions leave the domestic interest rate unaffected. He concludes that both "leaning against the wind" intervention ($\xi_1 > 0$) and target intervention ($\xi_2 > 0$), the latter provided that the target chosen by the monetary authorities is equal to the purchasing power parity-implied long-run equilibrium value, are effective according to his own definition. Both types of *sterilized* intervention appear to reduce the level of uncertainty about the exchange rate $\sigma^2_{s,1}$ and hence increase the volume of speculators' stabilizing position taking in foreign currency. The underlying mechanism by which this is accomplished remains rather nebulous. Of course, the central bank's transactions in foreign exchange initially have a bearing on the flow equilibrium. The stabilizing impact of the official operations in foreign currency might remove part of the uncertainty among private speculators and hence strengthen the initial effect of the official transaction. However, the central bank is only a minor participant on the market for foreign exchange. A huge amount of intervention may be required to convince private market participants. Then, sterilization involves voluminous offsetting open market transactions. For instance, when the central bank initially buys foreign exchange from the domestic non-bank private sector to bring the exchange rate closer to the PPP level from

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below, sales of domestic currency denominated government bonds are required to neutralize the money market effect of the intervention. The price of domestic bonds will decline and the interest rate will go up. Hence, the assumption of constant domestic and foreign interest rates, which is at the heart of the analysis of unsterilized intervention in Black (1985), seems to be questionable.

IV. The Asset Market Approach to Exchange Rate Determination

1. Introduction

The flow analysis according to Mundell-Fleming views the exchange rate as the relative price of national outputs. The enormous growth of financial markets turnovers in general and the surge in short-term international capital flows in particular cause a country's current account of the balance of payments to be swamped by the capital account. While short-term exchange rates are set in financial markets rather than in goods markets, the exchange rate is more and more viewed as an asset price which is equal to the price of one national money in terms of another. Furthermore, according to this approach exchange rate changes are not caused by shifts in the typical demand and supply schedules for foreign exchange because of real transactions; changes in the perception of the market as a whole with regard to the value of one currency *vis-à-vis* one or more other currencies are the crucial factor.

2. The flexible-price monetary model

One branch of asset market models of exchange rate determination assumes that wealth holders are indifferent as to the proportions of domestic and foreign currency denominated assets in their portfolios given that they yield the same return expressed in one currency. In other words, portfolio shares are infinitely sensitive to changes in expected rates of return. Hence, the perfect substitutability hypothesis implies that otherwise identical bonds denominated in different currencies can be viewed as one homogeneous asset. It follows that under risk-neutrality uncovered interest parity prevails (equation (3)) and the world bond market always clears instantaneously. Furthermore, purchasing power parity is assumed to hold continuously (equation (4)). This implies that the real exchange rate and, thus, the relative price of domestic and foreign goods is constant over time due to perfect international arbitrage on

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the goods market. Consequently, in the flexible-price monetary exchange rate model demand and supply conditions on the markets for goods and bonds are irrelevant; in the short run a bilateral exchange rate is determined by the requirement of money market equilibrium in the two countries involved whereby it is assumed that residents of each country hold only their own money (equations (1) and (2)).

The flexible-price monetary model

(1)	$m = p + \phi y - \lambda i$	home money market equilibrium
(2)	$m_t^* = p_t^* + \phi^* y_t^* - \lambda^* i_t^*$	foreign money market equilibrium
(3)	$i_t = i_t^* + E_t[s_{t+1}] - s_t$	uncovered interest parity
(4)	$s_t = p_t - p_t^*$	purchasing power parity
(5)	$s_t = \frac{1}{1+\lambda} \sum_{i=0}^{\infty} [\frac{\lambda}{1+\lambda}]^i E_t [(m_{t+i} - m_{t+i}^*) - \phi(y_{t+i}^* - y_{t+i})]$	solution for the exchange rate[6]

where ϕ and λ are the elasticity and the semi-elasticity of money demand with respect to income and the interest rate, respectively. Here these are assumed identical for both countries.

Under the assumption of flexible prices, the equations (1) - (4) can be solved for the exchange rate to arrive at equation (5). It states that the bilateral nominal exchange rate depends on the current and expected future values of relative money supplies and relative outputs in both countries. Thus, the flex-price monetary approach to the exchange rate predicts that an unsterilized purchase of foreign bonds from the domestic non-bank private sector conducted by the domestic central bank leads to a rise in the domestic currency price of foreign exchange. The purchase of foreign bonds causes the domestic money supply to increase. Through equation (1), the inherent excess supply of money is wiped out by an instantaneous rise in the domestic price level. Equation (4) implies that the domestic currency price of foreign exchange goes up as a consequence of the initial unsterilized purchase of foreign bonds.

Furthermore and perhaps more surprisingly, based on the expression in (5) some authors argue that sterilized intervention can be expected to alter the current exchange rate through what is called the *expectations channel of intervention*. Sterilized intervention can provide private exchange market participants with new information or a signal about the future course of monetary policy. The "signalling hypothesis" was

[6] For a lucid exposition on the derivation of this solution for the exchange rate in the monetary model with rational expectations, see *Visser* (1991, p. 121 - 124).

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first proposed by *Mussa* (1981). Accordingly, a sterilized purchase of domestic currency from the domestic private sector may signal an expansionary *future* domestic monetary policy. The expectations of future looser domestic monetary policy will make the domestic currency depreciate and hence the exchange rate go up, even though the initial intervention's money market effect is neutralized in the short-run (see equation (5)).

The relevance of the signalling or expectations channel of sterilized intervention is not undisputed. Private exchange market participants will only pay attention to the signal embodied in the sterilized intervention when a stable relationship has emerged with interventions leading changes in monetary policy aimed at some exchange rate objective. Whether this stable relationship exists and whether private exchange market participants pay attention to it is an empirical issue.[7] More importantly, for the signalling hypothesis to be valid central banks have to back up interventions with subsequent changes in monetary policy. In other words, current sterilized interventions pre-determine the path of future money growth and hence interfere with monetary policy. The neutralization of the initial intervention's money market effect is limited to the short run. This no longer meets the definition of sterilized intervention given above exactly.

3. *The sticky-price monetary model*

a) The standard sticky-price monetary model and intervention

The assumptions underlying the flexible-price monetary model are not compatible with the persistent rejection of purchasing power parity in empirical tests (see footnote 4). *Dornbusch* (1976) amends the flex-price monetary model to take account of this empirical regularity. In the resulting sticky-price monetary model goods prices initially do not respond to disturbances of the goods market equilibrium.[8] With the

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[7] *Klein* and *Rosengren* (1991) use newspaper reports on dollar intervention by the United States and Germany. They find that interventions did not precede changes in monetary policy and periods of active intervention were not followed by monetary policy changes. *Kaminsky* and *Lewis* (1993) strongly reject the hypothesis that interventions convey no signal. However, they also find that in some episodes, intervention signalled changes in monetary policy in the opposite direction of the conventional signalling story.

[8] A theoretical explanation for this phenomenon can be found in *Okun* (1981). He distinguishes customer markets from auction markets. The market for domes-

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abandonment of short-run purchasing power parity, an equation to explain the evolution of the price level is required. Dornbusch assumes that the price level adjusts in proportion to excess demand. This process continues until (long-run) purchasing power parity is restored.

The classical exercise in the Dornbusch-model analyses the effect of a monetary expansion in the domestic country. This happens to be compatible with an unsterilized purchase of foreign currency by the domestic central bank. In the short run, with domestic prices still unchanged, the increase in real money balances induces a decline in the domestic interest rate. This is the immediate liquidity effect of the initial unsterilized purchase of foreign currency. The money market effect of this intervention makes investors expect a long-run depreciation of the domestic currency. The decline in the domestic interest rate *plus* the expected depreciation of domestic currency seriously detract from the relative attractiveness of domestic bonds. Speculators want to be compensated for *both* factors. Consequently, the instantaneous restoration of goods and money market equilibrium after the monetary shock requires the exchange rate to overshoot its long-run value. The initial real depreciation (the exchange rate rises while domestic goods price remains constant) and the lower domestic interest rate increase the demand for domestic goods. This causes domestic prices to rise and the economy gradually moves to the new equilibrium. In sum, with the price level sticky, the system can not jump to the new long-run equilibrium. Instead, the exchange rate jumps, placing the domestic economy onto the stable path to the new long-run equilibrium. Along this path the domestic price level rises and the exchange rate falls.

The effectiveness of foreign exchange market intervention in both the flexible-price and the sticky-price monetary model depends crucially on its money market effect. Once this is neutralized not a single economic variable in the model is affected by the intervention operation. For instance, offsetting open market sales of domestic currency denominated government bonds carried out to sterilize the money market effect of an initial purchase of foreign currency lead to an incipient rise in the domestic interest rate. As otherwise identical bonds denominated in different currencies are perfect substitutes, the demand for domestic currency

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tic goods is a customer market on which the price is the result of an ongoing relationship between buyer and seller. Therefore it is costly to change this price. Money and bonds are traded in auction markets on which buyers and sellers are more or less anonymous. Moreover, market participants are used to prices changing in real time.

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denominated government bonds is perfectly elastic. The domestic interest rate does not have to rise for investors to be willing to hold the additional supply of these bonds. Put differently, when the economy is initially in a steady state the expected change in the exchange rate is zero. Consequently, the current exchange rate is equal to its long-run equilibrium value. Due to the lack of a money market effect, pure interventions do not alter the long-run equilibrium exchange rate. Hence pure interventions preserve a zero expected exchange rate change. Then, uncovered interest parity implies that interest rates at home and abroad have to remain equal.

b) Unsterilized intervention in Djajic and Bazzoni's (1992) sticky-price model

The effectiveness of monetary intervention in the sticky-price monetary model is undisputed. *Djajic* and *Bazzoni* (1992) modify *Dornbusch'* (1976) model to include a rule governing unsterilized foreign exchange market intervention (equation (1)). This rule describes the reaction pattern of the monetary authorities in response to shocks to the exchange rate. Accordingly, the domestic money supply is brought down below its pre-disturbance level m_0 in response to a depreciation of the domestic currency which has raised the exchange rate above its pre-disturbance level s_0. The extent of the monetary contraction is reflected by the value of the constant ω which is a policy-determined coefficient. Obviously, the polar cases $\omega = 0$ and $\omega = \infty$ are compatible with freely floating exchange rates and fixed exchange rates, respectively. Agents are assumed to be risk neutral, to know the structure of the model and to form their expectations rationally (equation (3)). Accordingly, the actual rate of depreciation $\dot{s}_t$ equals the expected rate of depreciation of domestic currency ($\dot{s}_t^e$). Hence, the uncovered interest parity condition can be written as in equation (4). With output fixed at the full employment level y, the change in the price level is given by equation (5), where ν is a shift parameter which reflects commodity-market disturbances.

Unsterilized intervention in Djajic and Bazzoni's (1992) sticky-price model

(1)	$m = m_0 - \omega\,(s - s_0)$	$0 \leq \omega \leq \infty$	intervention rule
(2)	$m = p + \phi y - \lambda i$		money market equilibrium
(3)	$\dot{s} = \dot{s}^e$		rational expectations
(4)	$i = i^* + \dot{s}^e$		uncovered interest parity
(5)	$\dot{p} = \pi\,(d - y) = \pi\,[\delta\,(s - p) + (\gamma - 1)\,y - \sigma\,i + \nu]$		goods price dynamics

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From the discussion of monetary intervention in the previous section, it is rather straightforward that the greater the magnitude of unsterilized "leaning against the wind" intervention, the greater the extent to which pressures on the domestic currency to fall (rise) in value, in response to, for example, an increase (decrease) in the foreign interest rate, are absorbed through a reduction in (an expansion of) the domestic money supply rather than a depreciation (an appreciation) of the domestic currency. Put differently, a move away from fixed exchange rates (i.e., a lower value of ω) allows for greater stability of monetary aggregates.

Djajic und *Bazzoni* stress that these are long-run considerations. They analyse the dynamic properties of the system in (1) - (5) for different values of ω, the parameter capturing the degree of "leaning against the wind" intervention. Rather than analysing short-run exchange rates over- or undershooting their long-run value, focus is on the evolution over time of the money stock as a function of ω, the degree of "leaning against the wind" intervention.

The crucial assumption in the Dornbusch model is that asset markets and exchange rates adjust fast relative to the goods market and the price of domestic output. A direct consequence of this assumption is that, in the face of shocks impinging on the domestic economy, jumps in the exchange rate are required to achieve short-run equilibrium in the goods and assets markets. It is not very likely that these jumps in the exchange rate are compatible with the objectives of the monetary authorities. Hence, intervention is called for. *Djajic* and *Bazzoni* examine the economy's adjustment to both a goods-market and an asset-market disturbance.

Initially, the economy is in a steady state. Consider the effect of an increase in the demand for exports, reflected by an increase in ν in equation (5). Firstly, under freely floating exchange rates the increased demand for exports simply leads to an instantaneous appreciation of the domestic currency which lowers exports to their original level. Secondly, in case the monetary authorities pursue a policy of 'leaning against the wind' they will partly resist the rise in the value of the domestic currency. This necessitates a jump in the money supply to bring the economy on the relevant stable path towards the new steady state. Along it, domestic prices rise according to equation (5). The rising price level increases the demand for money. The concomitant rise in the domestic interest rate (equation (2)) results in renewed upward pressure on the value of domestic currency (equations (4) and (5)). Due to the ongoing

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'leaning against the wind' policy this is partly translated into a gradually loosening monetary stance. Thirdly, under fixed exchange rates the increase in the demand for exports will set the economy on a path of gradually rising prices. Along this path to the new steady state the money supply must be increased in proportion to the increase in domestic prices to preserve the fixed exchange rate.

What stands out in the rather counter-intuitive finding of larger *short-run* movements of the nominal money supply under a 'leaning against the wind' policy than under fixed exchange rates. This result seems to be due mainly to the use of an asset market model of exchange rate determination to analyse the effect of a real shock. This is fallacious while in asset market models the exchange rate is essentially viewed as a monetary phenomenon. *Djajic* and *Bazzoni* argue that the increased demand for exports initially leaves the demand for money unaffected. Then, within the Dornbusch model, indeed there is no scope for an appreciation of the domestic currency. I would argue that, to examine the implications of various exchange rate regimes for the short-run effects of goods-market disturbances appropriately, flow models like the Mundell-Fleming model rather than asset market models offer the appropriate framework. In the former models an increased demand for exports will cause an incipient appreciation of the domestic currency. Then, under fixed exchange rates the monetary authorities are obliged to ease the monetary stance immediately after the goods-market shock occurs.

The Dornbusch model does offer an appropriate framework to analyse the implications of various exchange rate regimes for the short-run effects of financial-market disturbances like an increase in the foreign interest rate. The results presented by *Djajic* and *Bazzoni* for this casus are much less powerful and in line with intuition. The positive shock to the foreign interest rate induces a net outflow of capital. This leads to an (incipient) rise in the exchange rate. Official purchases of domestic currency by the domestic central bank lead to an instantaneous contraction of the money supply both under a 'leaning against the wind' rule for intervention *and* under fixed exchange rates.[9] Thus, Djajic and Bazzoni arrive at the plausible result that the reduction in the money supply in

[9] *Djajic* and *Bazzoni* show that for certain parameter values the jump in the money supply is slightly *larger* in case of "leaning against the wind" intervention than in case of fixed exchange rates. In my view this is a technical artefact of the model which defies economic explanation. Furthermore, it is not clear at all whether these parameter values imply a realistic degree of "leaning against the wind" intervention.

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response to an increase in the foreign interest rate is larger under fixed exchange rates than under a regime of managed floating.

c) (Partly) sterilized intervention in Natividad and Stone's (1990) sticky-price model

At the end of section IV.3a it was established that the sticky-price monetary model does not provide any scope for the effectiveness of sterilized interventions. In spite of that it could be of interest to investigate the implications of a varying degree of sterilization. *Natividad* and *Stone* (1990) extend the original Dornbusch model to include separate policy functions for domestic credit and central bank foreign exchange reserves while allowing for variable sterilization. The intervention reaction function (equation (1)) permits exogenous intervention (where a positive value of r_{EX} denotes a purchase of foreign currency by the domestic central bank) and endogenous responses to an observed gap between the contemporaneous and long-run equilibrium real exchange rate. The domestic credit reaction function (equation (2)) allows for exogenous operations (where a positive value of c_{EX} denotes monetary expansion through an open market purchase of domestic currency denominated government bonds by the domestic central bank), endogenous sterilization of a fraction w_1 of the effect of changes in the central bank's foreign exchange reserves and endogenous attempts to smooth deviations of the interest rate from its long-run equilibrium value. Equation (3) states that base money and, thus, the money supply is equal to the sum of domestic assets (c) and net foreign assets in the hands of the central bank ($r \equiv nfa^{CB}$). The interest parity relationship is quite similar to the equation determining the outflow of private capital in *Black* (1985). The net stock of bonds denominated in foreign currency the domestic residents are willing to hold is given by

$$f = nfa - nfa^{CB} = \beta[i^* - i + \dot{s}^e] \tag{0}$$

Thus equation (0) accounts for the fact that a country's net foreign assets can be in the hands of the private sector *and* in the hands of the central banks ($nfa^{CB} \equiv r$). Rewriting (0) leads to equation (6). When β goes to infinity, otherwise identical bonds denominated in different currencies are perfect substitutes and equation (6) reduces to the familiar uncovered interest parity relationship. Clearly, the model encompasses the monetary models and the portfolio-balance model, which will be delt with in section IV.4, as special cases. Real income is assumed to be

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demand-determined in the short run. Goods-market pressure which eventually results in price-adjustment is measured by the gap between contemporaneous and long-run equilibrium income (equation (8)).

Natividad and *Stone* analyse the effects of discretionary monetary policy (increase in c_{EX}), discretionary intervention (increase in r_{EX}) and of an exogenous change in the foreign interest rate. They note that in case of perfect substitutability between bonds denominated in different currencies and in the absence of sterilization ($w_1 = 0$) changes in monetary and exchange rate policy by the domestic monetary authorities have identical implications (see also footnote 3). Furthermore, they conclude that fully sterilized intervention has no effect in either the short or long run. This result was discussed at the end of section IV.3a. Natividad and Stone derive that the lower the degree of endogenous sterilization w_1, the larger the initial jump in the exchange rate after a discretionary intervention (positive value of r_{EX}). In other words, they find that the effect of an *ad hoc* policy measure by the central bank depends on the exact shape of its own mechanical reaction pattern. This result, which is not too straightforward, is mainly due to the implausible intervention reaction function. It is not clear why the central bank would feel the need to intervene discretionarily given that the intervention reaction function already accounts for "endogenous" intervention in response to observed movements in the exchange rate. More interestingly, Natividad and Stone find that the effect of the degree of sterilization on the degree of overshooting after a discretionary intervention is ambiguous. A lower degree of sterilization increases both the initial jump in the exchange rate and its new long-run equilibrium value.

(Partly) sterilized intervention in Natividad and Stone's (1990) sticky-price model

(1)	$r = r_{EX} - \xi\,[(s - p + p^*) - (\bar{s} - \bar{p} + \bar{p}^*)]$		intervention reaction function
(2)	$c = c_{EX} - w_1\, r + w_2\,(i - \bar{i})$	$0 \leq w_1 \leq 1$	domestic credit policy
(3)	$m = h_1\, c + h_2\, r$		money supply
(4)	$m^d - p = \phi\, y - \lambda\, i$		money demand
(5)	$\dot{s}^e = \dot{s}$		rational expectations
(6)	$i = i^* + \dot{s}^e - (1/\beta)\,(nfa - nfa^{CB})$		"uncovered interest parity"
(7)	$d = \delta\,(s - p + p^*) + \gamma\, y - \sigma\, i$		aggregate demand
(8)	$\dot{p} = \pi\,(d - \bar{y})$		price adjustment

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4. *The portfolio balance model*

a) The standard portfolio balance model and intervention

The asset market models for exchange rate determination analysed hitherto assume domestic and foreign assets to be perfect substitutes. Portfolio balance models explicitly leave open the possibility that risk-averse investors believe assets denominated in different currencies to have different risk characteristics, and, hence, that they want to be compensated for the higher perceived risk of holding foreign assets. When investors demand a nonzero risk premium on the domestic asset (RP^D) then a wedge is driven between the expected rates of return on domestic and foreign bonds. The uncovered interest parity relationship no longer holds:

(0) $i = i^* + \dot{s}^e + RP^D$ uncovered interest parity adjusted for a risk premium

In a world in which bonds denominated in different currencies are imperfect substitutes, the requirement of continuous money- and bond market equilibrium jointly determines the exchange rate and interest rates.

An elementary small country portfolio model of the exchange rate is presented in *Branson, Halttunen* and *Masson* (1977). There are three assets: domestic and foreign bonds and domestic money. In accordance with the short-run nature of the model accumulation of foreign bonds through current account surpluses is ruled out.[10] Furthermore, there is no interaction between the financial markets and the goods market. Therefore, the latter is not specified in the model. The demand for money (M), domestic bonds (B) and foreign bonds (SF, expressed in domestic currency) are assumed to depend upon wealth, the own rate of return and the cross rates whereby the rate of return on (narrow) money is set to zero and expectations are static. To bring down the value of the domestic currency, the domestic central bank can conduct an official purchase of foreign bonds in exchange for domestic money. In the framework of a portfolio balance model, this leads to an excess demand for foreign bonds and an excess supply of money. For given levels of the exchange rate the domestic interest rate has to decline in order for the investors to willingly hold the available stock of money. The open-

10 Stock-flow interaction in portfolio models of the exchange rate is discussed in section IV.5.

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market operation leaves the market for domestic bonds unaffected while the proportion of wealth held in the form of domestic bonds is unchanged. In the new equilibrium all three markets have to be in equilibrium again. The interest rate is lower so as to clear the excess supply of money (substitution effect). The value of foreign currency is higher in order to bid up the proportion of wealth held in the form of foreign bonds (wealth effect).

The effect of an unsterilized intervention in the framework of the portfolio balance model is rather straightforward, as is the case in other models for exchange rate determination. It neither depends crucially on the small-country assumption or the assumption of static expectations nor on the degree of substitutability between domestic and foreign bonds. The picture changes when one considers the effect of a sterilized intervention in the framework of the portfolio balance model. Imagine the domestic central bank wants to bring down the value of the domestic currency without altering the domestic money supply. To do so, it can buy foreign currency-denominated bonds from the private sector and at the same time sell domestic currency-denominated bonds to the private sector, leaving total private sector wealth unchanged. How exactly are investors going to react given that their portfolio shares are not infinitely sensitive to changes in expected rates of return on domestic and foreign bonds?

With the economy initially in equilibrium, the swap of domestic bonds for foreign bonds in the portfolio of the private sector leads to an excess supply of domestic bonds and an excess demand for foreign bonds. The money market remains in equilibrium with both the money supply and total private sector wealth unchanged. In the new equilibrium the domestic interest rate is higher clearing the excess supply of domestic bonds. The value of foreign currency is higher bidding up the proportion of wealth held in the form of foreign bonds therewith wiping out the initial excess demand for foreign bonds. Thus, the sterilized purchase of foreign bonds in exchange for domestic bonds leads to a depreciation of the domestic currency.

Many authors find it hard to clarify the underlying mechanism by which a pure intervention alters the exchange rate; especially when the assumption of static expectations and the small country assumption are dropped. The excess demand (supply) for (of) foreign (domestic) bonds causes the price of these bonds to rise (decline) and, hence, causes the foreign (domestic) interest rate to decline (rise). Obviously, although these interest rate changes make domestic bonds relatively more attrac-

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tive than foreign ones, they are mere mechanical reactions to changes in the supply-conditions on the markets for both types of bonds. According to *Henderson* and *Sampson* (1983), given imperfect substitutability, investors require an additional inducement to switch their foreign bonds for domestic bonds. The authors have in mind the uncovered interest parity relation adjusted for a risk premium (equation (0)). In addition to the mechanical price changes the expected rate of return on domestic bonds (i) has to rise relative to that on foreign bonds ($i^* + (E_t s_{t+1} - s_t)$) to enhance the attractiveness of domestic bonds. Thus, with the expected exchange rate ($E_t s_{t+1}$) assumed constant, the value of domestic currency has to decline initially (rise in s_t) in order to orchestrate an expected appreciation of the domestic currency.[11]

b) Unsterilized intervention in the portfolio model by Moreno and Yin (1992)

Until now, the effectiveness of intervention working through the monetary channel is undisputed. *Moreno* and *Yin* (1992) come up with some new theoretical insights. They draw on the experience of Taiwan in the 1980s which tried to limit fluctuations in the New Taiwan (NT) dollar/U.S. dollar-exchange rate. The authors develop a small country portfolio model with flexible prices. There are three assets: domestic money (m), domestic bonds (b) and foreign bonds (f). The real demand for each of these assets is a function of the nominal return on domestic bonds, the expected rate of depreciation of the domestic currency ($E_t s_{t+1} - s_t$), real wealth (w) and real income (y). The small country assumption implies a fixed foreign interest rate. In the model it is normalized at zero. Central to the analysis by Moreno and Yin are the reduced form responses of the exchange rate and the price level to shocks to the exogenous variables.

$$(1) \qquad \Delta s_t = s_s \Delta (E_t s_{t+1} - s_t) + s_m \Delta m_t^s + s_f \Delta f_t^s \quad s_s > 0, s_m < 0, s_f > 0$$

$$(2) \qquad \Delta p_t = p_s \Delta (E_t s_{t+1} - s_t) + p_m \Delta m_t^s + p_f \Delta f_t^s \quad p_s > 0, p_m > 0, p_f < 0$$

whereby

11 In case of perfect substitutability the latter exchange rate change does not occur. Furthermore, the demand for bonds denominated in either currency are perfectly elastic. Hence, after the swap of domestic for foreign bonds only an incipient rise (decline) of the domestic (foreign) interest rate is sufficient to restore equilibrium in all three financial markets.

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(3) $\Delta s_1^P = s_s \Delta (E_t s_{t+1} - s_t)$ change in expectations of private sector

(4) $\Delta s_1^{CB} = -\xi \Delta s_1^P = -\xi s_s \Delta (E_t s_{t+1} - s_t)$ intervention rule, with $0 \leq \xi < 1$

Moreno and Yin trace out the effect of a shock which causes an expected appreciation of domestic currency. The expected rise in the value of domestic currency ($\Delta (E_t s_{t+1} - s_t) < 0$) increases the demand for assets denominated in domestic currency. As a result, the domestic currency appreciates (equation (1)). The authors analyse the extent to which the central bank is able to neutralize this appreciation by conducting unsterilized purchases of foreign bonds according to the rule in equation (4). The intervention operation leads to an increase in the domestic money supply and a matching reduction in the supply of foreign assets held by domestic residents. As a result, the initial appreciation of domestic currency is (partly) reversed. The authors arrive at the familiar insight that the domestic central bank can limit exchange rate changes to any degree desired (by chosing a high value of ξ) but only at the cost of larger changes in its holdings of net foreign assets and, hence, in the domestic money supply. Moreno and Yin point out that the story not necessarily ends here. The exchange rate change to which the central bank reacted was initiated by a shock to private investors' exchange rate expectations. In the terminology of the authors the intervention outcome is credible when investors believe that, after the monetary intervention in reaction to the expectations' induced change in the exchange rate, there will be no further change in the exchange rate. By contrast, the outcome of intervention is not credible when investors "believe that the exchange rate must ultimately adjust to some target exchange rate s^*, regardless of the short-run attempts of policymakers to prevent such adjustment" (p. 20). As before, attempts by the central bank to prevent (part of) the current exchange rate's adjustment to the target level will in first instance reverse (part of) the initial appreciation of the domestic currency. However, the resulting level of the exchange rate lacks credibility and the expectation of an appreciation of domestic currency persists as long as $s > s^*$. This leads to renewed excess demand for assets denominated in domestic currency. It depends on the intensity of unsterilized intervention how long it will take exactly but, as the reserves of a central bank are finite, the exchange rate will ultimately become equal to the target rate investors have in mind. Of course, in the absence of intervention ($\xi = 0$) the full impact of the shock to expectations is felt in the first period. A higher value of ξ leads to a distribution of the impact of the one-time shock over time at the cost of higher cumulative intervention.

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At first sight, the persistence in the appreciation-expectation does not seem very plausible. The unsterilized interventions lead to an increase in the domestic money supply and this will eventually lead to a rise in domestic inflation. For an open economy which has a competitive advantage over other countries, a rise in domestic prices is a close substitute for an appreciation of the domestic currency; both detract from the competitiveness of domestic industries and, hence, will go a long way in removing the cause of the initial expected appreciation of domestic currency. *Moreno* and *Yin* come up with an interesting explanation which also sheds a new light on the exposition in section II. In the short run, unsterilized intervention can prevent equilibrium exchange rate adjustment. This may result in a sequence of growing trade surpluses for the domestic country. At the same time, investors may revise their estimates of s_t^* downward when confronted with news indicating no reduction in the trade surplus or complaints by trading partners.[12] The unsterilized purchases of foreign bonds in exchange for domestic money both have an inflationary effect on the domestic economy whereas the recurrent updating of the expected appreciation has a deflationary effect.[13] Thus, the increase in the money supply resulting from intervention will be associated with a less than proportional increase in inflation. The innovations in the appreciation-expectation hamper the adjustment process which underlies the working of the monetary channel of intervention. Moreno and Yin conclude from the analysis that the persistent and accelerating appreciation of the NT dollar in the 1980s may have been related to government efforts to limit such appreciation which lacked credibility.

c) Sterilized intervention in Blundell-Wignall and Masson's (1985) model

In fact, there is only a minor difference between the sticky-price monetary model and the portfolio model of exchange rate determination.

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12 Note that a subscript t is attached to this expression for the target exchange rate. This indicates that the current analysis is concerned with a sequence of negative shocks to exchange rate expectations rather than a one-time expected appreciation of the domestic currency. The updating of the target rate by investors in this case implies that $E_t s_{t+1} > E_{t+1} s_{t+2} > E_{t+2} s_{t+3}$, etc.

13 Due to the intervention:
$\Delta f_t^S < 0$, from equation (2) with $p_f < 0$ it follows that $\Delta p_t > 0$
Due to the intervention:
$\Delta m_t^S > 0$, from equation (2) with $p_m > 0$ it follows that $\Delta p_t > 0$
Revision of expectations:
$\Delta (E_t s_{t+1} - s_t) < 0$, from (2) with $p_s > 0$ it follows that $\Delta p_t < 0$

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Blundell-Wignall and *Masson* (1985) extend *Dornbusch*'s (1976) model to include assets denominated in domestic and foreign currencies that are not perfect substitutes. Equation (4) reflects that, in order to be induced to hold more foreign assets, domestic investors require a higher expected return on them. The risk premium on foreign assets is assumed to depend on the private stock of net claims on foreigners ($nfa - nfa^{CB}$). Blundell-Wignall and Masson assume that the central bank systematically tries to resist movements in the real exchange rate away from a constant long-run equilibrium value which is, moreover, publicly known. When the current real exchange rate is above its long-run value $\bar{s}_R$ the central bank will enter the foreign exchange market to buy domestic currency ($\xi_1 \succ 0$). Furthermore, the central bank tries to prevent the stock of reserves from deviating too far from some target level $\bar{r}$ (equation (1)). A country which experiences a current account surplus accumulates foreign currency-denominated assets. Stock/flow-interaction is not incorporated in the model, i.e. the current account and the net foreign asset-position are exogenous. According to equation (7), the current real exchange rate may differ from its equilibrium level either because real interest rates differ at home and abroad or because private net claims on foreigners are nonzero. Obviously, sterilized purchases of foreign bonds affects the volume of private net claims on foreigners and, hence, have a bearing on the current real exchange rate through the portfolio channel described at the end of section IV.4a. Blundell-Wignall and Masson establish that the model is stable whatever the value of the intervention parameter ξ. It follows that the rule for sterilized intervention in equation (1) allows the monetary authorities "to guide the exchange rate toward its long-run equilibrium value without inducing short-run fluctuations in that rate" (p. 140).

Sterilized intervention in Masson and Blundell-Wignall's (1985) sticky-price model

(0)	$s_R = s - p + p^*$	definition of the real exchange rate
(1)	$\dot{r} = \xi_1 (\bar{s}_R - s_R) + \xi_2 (\bar{r} - r)$	intervention reaction function
(2)	$m = p + \phi y - \lambda i$	money market equilibrium
(3)	$\dot{s}_R^e = \theta (\bar{s}_R - s_R)$	expected real depreciation
(4)	$i = i^* + \dot{s}^e - (1/\beta) (nfa - nfa^{CB})$	"uncovered interest parity"
(5)	$d = \delta s_R + \gamma y - \sigma (i - \dot{p}^e)$	aggregate demand
(6)	$\dot{p} = \pi (d - \bar{y}) + \dot{p}^e$	price adjustment
(7)	$s_R = \bar{s}_R + [(i^* - \dot{p}^{*e}) - (i - \dot{p}^e)]/\theta - (nfa - r)/\theta\beta$	solution

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From equation (3) it appears that private exchange market participants either do not anticipate the intervention behaviour or, if they do, consider it has no effect. To correct for this feature, *Blundell-Wignall* and *Masson* modify the model so as to let expectations correctly take account of intervention. With fully rational expectations regarding the exchange rate, equation (3) reduces to $\dot{s}^e = \dot{s}$ and equation (4) can be rewritten as $\dot{s} = i - i^* + (1/\beta)(nfa - r)$. The authors show that the resulting model has the saddle-point property and, provided that it is sufficiently strong, sterilized intervention does not lead to cyclical fluctuations in the exchange rate. The mechanics of sterilized intervention in the amended Dornbusch model are not made clear entirely. Shocks cause short-run misalignments of the real exchange rate but leave the long-run equilibrium value unaffected. The famous Dornbusch-overshooting refers to nominal exchange rates overshooting their long-run value in response to an increase in the domestic money supply. With prices sticky in the short-run, the real exchange rate also overshoots. Sterilized intervention, supposedly working through the channel due to *Henderson* and *Sampson* (1983) described above, is said to "speed up adjustment to past shocks" and to "help lessen overshooting" (Blundell-Wignall and Masson 1985, p. 142).

5. *Stock-flow interaction in portfolio models of exchange rate determination*

The portfolio model discussed in section IV.4 are essentially short-run asset market models. There is no interaction between the asset markets and the goods market. Furthermore, in accordance with the short-run nature of the model accumulation of foreign assets through current account surpluses is ruled out. However, the instantaneous restoration of equilibrium on the financial markets after a shock to the system involves an adjustment of the exchange rate. This change in the value of foreign exchange alters the ratio of domestic to foreign goods prices expressed in a common currency. The trade balance improves or deteriorates and, hence, the current account of the balance of payments will show a surplus or a deficit. In turn, this will cause an accumulation or a decumulation of foreign assets in the hands of the domestic private sector. It follows that, beyond the short-run, the course of the exchange rate is determined by current account and capital account flows of foreign exchange which induce an adjustment of the stocks of foreign and domestic assets in the hands of the private sector. The exchange rate moves until the current account and the capital account are again individually in equilibrium.

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Dornbusch and *Fischer* (1980) is a seminal article on long-term adjustment processes and the concomitant interaction between flows of foreign exchange and the dynamics of asset stocks. Current- and capital account dynamics and the adjustment path of the exchange rate after an unsterilized and a sterilized intervention can be studied in the framework of *Branson* (1983) and *Hallwood* and *MacDonald* (1986, Chapter 7). In section IV.4 it was established that both the monetary and the pure intervention lead to an instantaneous depreciation of the domestic currency. As a consequence, a current account surplus emerges and the domestic economy accumulates additional foreign assets. The current account surplus puts upward pressure on the value of domestic currency. Therefore, in the course of the adjustment to the new steady state the domestic currency *appreciates* and the rate of accumulation of net foreign assets diminishes gradually to zero. In the new long-run equilibrium consequent upon the initial monetary or pure intervention the nominal exchange rate has risen but the real exchange rate has fallen (see *Almekinders* 1995, ch. 2).

V. Alternative Approaches to the Study of Forex Intervention

1. Introduction

The theoretical investigations discussed in the previous sections all assumed that some structural model of exchange rate determination provides a valid framework for the analysis of the effectiveness of foreign exchange market intervention. After surveying the empirical evidence on exchange rate models, *MacDonald* and *Taylor* (1992, p. 24) conclude that "... the asset approach models have performed well for some time periods, such as the interwar period, and, to some extent, for the first part of the recent floating experience (that is, 1973 - 1978); but they have provided largely inadequate explanations for the behavior of the major exchange rates during the latter part of the float". Discontent with the performance of traditional structural exchange rate models in explaining the actual behaviour of exchange rates has led many economists to adopt new research strategies in exploring the field of exchange rate economics.

2. De Grauwe's (1989) near-rationality model

De Grauwe (1989) emphasizes the crucial role of uncertainty among foreign exchange market participants regarding the future course of cur-

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rency movements. In his integrated approach, noise trading behaviour seems to follow directly and in a consistent way from trading strategies based on fundamental economic analysis which are assumed to prevail in the structural models of exchange rate determination examined in the previous sections. De Grauwe argues that economic models providing a reliable guide for forecasting the future exchange rate are lacking. Within a mean variance framework he shows that it is not necessarily profitable to use all available fundamental economic information. For instance, an individual exchange market participant may observe a gap between the actual level of the exchange rate and the perceived fundamental equilibrium value. In a highly uncertain economic environment, the expected gain from taking a forward position aimed at exploiting this gap may not outweigh the risk involved. Therefore, it can be rational for exchange market participants to implement technical rather than fundamental analysis. De Grauwe presents a rule for the formation of exchange rate expectations that consists of a backward-looking and a forward-looking component, the first term and the second term on the right-hand side of (1), respectively:

$$E_t \Delta S_{t+1} = k \left(\sum_{i=0}^{n} c_i \Delta S_{t-i} \right) + (1 - k)(S^* - S_t) \tag{1}$$

The parameter k which represents the weight given to each of the expectation rules is assumed to be endogenous. Exchange market participants choose to let the backward-looking component dominate their expectations formation (high value of k) when the actual exchange rate is not too far away from the equilibrium rate they have in mind (S^*). This implies that they resort to technical analysis. A higher weight is assigned to the forward-looking component (lower value of k) only in case it is obvious that the actual exchange rate is at an unsustainable level. Foreign exchange trading based on fundamental analysis becomes less risky leading to a larger expected utility in a mean variance framework. By assuming that exchange market participants revert to backward-looking technical analysis instead of forward-looking fundamental analysis in case of extreme uncertainty, De Grauwe's near rationality model can account for some stylized facts of (real) exchange rates which are left unexplained by perfect foresight rational expectations models, i.e. real exchange rates wandering away from fundamentals for long periods of time before being pushed back towards equilibrium and the relative sluggishness of exchange rate movements as compared to stock and commodity price movements.[14]

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While the current global exchange rate system offers no credible anchor for exchange rate expectations, *De Grauwe* (1989) sees no role for *ad hoc* (un)sterilized intervention to remedy persistent deviations of exchange rates from their perceived equilibrium values. In his view, even changes in fundamentals brought about by monetary or fiscal policy will not help. Due to the extreme uncertainty as to the true model, market participants do not know how to interpret these changes. De Grauwe argues that only a credible exchange rate commitment by the monetary authorities, i.e. a commitment embodying a clear and stabilizing guide for exchange market participants' expectations, can facilitate an efficient functioning of the foreign exchange market comparable to stock and commodity markets. This would require systematic unsterilized interventions rather than *ad hoc* (un)sterilized central bank operations in foreign exchange with which the analysis in the previous sections was concerned. In sum, De Grauwe takes account of non-fundamentalist behaviour or, to be more precise, chartist behaviour by (some) foreign exchange market participants. This does not open up a distinct channel through which foreign exchange intervention can affect the course of currency movements.

3. Chartist channel and noise trading signaling channel of intervention

Fukao (1985) argues that the scope for intervention changes quite dramatically when one is willing to drop the assumption that the foreign exchange market is efficient in the sense that market participants use some structural model as a yardstick when taking positions on the foreign exchange market. Fukao presents the following table which is both simple and insightful.

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14 *Menkhoff* (1992) provides a survey on feedback trading on foreign exchange markets. In an attempt to ascertain the extent and manner by which chartism is used *Allen* and *Taylor* (1989) conducted a questionnaire survey of chief foreign exchange dealers in the London market. They found, *inter alia,* that "at the shortest horizons, intraday to one week, approximately 90% of respondents use some chartist input in forming their exchange rate expectations, with 60% judging charts to be at least as important as fundamentals. At longer forecast horizons, of one to three months or six months to one year, the weight given to fundamentals increases ..." (p. 50). Furthermore, in a recent study *De Grauwe* and *Decupere* (1992) cannot reject the hypothesis that psychological barriers exist in the yen-U.S. dollar market. For the DM-U.S. dollar market the results are mixed.

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Table 2

Effectiveness of Intervention and the State of the Foreign Exchange Market

	Substitutability of bonds denominated in different currencies	
	Perfect	Imperfect
Efficient Market	Intervention is ineffective	Intervention is effective
Inefficient Market	Intervention is effective	Intervention is effective

Source: Fukao (1985, p. 26).

Fukao (1985) does not clarify how the inefficiency of the foreign exchange market opens up a distinct channel through which foreign exchange intervention can affect the exchange rate. *Hung* (1991a, b) contends that the presence of non-fundamentalist market participants whose trading behaviour is more or less predictable constitutes a channel through which sterilized intervention can be effective. Hung's approach is slightly different from that of *De Grauwe* (1989). The noise trading behaviour by exchange market participants is not derived formally. Earlier work on noise trading is just put to the right use. As De Grauwe, Hung arrives at the important insight that fundamentalists can (at times) turn into noise traders due to the extreme uncertainty regarding the future path of the exchange rate. She distinguishes two categories of non-fundamentalist or noise traders. *Chartists* are assumed to '... rely on analysis of past price patterns to predict the future direction of exchange rate movements' (Hung 1991a, p. 12). Market participants who base trading on their prediction of the market's reaction to news and rumors are called *non-chartist noise traders*. The analysis is conducted in the framework of a partial equilibrium flow market approach to exchange rate determination. If a large enough group of noise traders use the same forecasting technique or share the same belief with respect to the future course of the exchange rate, expectations may turn out to be self-fulfilling. The central bank may want to counter the resulting currency movements. Hung argues that the noise trading behaviour displayed by market participants in itself offers an opportunity for the central bank to do this successfully.

A necessary but of course not sufficient condition for intervention to be effective is that the central bank can imagine itself in the position of the two groups of noise traders distinguished. Current intervention

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volumes are insufficient to counter a strong underlying trend in the exchange rate. Therefore, the decision when and how to intervene has to be made conditional on information about the general market sentiment and the (strength of the) buy or sell signals adherents of technical analysis derive from their charts. *Hung* (1991a, p. 20) presents an ideal picture in which chartists "... help amplify and prolong the effect of intervention" which may be transitory by itself. The central bank should select a time period during which the market is sufficiently thin. Concealed intervention carried out through brokers may cause just enough upward or downward pressure on the currency under consideration which, if incorporated in the chartists' trendline analysis induces them to reinforce the movement of the exchange rate in the direction favoured by the central bank. This is what Hung calls the *chartist channel of intervention.* When the interventions indeed remain anonymous, the central bank has nothing to loose in terms of reputation. The latter condition may account for the fact that detailed intervention data are not made publicly available. On the other hand, Hung (1991b, p. 7) admits that "... chart analysis has a large subjective element, and there are probably as many methods of combining and interpreting the various techniques as there are chartists themselves". A second channel is the *noise trading signaling channel.* For this channel, the opportunity to influence the course of the exchange rate does not lie in the thinness of the market or the fact that traders only stare at their charts. For the noise trading signaling channel to be effective, noise traders must be "... already looking for any sign or excuse to reverse their position" (Hung 1991b, p. 12). Highly visible interventions, conducted via the interbank market could give just such a signal.

VI. Conclusions

It has been the aim of this study to provide a comprehensive picture of theories on the scope for foreign exchange market intervention and to find out whether and how intervention is able to influence the course of the exchange rate. In section II a definition of exchange market intervention is given. Unsterilized interventions conducted by the domestic central bank cause a change in the domestic monetary base. By contrast, sterilized interventions lack a money market effect. They do lead to a change in the currency composition of private investors' portfolios.

The effectiveness of monetary intervention in the various models studied in section III and IV is undisputed. Even elementary purchasing

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power parity predicts that an unsterilized intervention will in the long run, *ceteris paribus,* influence the level of the exchange rate in a one to one relationship with a purchase of foreign currency by the domestic central bank leading to a rise in the value of foreign exchange in terms of the domestic currency. In the theoretical models investigated in section III and IV, sterilized intervention can only be effective in case risk-averse investors believe assets denominated in different currencies to have different risk characteristics, and, hence, that they want to be compensated for the higher perceived risk of holding either domestic or foreign assets. In that case, a swap of domestic bonds for foreign bonds in the portfolio of the private sector brought about by a sterilized purchase of foreign currency by the domestic central bank can lead to an appreciation of foreign currency. The practical relevence of this channel of influence is an empirical issue.

Attention is also paid to the popular insight that sterilized intervention can alter the current exchange rate through what is called the expectations or signalling channel of intervention by providing private exchange market participants with new information or a signal about the future course of monetary policy. The paper develops the argument that for the signalling hypothesis to be valid central banks have to back up interventions with subsequent changes in monetary policy. In other words, current sterilized interventions pre-determine the path of future money growth and hence interfere with monetary policy. The neutralization of the initial intervention's money market effect is limited to the short run. This no longer meets the definition of sterilized intervention presented in section II.

From section V it appears that the scope for intervention changes quite dramatically when one is willing to drop the assumption that the foreign exchange market is efficient in the sense that market participants use some structural model as a yardstick when taking position on the foreign exchange market. However, the literature on how the inefficiency of the foreign exchange market opens up distinct channels through which intervention can affect the exchange rate is still in its infancy.

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Summary

Theories on the Scope for Foreign Exchange Market Intervention

This paper traces out recent developments in modeling foreign exchange market intervention. The central question is whether and how intervention is able to influence the course of the exchange rate. The channels of influence of unsterilized and sterilized intervention in some well-established models of exchange rate determination are set out. Furthermore, the mechanics of foreign exchange market intervention in some recent studies are analysed. These studies adhere to the assumption that the foreign exchange market is efficient in the sense that market participants use some structural model as a yardstick when taking positions on the foreign exchange market. Finally, some alternative approaches to the study of foreign exchange intervention are discussed. The latter approaches drop the assumption that the foreign exchange market is efficient.

Zusammenfassung

Theorien zum Spielraum für Interventionen am Devisenmarkt

In diesem Beitrag werden Entwicklungen in der Gestaltung von Interventionen am Devisenmarkt in der jüngeren Vergangenheit nachgezeichnet. Die zentrale Frage ist, ob und auf welche Weise Interventionen den Verlauf von Wechselkursen beeinflussen können. Es werden die Einflußkanäle von nicht sterilisierten und von

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sterilisierten Interventionen in einigen wohl eingeführten Modellen für die Wechselkursbestimmung dargelegt. Ferner wird die einigen Studien der jüngeren Vergangenheit zugrundeliegende Mechanik von Interventionen am Devisenmarkt untersucht. Diese Studien gehen von der Annahme aus, daß der Devisenmarkt in dem Sinne effizient ist, daß die Marktteilnehmer ein gewisses Strukturmodell als Meßlatte verwenden, wenn sie auf den Devisenmärkten Position beziehen. Schließlich werden gewisse alternative Betrachtungsweisen in bezug auf die Studie der Devisenmärkte erörtert. Diese letzteren Betrachtungsweisen nehmen Abstand von der Annahme, daß der Devisenmarkt effizient ist.

Résumé

Théories sur la portée des interventions sur les marchés des changes

Cet article trace les développements récents des interventions-types sur les marchés des changes. La question centrale est la suivante: les interventions sont-elles capables d'influencer le cours des taux de change et dans ce cas, comment? Les voies d'influence des interventions non-neutralisées et neutralisées dans quelques modèles bien établis de détermination des taux de change sont énoncés. En outre, les mécanismes des interventions sur le marché des changes est analysé dans quelques études récentes. Ces études maintiennent l'hypothèse que le marché des taux de change est efficace en ce sens que les participants du marché utilisent comme point de référence un modèle structurel quand ils prennent leurs positions sur le marché des changes. Finalement, l'auteur discute quelques approches alternatives de l'étude des interventions sur les marché de change. Celles-ci rejettent l'hypothèse que le marché des changes est efficace.

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