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Limiting exchange rate swings under a managed floating regime: Evidence from a panel of 24 currencies

Nevin Cavusoglu Yalcin
University of New Hampshire, Durham

LIMITING EXCHANGE RATE SWINGS UNDER A MANAGED FLOATING REGIME: EVIDENCE FROM A PANEL OF 24 CURRENCIES

BY

NEVIN ÇAVUŞOĞLU YALÇIN

B.S. in Economics, Middle East Technical University, 1997

M.A. in Economics, University of New Hampshire, 2002

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This dissertation has been examined and approved.

Dissertation Director, Dr. Michael D. Goldberg
Associate Professor of Economics

Dr. James R. Wible
Professor of Economics

Dr. Bruce T. Elmslie
Professor of Economics

Dr. Roman Frydman
Professor of Economics, New York University

Dr. C.Y. Choi
Assistant Professor of Economics,
University of Texas at Arlington

Date May 10, 2007

DEDICATION

To my husband.

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ABSTRACT

LIMITING EXCHANGE RATE SWINGS UNDER A MANAGED FLOATING REGIME: EVIDENCE FROM A PANEL OF 24 CURRENCIES

by

Nevin Çavuşoğlu Yalçın

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The monetary authorities of many open economies regularly intervene in foreign exchange markets with the aim of limiting swings in exchange rates. A survey of exchange rate models reveals, however, that the literature lacks a model that provides an explanation for exchange rate swings *and* at the same time offers a role for official intervention and parity announcement to affect exchange rate movements. Furthermore, empirical studies suggest that official intervention can have a significant effect on exchange rate movements, but only in the short run (up to 3 months). In this dissertation, I build on the premium model by Frydman and Goldberg (2007), which is based on endogenous prospect theory, and construct a model that provides for swings and a role for intervention. The model implies that intervention aimed at pushing the exchange rate back to some announced or even unannounced parity level at unpredictable moments in time can lead to more limited swings in exchange rates compared to regimes without such policy through an *uncertainty premium* channel. This new channel follows from one of

the key implications of endogenous prospect theory that market participants require a premium as compensation for their greater sensitivity to losses before they are willing to speculate in currency markets. This so-called uncertainty premium depends positively on the gap between the forecast of the future exchange rate and its perceived historical benchmark level. The main contribution of this research is empirical. I first test for the positive relationship between the premium and the gap using a contingency table analysis and regression analysis based on an autoregressive distributive lag model. Then I investigate whether central banks can take advantage of this positive relationship between the gap and the premium in limiting exchange rate swings. My results provide evidence that the gap and the premium are positively related, and that central bank intervention supporting some parity level can lead to swings of smaller magnitude. My empirical analysis is based on survey data on exchange rate forecasts, exchange rate regime classifications and data on changes in reserves, and includes 24 currencies from developed and developing countries.

OVERVIEW OF STUDY

The modern era of floating currencies has been characterized by long swings: exchange rates tend to move persistently away from benchmark levels (such as purchasing power parity, PPP[1]) for extended periods of time, and then tend to exhibit sustained countermovements towards PPP.[2]

Policy officials have long worried about the long-swings nature of floating exchange rates. Long swings are viewed as undesirable because they pose a challenge for firms that engage in international business. They lead to changes in competitiveness and terms of trade effects[3], which require costly reallocation of resources. Loss in competitiveness and negative terms of trade effects can also lead to declines in income and increasing unemployment, accompanied by protectionist measures (Williamson, 1985; Dominguez and Frankel, 1993b).[4]

In attempts to limit such long swings in exchange rates, the monetary authorities of many open economies have been regularly intervening in foreign exchange markets for years by selling or purchasing foreign currency (referred to as official intervention). Such

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[1] PPP is often used as a benchmark level for the exchange rate in the open-economy macroeconomics literature. A historical benchmark is a stable and slowly moving rate that exchange rates tend to move away from and come back to at unpredictable moments. For evidence that PPP acts as such a benchmark, see Section 3 in Chapter 4.

[2] See Figures 1.1 and 1.2 at the end of Chapter 1.

[3] The terms of trade is defined as the price of a country's exports divided by the price of its imports.

[4] These effects can be especially large for small economies. Small open economies are usually characterized by high export concentration due to the difficulty of diversifying their export structure, and a high degree of openness to satisfy domestic demand. These characteristics lead to higher terms of trade and income volatility effects.

official intervention sometimes has also been accompanied by the defense of some announced parity level for the exchange rate or bands around a parity level.

In the first two chapters of my dissertation, I survey the theoretical and empirical exchange rate literature, respectively, on the effects of official intervention and parity announcement on exchange rate swings. The main conclusion of Chapter 1 is that the literature lacks a model that provides an explanation for exchange rate swings *and* at the same time offers a role for official intervention and parity announcement to affect exchange rate movements. On the one hand, researchers have constructed models of exchange rate swings, such as the rational bubble, behavioral and heterodox approaches, which, on the most part, explain swings as movements away from levels based on macroeconomic fundamentals and/or as arising from bubbles, irrationality and market psychology.[5] Since exchange rate swings in these models do not depend on fundamentals, they provide no role for official intervention and parity announcement based on such fundamentals, to influence exchange rate swings. On the other hand, there are models, such as the target zone and portfolio balance models, in which central bank policies do influence exchange rate movements, but according to these, exchange rate swings should not occur. Consequently, these models provide no insight into the ability of official intervention and parity announcement to limit the magnitude of exchange rate swings.

The major finding of empirical studies investigating the effectiveness of central bank intervention (surveyed in Chapter 2) is that it has a significant but a short-lasting effect on exchange rates (up to 3 months). Studies have also investigated the effects of official communication by authorities on their views about the stance of the exchange

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[5] Macroeconomic fundamentals include variables such as interest rates, output, prices and the current account.

rate in relation to macroeconomic fundamentals. Findings indicate almost unanimously that such exchange rate communications have a significant effect on exchange rate movements, suggesting that perhaps the announcement of some parity by central banks may matter for short-run exchange rate movements.[6] However, while these studies provide valuable evidence on the short-run effectiveness of exchange rate policy, they miss a key question: **Does intervention supporting a parity level provide a way for central banks to limit the magnitude of exchange rate swings away from benchmark levels?**

This question is the main focus of my dissertation. In Chapter 3, I build on the premium model by Frydman and Goldberg (2007), and show that central bank intervention aimed at pushing the exchange rate back to some announced or even unannounced parity level at unpredictable moments in time could lead to more limited swings in exchange rates through the *uncertainty premium* channel.[7] This new channel follows from one of the key implications of endogenous prospect theory, which Frydman and Goldberg (2007) use to model individual preferences instead of the usual assumptions of risk aversion and expected utility theory.[8]

Endogenous prospect theory implies that market participants require a premium as compensation for their greater sensitivity to losses before they are willing to speculate in

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[6] This argument is also supported by the strong evidence of exchange rate reaction to news and survey studies indicating that fundamentals, which authorities use to determine a parity level for the exchange rate, are important for exchange rates.

[7] A channel is the transmission mechanism through which central bank policy affects the exchange rate, or the link between the variables in the model that transmit changes in central bank policy to exchange rates.

[8] Frydman and Goldberg (2007) formulate endogenous prospect theory by building on the prospect theory by Kahneman and Tversky (1979) and incorporating limits to speculation. The original version of prospect theory implies that speculators would want to hold speculative positions of unlimited size whenever they perceive profit opportunities.

currency markets. Frydman and Goldberg model this so-called uncertainty premium as depending positively on the gap between the forecast of the future exchange rate and its perceived historical benchmark level. It is this positive link between the aggregate uncertainty premium and the gap from historical benchmark that provides this new channel through which central bank intervention supporting some parity level can influence the magnitude of swings in the exchange rate.

How does this work? As the market forecasts say a further movement away from historical benchmark from above, the market becomes more concerned about the possibility of a countermovement back to the benchmark. And the farther away the exchange rate is from the benchmark, the more concerned they get, asking for a higher uncertainty premium. This higher uncertainty premium limits their willingness to put more money at risk, resulting in less speculation in the foreign exchange market, and thus, less movement in the spot exchange rate.

This suggests that if policy officials can induce individuals to increase the weight they attach to the benchmark level in forming their forecasts, this would lead to a higher aggregate uncertainty premium, and thus, smaller swings in the exchange rate. This leads to a key theoretical result suggesting that official intervention and perhaps the announcement of parity can limit the magnitude of exchange rate swings. In Chapters 5 and 6 of the dissertation I respectively test for the positive relationship between the premium and the gap from the historical benchmark, and whether central banks can utilize this link for limiting exchange rate swings.

Frydman and Goldberg (2007) provide strong empirical support for the positive relationship between the premium and the gap from PPP using data for three major currencies. In Chapter 5, I also test for these currencies, but with a different data set for exchange rate expectations and with a different time frame. Furthermore, I extend the analysis of Frydman and Goldberg (2007) to a total of 24 currencies. Thus, my results help generalize the empirical findings on the positive relationship between the premium and the gap from historical benchmark. In addition, my series are based not on individual currencies but on exchange rate regimes. That is the case because the implication of the premium model is that central bank policy might lead market participants to attach a higher weight to the gap from the historical benchmark, compared to the gap weight under freely floating regimes. Therefore, it would not be appropriate to estimate one gap weight for a period that spans two different exchange rate regimes.

In estimating the relationship between the market premium and the gap from historical benchmark, I follow two different approaches: contingency table analysis (CTA) and regression analysis based on an autoregressive distributive lag (ADL) model. CTA is a very simple non-parametric technique that tests the model's prediction by looking whether the number of observations for which the gap and the premium move in the same direction is larger than the number of observations for which they move in opposite directions. An ADL model takes the nonstationarity of the series into account and allows one to make inference on the significance level of parameter estimates. Results from the CTA and ADL analyses provide evidence of the positive relationship between the gap and the premium.

In Chapter 6, I investigate whether central banks can take advantage of this positive relationship between the gap and the premium in limiting exchange rate swings. However, I do not investigate this question by developing a measure for the magnitude of swings and then regressing that on intervention. The reason is that different regimes may experience different shocks and an effective intervention policy might not appear so if the currency has been subject to a bigger shock compared to a freely floating regime. To circumvent this problem, I test if central banks can take advantage of the positive relationship uncertainty premium channel in limiting exchange rate swings. I test my model's implication that on average the weight the market attaches to the gap from historical benchmark in assessing potential losses is higher for countries in which the central bank intervenes to push the exchange rate back to some parity, called managed regimes, versus a free float.[9] A larger weight attached to the gap from PPP would then imply exchange rate swings of smaller magnitude *for the same swing in exchange rate expectations*. My results provide some empirical evidence suggesting that official intervention supporting a parity level has led to a higher gap weight, and thus, smaller swings in exchange rates.

Performing the tests related to the uncertainty premium channel in Chapters 5 and 6 requires data on exchange rate forecasts.[10] It also requires classifying exchange rate regimes. I capture exchange rate forecasts by using a novel survey dataset provided by Forecasts Unlimited, Inc for twenty-four developed and developing countries from August 1986 through September 2000. Survey data on market participants' forecasts concerning the future exchange rates have been used fairly extensively in the literature. Although there are some bias problems with forecasts from survey data, most researchers believe that even if there are biases in the forecast data they are not systematic.

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[9] Managed regimes include intermediate regimes such as conventional fixed pegs, crawling pegs and bands, and managed floats. For definitions of these regimes and others, see Table 4.1.

[10] I discuss the methodology and data in Chapter 4.

There are several issues concerning the survey data. To construct a series for the market premium I need data on forward exchange rates, and ideally, these forward exchange rates will be derived from the spot exchange rate that survey participants considered when forming their forecasts. The survey, however, does not collect such data. Instead, it reports spot and forward exchange rates 3-7 days later than the date on which the exchange rate forecasts were formulated. There is this range of a 3-7 day lag because survey participants are given a deadline of two business days to respond to the survey, and the date on which the forecasts are reported is not being recorded. Since exchange rates can change drastically from one day to another, such a lag might significantly bias the results. Therefore, I have collected daily data on forward exchange rates and have taken the average of the forward rate for the two days on which, as I am informed, most of the surveys are being collected.

Exchange rate regime classification is important because the model predicts that the market would attach a different weight to the gap from historical benchmark depending on the regime. One of the crucial things here is to be able to classify countries according to the exchange rate regime that they actually adopt. In this dissertation I consider three studies - Bubula and Ötker-Robe (2002), Levy-Yeyati and Sturzenegger (2002), and Reinhart and Rogoff (2004) - that have used different methods and have arrived at different classifications. Besides other issues, one problem that pertains specifically to the last two classifications is their primary reliance on exchange rate behavior, and more particularly, its volatility. This raises the concern of first using exchange rate volatility to classify exchange rates into different regimes and then using these exchange rate regimes to test for long run misalignments in the exchange rates – the endogeneity problem.

One way to deal with the problem of classifying exchange rate regimes is to utilize data on international reserves as proxy for official intervention and test if the market attaches a larger weight to the gap in assessing potential losses during regimes with greater intervention. If that is the case, we would expect to observe smaller exchange rate swings in these markets.

The use of official reserves as a proxy for official intervention has been criticized by some researchers. They have argued that international reserves are not well correlated with official intervention since they may change due to reasons that are unrelated to official intervention, such as fluctuations in valuations and accrual of interest earnings. Many of these shortcomings, however, do not pertain to my analysis because I use international reserves *in U.S. dollars* and I look for the *relative effects* of intervention across countries. Therefore, fluctuations in valuations, or the accrual of interest earnings as well as the use of other policy tools besides the purchase and sale of foreign exchange to affect exchange rate behavior, may not play a crucial role for my results (assuming that the use of such policy tools is proportionate across countries). My empirical findings suggest that more intervention leads to a higher weight attached to the gap from historical benchmark, and thus, smaller swings in exchange rates.

My overall findings imply that central bank intervention supporting some announced or even unannounced parity level at unpredictable moments in time could lead to more limited swings in exchange rates compared to regimes without such policy through the *uncertainty premium* channel.

CHAPTER 1

EXCHANGE RATE THEORY
ON THE EFFECTS OF OFFICIAL INTERVENTION AND PARITY ANNOUNCEMENT ON EXCHANGE RATE SWINGS

1 Introduction

The modern era of floating exchange rates has been characterized by long swings: exchange rates often move persistently away from historical benchmark levels for long periods of time and then tend to exhibit sustained countermovements toward benchmark levels. Figures 1.1 and 1.2 at the end of the chapter provide plots of the German mark/U.S. dollar and the Japanese yen/U.S. dollar exchange rates along with their purchasing power parity (PPP) levels for the period from and May 1973 to December 1998 and June 2003, respectively.[1 2 3]

As can be seen from these graphs, the two markets exhibit swings of different magnitudes and of different lengths, but they both display long-swings behavior. As argued by Bergsten and Williamson (1983) and later Williamson (1985, 2002), the

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[1] PPP is often used as a benchmark level (or a long run anchor) for the exchange rate in open-economy macroeconomics. For evidence that PPP provides such an anchor see Taylor and Peel (2000), Taylor, Peel and Sarno (2001) and Taylor and Taylor (2004). See also Section 3 in Chapter 4.

[2] The PPP exchange rates in Figures 1.1 and 1.2 are calculated by using the Big Mac purchasing power parity exchange rates reported in *The Economist* magazine and CPI inflation rate differentials from the IMF's International Financial Statistics.

[3] The spot exchange rate in Figure 1.1 or 1.2 is usually thought of as depicting equilibrium in asset markets, whereas the PPP exchange rate is generally thought to depict equilibrium in goods markets. Given this interpretation, the long swings in the figures can be viewed as departures from equilibrium in goods markets.

fundamental problem of floating exchange rate regimes has been "the propensity of floating rates to become misaligned [relative to PPP], that is, systematically and substantially overvalued for prolonged periods." (Williamson, 2002: 78)

The monetary authorities of many open economies have been regularly intervening in foreign exchange markets for years by selling or purchasing foreign currency. Sometimes this intervention has been accompanied by an announcement of a parity level – an exchange rate level such as PPP - that policymakers believe is desirable. The aim of such policy has been to limit volatility in the exchange rate and/or to push the exchange rate back to parity.

A key question for international macroeconomics is whether official intervention that is perhaps accompanied by a parity announcement during some period of time would be effective at reducing the magnitude of the exchange rate swings that would arise during that period if such policies were absent. In this chapter, I survey the theoretical exchange rate literature on this question. Strikingly I find that this literature has little to say. This literature lacks a model that provides an explanation for swings in the exchange rate *and* at the same time offers a role for official intervention and parity announcement to affect such exchange rate movements. On the one hand, researchers have constructed models of exchange rate swings in which there is no role for official intervention and parity announcement. On the other, there are models in which such policies do influence exchange rate movements, but according to these, exchange rate swings should not occur.

Models that generate swings in exchange rates include the "rational" bubble model due to Blanchard and Watson (1982), the behavioral or noise-trader approach pioneered by Frankel and Froot (1986), and the heterodox approach by Schulmeister

(1988). In these models, exchange rate swings, for the most part, are explained as movements away from levels that are implied by macroeconomic fundamentals, and as arising because of bubbles, irrationality, and market psychology.[4] But if fundamentals do not matter for exchange rates, then central bank intervention supporting some parity level - which impacts the exchange rate through its ability to influence fundamentals - has no ability to influence exchange rate swings. According to these theories, there is little policymakers can do to limit the magnitude of exchange rate swings, except for fixing their exchange. I discuss these models in Sections 2 and 3.

Target zone and portfolio balance models offer some role for official intervention and parity announcement to influence exchange rate movements. But, because they rely on the rational expectations hypothesis (REH) to model expectations, they do not generate exchange rate swings. Consequently, these models provide no insight into the ability of official intervention and parity announcement to limit the magnitude of exchange rate swings. The target zone and the portfolio balance models are discussed in Section 4.

The main conclusion of this chapter is that there is need for a model that provides not only an explanation of exchange rate swings, but also a channel through which official intervention aimed at pushing the exchange rate back to some parity level can affect exchange rate movements.

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[4] Macroeconomic fundamentals include variables such as interest rates, output, prices and the current account.

2 Exchange Rate Swings as Movements Away from Fundamentals

Two major research areas in the international finance literature led economists to construct exchange rate models in which exchange rate swings are driven by factors other than fundamental variables. One is the inability of conventional flexible-price and sticky-price monetary models to explain swings in exchange rates.[5] The other is the main conclusion of empirical studies testing these models that macroeconomic fundamentals do not appear to have significant effects on exchange rates over the short and medium runs.[6]

Flexible-price monetary models assume that relative (domestic minus foreign) prices adjust to their equilibrium level instantaneously.[7] In these models, long swings in exchange rates arise due to "real disturbances to supplies of goods or demands for goods [which] cause changes in relative prices, including the "real exchange rate." (Stockman, 1987: 12). To generate exchange rate swings, these models require frequent and persistent changes in tastes and technology, which are not plausible. As argued by Dornbusch, "[t]he events were too large and the reversal too sharp and complete to allude to mystical shifts in tastes and technology." (Dornbusch, 1989: 415)

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[5] Conventional refers to models that incorporate a set of *a priory* assumptions on how 'rational' individuals make decisions.

[6] Short run refers to the time frame for which goods prices are fixed. Medium run refers to the time period within which prices have fully adjusted to their new equlibrium levels. Medium run is different from the long run in the sense that it does not imply that variables adjust to their steady state values. The reason is that the notion of a steady state implies a stable long run relationship between variables, which might not exist. See Frydman and Goldberg (2007).

[7] The seminal articles in this literature are Stockman (1980) and Lucas (1982). See also Helpman (1981) and Svensson (1985). These models can be seen as generalizations of the flexible-price monetary models of Frenkel (1976) and Bilson (1978).

To explain deviations of exchange rates from their PPP levels, Dornbusch (1976) and Frankel (1979) pioneered the so-called sticky-price monetary model, where goods prices and/or wages adjust to their long-run equilibrium levels sluggishly. In the Dornbusch-Frankel sticky-price monetary model, nominal and real exchange rates can overshoot their long-run equilibrium levels in the short run due to unanticipated one-time changes in money supply or money growth rates.[8] This model therefore is often referred to as the overshooting model.

In the Dornbusch-Frankel overshooting model, unanticipated changes in policy variables, such as the money supply, generate temporary deviations of exchange rates from their PPP levels. However, this model is difficult to reconcile with long-swings, since the assumption of REH implies that whenever the exchange rate deviates from PPP, it will move persistently back over time at a constant rate. In this model, persistent movements away from PPP can arise if there is a sequence of unanticipated monetary shocks in the same direction. However, such an explanation is not plausible because it assumes that market participants can be caught by surprise over and over again. Therefore, although the overshooting model offers an explanation for temporary deviations of exchange rates from PPP, it does not explain persistent swings.

Despite the apparent inability of these models to explain swings in exchange rates, however, many studies have confronted these models with data to test the role of fundamental variables for the exchange rate over the short- and medium runs. The main conclusion of such empirical studies has been that macroeconomic fundamentals do not

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[8] In the Dornbusch (1976) model, short-run deviations in exchange rates from their long run equilibrium values occur due to unanticipated one-time changes in money supply. Frankel (1979) extends the model to show that such deviations could also occur due to unanticipated changes in money growth rates.

appear to have significant effects on exchange rates.[9] This failure of conventional exchange rate models to explain exchange rate movements in the short run and the medium run, known as the exchange rate disconnect puzzle has led to the conclusion that "exchange rates are moved largely by factors other than the obvious, observable, macroeconomic fundamentals." (Dornbusch and Frankel, 1995: 10-11)

2.1 Bubbles, Irrationality and Market Psychology

Confronted with the failure of empirical studies to find significant effects of fundamentals in the short and medium runs and the difficulty of REH models to explain long swings, economists have constructed models in which swings in exchange rates arise because market participants increasingly ignore fundamentals in forming their forecasts of future exchange rate movements.

Among the popular mainstream explanations of long swings in exchange rates are the rational bubble model due to Blanchard and Watson (1982) and the noise-trader approach pioneered by Frankel and Froot (1986). These models have a common approach – they explain exchange rate swings as arising from factors other than fundamentals – bubbles, irrationality or market psychology. As such, they do not provide any role for policy involving official intervention supporting some parity level that is based on fundamentals to limit swings in exchange rates.

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[9] See Frankel (1984), Dornbusch (1980), Backus (1984), Meese (1986), Meese and Rogoff (1983, 1988), and Meese and Rose (1991). Perhaps the most widely cited study illustrating the empirical failure of conventional exchange rate models, Meese and Rogoff (1983), concludes that macroeconomic fundamentals provide no more help in understanding exchange rate movements than flipping a coin.

2.1.1 The Rational Bubble Approach to Long Swings.[10] One popular explanation of long swings has been provided by models in which expectations are modeled using REH and that build on the unstable bubble solutions implied by the Dornbusch-Frankel overshooting model – the rational bubble approach.[11] In these models, exchange rate bubbles arise because market participants ignore macroeconomic fundamentals in driving exchange rates away from benchmark values: "a speculative bubble can be defined as an increase in the price resulting from an increase in demand that is not related to fundamentals or to expectations of fundamentals but that is rather a self-fulfilling response to expectations that the price will go up." (Dominguez and Frankel, 1993b: 41) These bubbles appeal to an old idea that swings occur because market participants attempt to forecast "what average opinion expects average opinion to be." (Keynes, 1936: 156) In contrast to contemporary models, however, Keynes attributed the problem of guessing the average opinion to imperfect knowledge. In the foreign exchange market, REH bubbles constitute one of the leading explanations for long swings.[12]

The following model will help illustrate the bubble explanation of exchange rate swings:

$$E\left(s_{t|t+1} \mid x_t\right) - s_t = i_{r,t} \tag{1}$$

$$m_{r,t} = p_{r,t} + \phi y_{r,t} - \lambda i_{r,t} \tag{2}$$

$$s_t - p_{r,t} = u_t \ , \quad u_t = u_{t-1} + \varepsilon_t \tag{3}$$

[10] For surveys of the rational bubble approach see Adam and Szafarz (1992), and Sarno and Taylor (2002).

[11] The flexible-price monetary model also generates bubble trajectories that involve a steadily rising or falling nominal exchange rate. However, since PPP holds at all times along each of these trajectories, these bubbles do not provide an explanation of persistent deviations from PPP.

[12] See, for example, Frankel (1985), Krugman (1986), Evans (1986) and Meese (1986).

where $m_{r,t}$, $p_{r,t}$, $y_{r,t}$ and $i_{r,t}$ denote the time t log levels of the relative (i.e. domestic minus foreign) money supplies, price levels, income levels and short run nominal interest rates respectively; s_t stands for the log level of the exchange rate defined as the amount of domestic currency necessary to buy a unit of foreign currency; $E\left(s_{t|t+1} \mid x_t\right)$ is the expected exchange rate at time t for time t+1, given the information set at time t, x_t; ε_t is a white noise process; and ϕ and λ are constant parameters.

Equation (1) is uncovered interest rate parity (UIP), which is the equilibrium condition for the foreign exchange market under the assumptions of perfectly substitutable domestic and foreign assets, perfect capital mobility and homogeneous expectations. UIP states that equilibrium in the foreign exchange market occurs when on average the expected return on domestic and foreign assets are equal. Equation (2) is the relative equilibrium condition for the domestic and foreign money markets, where m_t and y_t are assumed to be exogenous to the model. It states that equilibrium in the money market occurs when the real money supply is equal to real money demand. Equation (3) assumes that deviations from PPP follow a random walk, following Meese (1986).

Substituting for $p_{r,t}$ from equation (2), and for $i_{r,t}$ from equation (1) into equation (3), and rearranging we get:

$$s_t = (1-\beta)\left(m_{r,t} - \phi y_{r,t}\right) + \beta E\left(s_{t|t+1} \mid x_t\right) + (1-\beta)u_t \tag{4}$$

where $\beta = \dfrac{\lambda}{1+\lambda}$

Taking the first difference to address the nonstationary nature of exchange rates and solving forward, one obtains the no-bubble (or market fundamental) solution to (4):[13] [14]

$$s_t^* = (1-\beta)\sum_{i=0}^{\infty}\beta^i E\left(f_{t|t+i} \mid x_t\right) + \varepsilon_t \tag{5}$$

where

$$f_t = m_{r,t} - \phi y_{r,t} \tag{6}$$

and $\varepsilon_t = (1-\beta)\sum_{i=0}^{\infty}\beta^i u_t$

However, (5) is only one solution to (4) from an infinite number of solutions of the general form: [15]

$$s_t = s_t^* + b_t \tag{7}$$

where the exchange rate is assumed to depend on fundamental variables as captured by s_t^*, and a rational speculative bubble, b_t, that satisfies:

$$b_t = \beta E\left(b_{t+1}\right) \tag{8}$$

where $\beta < 1$.

Before discussing the implications of such a rational speculative bubble for exchange rate swings, let is first see how (7) represents a solution to (4). Let us write (7) for time $t+1$ and take the expected value to obtain:[16]

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[13] This solution is obtained by assuming that the tranversality condition holds: $\lim_{\tau\to\infty}\beta^{\tau}E\left(s_{t|t+1} \mid x_t\right) = 0$.

[14] The sample mean and variance of nonstationary series are not constant over time, and successive observations are highly interdependent, posing problems for statistical inference.

[15] Then the transversality condition is violated.

$$E\left(s_{t|t+1} \mid x_t\right) = E\left(s^*_{t|t+1} \mid x_t\right) + E\left(b_{t+1}\right)$$
$$= \sum_{i=0}^{\infty} \beta^i E\left(f_{t|t+i+1} \mid x_t\right) + (1-\beta)\sum_{i=0}^{\infty} \beta^i u_{t+1} + E\left(b_{t+1}\right) \quad (9)$$

Multiplying both sides by β and using (8) gives:

$$\beta E\left(s_{t|t+1} \mid x_t\right) = \sum_{i=0}^{\infty} \beta^{i+1} E\left(f_{t|t+i+1} \mid x_t\right) + (1-\beta)\sum_{i=0}^{\infty} \beta^{i+1} u_{t+1} + b_t$$
$$= s^*_t - (1-\beta) f_t - (1-\beta) u_t + b_t \quad (10)$$

or using (7):

$$s_t = (1-\beta)\left(m_{r,t} - \phi y_{r,t}\right) + \beta E\left(s_{t|t+1} \mid x_t\right) + (1-\beta) u_t \quad (11)$$

Equation (11) is identical to the original equation in (4), therefore, (7) represents a feasible solution to (4).

A rational bubble captures the market psychology of an ever-rising exchange rate. This can be seen by considering the following deterministic rational bubble at time $t+k$:

$$E\left(b_{t+k} \mid x_t\right) = \gamma \beta^{-k} b_t \quad (12)$$

where $0 < \beta < 1$ and γ is an arbitrary number.

In the rational bubble approach, swings in exchange rates arise if, when forming their forecasts at time t, market participants believe that a bubble has begun, i.e. the exchange rate has started moving away from its fundamental value, and collectively set the bubble term, b_t, to equal some non-zero value. This bubble term is usually interpreted as “market sentiment,” and is thought to capture the collective "belief" of market

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[16] The second part of the equation is obtained by substituting in for $E\left(s^*_{t|t+1} \mid x_t\right)$ from equation (5).

participants who forecast "what average opinion expects average opinion to be." (Keynes, 1936: 156) Once a bubble is formed, since $\beta < 1$, this deterministic bubble grows exponentially.

Because such an ever-increasing bubble is implausible, however, researchers consider stochastic rational bubbles, where the bubble continues to grow with some probability π, and it bursts with probability $1-\pi$. Such a bubble is represented by

$$b_{t+1} = \begin{cases} (\beta\pi)^{-1} b_t + \mu_{t+1} & \text{with probability } \pi \\ \mu_{t+1} & \text{with probability } 1-\pi \end{cases}, \text{ where } E(\mu_{t+1} \mid b_t) = 0.$$

With the stochastic rule, once a bubble is formed, it grows at a rate of $(\beta\pi)^{-1}$ with probability π.

To sum up, in the rational bubble approach to exchange rate swings, swings are not connected to fundamental variables. Rather, they arise as a result of perfectly coordinated self-fulfilling expectations. Therefore, in this approach, it is hard to see how official intervention and parity announcement based on macroeconomic fundamentals would affect exchange rates and exchange rate swings.

2.1.2 Behavioral Approach to Long Swings. Another popular explanation in which movements away from PPP are also unrelated to macroeconomic fundamentals, but which does not rely on REH, is offered by behavioral economists – the noise trader approach. This approach was pioneered by Frankel and Froot (1986).[17] [18] It is in essence

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[17] For a detailed analysis of the Frankel and Froot (1986) model and subsequent research see Sarno and Taylor (2002).

[18] Other studies that build on Frankel and Froot (1986) to explain long swings include Goodhart (1988), Brock and Hommes (1999) and DeGrauwe and Grimaldi (2005a, b; 2006). The studies by Brock and Hommes (1999) and DeGrauwe and Grimaldi (2005a, b; 2006) assume that individuals use some 'fitness

a speculative bubble approach that is not constrained by rational expectations in the sense of knowing the true model governing exchange rate movements.

Most behavioral models involve two different groups of traders, one of which consists of fully informed market participants who base their forecasts on some economic model ('rational' fundamentalists), and another group of participants who trade on some chartist rule that looks at past prices ('irrational' noise traders, or chartists). Fundamentalists are considered rational because they base their expectations of the future exchange rate on the fundamental value of the exchange rate. Chartists, on the other hand, base their expectations on noisy information and are therefore considered to be irrational.

In these models, persistent movements of the exchange rate away from PPP occur because the weight the market attaches to the chartist rule increases gradually, i.e. the models base exchange rate swings on irrationality on the part of market participants.

The exchange rate model that Frankel and Froot (1986) use is given by:

$$s_t = c\Delta s^m_{t+1} + z_t \tag{13}$$

where s_t is the log of the spot exchange rate at time t, Δs^m_{t+1} is the expected rate of depreciation by the market from time t to $t+1$, and z_t represents other contemporaneous factors time t affecting the exchange rate at (such as macroeconomic fundamentals). In this model the exchange rate is driven by the speculative decision of portfolio managers who use a weighted average of the expectations of chartists and fundamentalists:[19]

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measure' (such as realized profits) to check the profitability of a specific forecasting strategy *ex post*, and that they switch to the more profitable strategies.

[19] Portfolio managers are assumed to possess homogeneous expectations.

$$\Delta s_{t+1}^{m} = \omega_t \Delta s_{t+1}^{f} + (1-\omega_t)\Delta s_{t+1}^{c} \tag{14}$$

where Δs_{t+1}^{f} and Δs_{t+1}^{c} stand for the rate of change in the exchange rate from time t to $t+1$ expected by fundamentalists and chartists, respectively, and ω_t and $1-\omega_t$ represent the weight that portfolio managers attach to the fundamentalists and chartists views, respectively.[20]

In this model then, the 'bubble' path of the exchange rate is driven by the expected depreciation of portfolio managers. The portfolio managers' problem consists of choosing the weight that they want to attach to the fundamentalist and chartist views at each point in time. The weight that portfolio managers attach to the fundamentalist view is assumed to evolve over time according to:[21]

$$\Delta \omega_t = \delta(\hat{\omega}_{t-1} - \omega_{t-1}) \tag{15}$$

where $\hat{\omega}_{t-1}$ is the weight on the fundamentalist view, computed ex-post, that would have accurately predicted the contemporaneous change in the exchange rate from t to $t+1$:

$$\Delta s_t = \hat{\omega}_{t-1}\theta\left(s_{t-1}^{PPP} - s_{t-1}\right) \tag{16}$$

where s_{t-1}^{PPP} is the long run equilibrium, PPP, exchange rate.

Rewriting equation (16) in terms of $\hat{\omega}_t$ and substituting in equation (15) gives

$$\Delta \omega_t = \delta\left[\frac{\Delta s_t}{\theta\left(s_{t-1}^{PPP} - s_{t-1}\right)} - \omega_{t-1}\right] \quad \text{when} \quad 0 < \omega_{t-1} < 1 \tag{17}$$

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[20] For the fundamentalist view, Frankel and Froot assume a sticky price model, and for the chartist view they assume a random walk.

[21] In an appendix, Frankel and Froot (1986) allow for the weight to change according to a Bayesian rule.

where the coefficient $0 \le \delta \le 1$ reflects the weight that portfolio managers attach to prior information. When portfolio managers attach more weight to *prior* information, δ tends to be small.[22]

To see how exchange rate movements determine the weight attached to the fundamental solution, and how the weight in turn affects exchange rate movements, we need to solve for these variables simultaneously. So, taking the first difference of (13) and substituting (14) for Δs_{t+1}^{m} by assuming, for simplicity, that the chartists believe that the exchange rate follows a random walk, in which case $\Delta s_{t+1}^{c} = 0$, we obtain

$$\Delta s_{t+1} = \frac{c\theta\left(s_t^{PPP} - s_t\right)\Delta\omega_{t+1}}{1 + c\theta\omega_t} \qquad (18)$$

Then solving equations (17) in terms of $\Delta\omega_{t+1}$ and (18) simultaneously gives

$$\Delta s_{t+1} = -\frac{\delta c\theta\omega_t}{1 + c\theta\omega_t - \delta c}\left(s_t^{PPP} - s_t\right) \qquad (19)$$

and

$$\Delta\omega_{t+1} = -\frac{\delta\omega_t\left(1 + c\theta\omega_t\right)}{1 + c\theta\omega_t - \delta c} \qquad (20)$$

We can now use equations (19) and (20) to see how swings arise in this model. Note first that when portfolio managers attach a substantial weight to prior information, so that δ is small, the denominator in equations (19) and (20) takes on a positive value.

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[22] This is seen more clearly when equation (15) is rewritten as $\omega_t = \delta\hat{\omega}_{t-1} + \left(1-\delta\right)\omega_{t-1}$. When portfolio managers attach no weight to prior information, $\delta = 1$ so that $\omega_t = \hat{\omega}_{t-1}$; when they attach substantial weight to prior information, δ is small.

In this case, what these equations imply is that if there is a shock that causes the exchange rate to move away from its long run benchmark level, then portfolio managers will decrease the weight on the fundamentalist view, ω_{t+1}, and increase the weight that they attach to the chartist view. As the weight on the chartist view increases, this causes a further movement away from PPP along a bubble path.

To see why portfolio managers increase the weight they attach to the chartist view, suppose that we start at long run equilibrium where $s_t = s_t^{PPP}$ and $\omega_t = 1$. Now suppose that there is an unanticipated appreciation of the domestic currency, causing a fall in the exchange rate. The fundamentalist view will then predict a future depreciation of the domestic currency.[23] However, if portfolio managers attach substantial weight to prior information, i.e. δ is small, they lower the weight attached on the fundamentalist view and start switching to the chartist view.[24] This switch causes a further fall in the exchange rate, leading again to a higher weight on the chartist view.[25] So in the Frankel and Froot (1986) model, when portfolio managers attach substantial weight to prior information, any shock to the exchange rate tends to move it away from its long run value.[26]

The noise-trader approach by construction allows for fundamental variables to affect the exchange rate, but it explains swings in exchange rates as movements away

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[23] Equation (16) implies that following a deviation from PPP, the exchange rate will tend to move back to PPP.

[24] Portfolio managers switch to the chartist view because as captured by equation (20), any change in the exchange rate leads to a lower weight on the fundamental view.

[25] According to equation (19) a lower weight on the fundamentalist view leads to a further fall in the exchange rate.

[26] Frydman and Goldberg (2007) have criticized the model because it does not allow for change in forecasting rules.

from these fundamentals and as arising from irrationality. Thus, similarly to the bubble approach, it does not provide a role for policy intervention based on fundamentals.[27]

To sum up, this section discussed approaches to explaining exchange rate swings that are based on factors other than macroeconomic fundamentals, namely bubbles, irrationality and market psychology. However, if it is in fact the case that exchange rate swings are driven by factors other than fundamentals, then it is unclear how a official intervention and parity announcement by the Central Bank based on such fundamentals will have any effect on swings. Thus, although these models provide some explanations for exchange rate swings, they do not provide a role for policy intervention to affect swings in exchange rates.

3 Heterodox Approaches to Explaining Long Swings in Exchange Rates

Besides the two popular mainstream explanations of exchange rate swings, namely the REH bubble approach and the noise-trader approach, few non-mainstream economists have tried to model exchange rate swings. As with mainstream models, the Post Keynesian approach to exchange rate determination is also based on the insight that expectations drive exchange rate movements. And similarly to the behavioral approach to exchange rates, the few Post Keynesian studies have tried to model expectations without REH. As noted by Harvey (1999: 304), however, "even though all the non-mainstream approaches have emphasized the role of market participants' expectations, none has offered more than an ad hoc theory of them."

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[27] Chapter 2, Section 3 discusses a noise-trader model by Kubelec (2004a,b) that provides a rationale for official intervention to limit exchange rate swings based on a fitness measure.

The most prominent of the studies in this field are Schulmeister (1988) and Harvey (1991, 1993).[28] Schulmeister (1988) distinguishes between short run and medium run dynamics in exchange rates. Short run exchange rate dynamics are based on the use of technical trading rules, while long swings in exchange rates arise due to expectational bias that is either in favor or against a particular currency:

> "exchange rate dynamics in the medium run [read long swings in exchange rates] can be viewed as a sequence of bubble-like trends, based on an upward or downward expectational bias and non-directional movements based on an ambiguity in the formation of expectations (i.e. conflicting signals emanating from the goods and asset markets and thus the prevailing of a "precarious equilibrium")."
>
> Schulmeister (1988: 362)

Such expectational bias arises when both the goods and assets markets provide the same signal to the market in terms of an expected appreciation or depreciation of a particular currency, say the U.S. dollar. For example, a large U.S. current account surplus combined with a higher U.S. interest rate in relation to the euro interest rate would cause the market to expect an appreciation in the dollar, forming an expectational bias in favor of the dollar. This positive expectational bias then leads market participants to hold long positions in the dollar for a longer time compared to the short dollar positions. This behavior leads to longer lasting upward runs compared to downward runs thus leading to the stepwise appreciation of the dollar.[29] Then the feedback between the profitability of currency speculation and the effects of this profitability on the exchange rate makes the

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[28] In a way similar to the work of Schulmeister (1988), but more incomplete, Davidson (1982) emphasizes the role of changing expectations under uncertainty on the volatility of the exchange rate. Krause (1991) develops a simple model of exchange rates in which he constructs an explanation of speculative bubbles based on the speculators' success in predicting the behavior of other speculators. Harvey (1991) builds on the insights provided by Schulmeister (1988).

[29] A run is defined as monotonic or "almost" monotonic movements (Schulmeister, 1988: 344).

appreciation process self-sustainable for some period of time. Eventually this appreciation of the dollar ends due to a deterioration in the current account, or a falling domestic interest rate, and the market observes a countermovement. Thus, while in the short run the exchange rate is characterized by "a sequence of upward and downward price runs", in the long run, "the exchange rate fluctuates around the purchasing power parity as its "center of gravity." (Schulmeister, 1988: 343 and 363)

Schulmeister explains the development of a single run, which pertains to the short run dynamics of the exchange rate, as a result of the interaction between two effects: the bandwagon effect and the cash-in effect. The bandwagon effect is generated when, in response to particular economic or political news, more and more traders act on the signal generated by technical trading rules to either buy or sell the foreign currency. The longer the run lasts, the larger becomes the temptation to abandon the bandwagon by cashing in the profits. The bandwagon effect becomes smaller, and market participants become more sensitive towards any piece of news that could be interpreted by other market participants as a signal of a "tilt" in the run. As will be discussed in Chapter 3, the increasing sensitivity of traders with the length of the run in Schulmester's model is similar to the intuition behind the premium model that I use in this dissertation.

Schulmeister (1988) provides an explanation of long swings in exchange rates, which, unlike the REH bubble and behavioral models, does not build on irrationality or market psychology. Because exchange rate swigs arise due to macroeconomic fundamentals, central bank intervention could influence exchange rates through its effect on the interest rate differential. However, Schulmeister (1988) does not provide a formal model.

4 Policy Implications for Limiting Swings by Models with No Swings

In a different array of research, economists have concentrated on the policy question of what officials can do to limit exchange rate misaligments. The portfolio balance model and the target zone model are the main ones. Target zone models provide some role for central bank intervention and parity announcement, but because they rely on flexible prices, or sticky prices and REH, they do not generate swings. Moreover, the target zone models have demonstrated very poor empirical performance.

Portfolio balance models also provide a channel for central bank intervention. However, because they rely on REH, they also do not generate swings. Moreover, they do not have a role for parity announcement. Portfolio balance models have also been strongly refuted empirically.

4.1 Target Zone Models[30]

The target zone model was pioneered by Krugman (1991). In this model, there is a fixed band around the exchange, which monetary authorities are obligated to defend by intervening in the foreign exchange market. Besides flexible prices (implying that the exchange rate is equal to its PPP level at all times), the two other major assumptions of the model are perfect credibility (in the sense that individuals believe that the exchange rate will remain within the fixed band and that the band will not change) and marginal intervention (meaning that the central bank intervenes only when the rate hits one of the band margins).

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[30] The term "target zone" was first introduced by Williamson (1985) as a wide target zone for real exchange rates as a method of international cooperation on economic policy, without an explicit target zone model. The Krugman target zone model is different, since it has narrow bands around the nominal exchange rate.

In the target zone model, the exchange rate, s, defined as the domestic price of the foreign currency, is assumed to depend on the expected rate of depreciation of the domestic currency, $\frac{E(ds)}{dt}$, and a fundamental variable that consists of two components: the exogenous velocity component, v, and the endogenous money supply component, m:

$$s = m + v + \gamma \frac{E(ds)}{dt} \qquad (21)$$

The velocity is assumed to be a Brownian motion without a drift:[31]

$$dv = \sigma dz \qquad (22)$$

where σ is a constant and dz is the increment of a Wiener process.

With this assumption, a freely floating exchange rate would behave like a random walk. The central bank can control the money supply, and thus the exchange rate.

Figure 1.3 illustrates the relation between the exchange rate and the fundamental under both a free float and a target zone. The dashed FF is a 45-degree line for the free float, which is obtained by assuming that the exchange rate always is determined by the fundamental variables alone, $m+v$, and $\frac{E(ds)}{dt} = 0$. The target zone relation is given by the S-shaped solid curve TT where $s_{\max}$ and $s_{\min}$ capture the band.

The two main features of the Krugman model are depicted by the TT function: the "honeymoon effect" and the "smooth-pasting conditions". The honeymoon effect is related to the slope of the S-shaped curve being less than one at all times. When the

[31] Brownian motion is the continuous time version of a random walk, sometimes also referred to as a Wiener process.

exchange rate is closer to the upper band, the probability that the central bank will intervene to reduce the money supply to strengthen the currency is higher. Since the market expects the intervention, it will take the expected currency appreciation into account, and thus the increase in the exchange rate will be less than the change predicted by fundamentals alone. Put differently, for a given level of the fundamentals, the target zone exchange rate is less than the free-float exchange rate, implying a coordinating role for the band stabilizing market expectations. The same logic applies to the lower band.

The smooth-pasting characteristic is related to the slope of the S-shaped curve flattening to zero at the edges of the band. This property of the S-shaped curve eliminates one-way sure bets from the model. If the exchange rate were to simply bump into the edge of the upper band, for example, traders would be given a riskless profit opportunity. They could just sell the foreign currency right before the intervention and purchase it back right after intervention.

The basic target zone model by Krugman (1991) provides a role for official intervention and parity announcement to limit movements in exchange rates, however, since its assumption of flexible prices implies that the exchange rate should be equal to PPP value at every point in time, it does not generate swings in exchange rates.

Some economists have extended the basic target zone framework due to its poor empirical performance in terms of its predictions about the behavior of exchange rates under target zones and its assumptions of perfect credibility and marginal intervention.[32] Some have included intra-marginal interventions and imperfect credibility, but since these have kept the assumption of flexible prices, they do not generate swings in

[32] For detailed discussions of these models see Svensson (1992), Krugman and Miller (1992) and Sarno and Taylor (2002).

exchange rates.[33] The target zone models with sticky prices assume REH, in which case the exchange rate can experience one-time deviations from its PPP level, but then it should always move back to it. Therefore, as with the basic model, the modified target zone models do not generate swings in exchange rates.

Krugman and Miller (1993) provide an extension to the basic target zone model by incorporating market irrationalities captured by stop-loss trading. Stop-loss traders are risk averse investors that try to limit their potential losses from movements in exchange rates by specifying a particular level for the domestic price of foreign exchange at which they buy or sell domestic assets. There is a group of domestic investors that would sell their foreign asset holdings and purchase domestic assets if the domestic price of foreign exchange falls below some value s_{buy}. Similarly, there is group of foreign investors that sell all their domestic asset holdings and purchase foreign assets if the price rises above some value s_{sell}.

Krugman and Miller show that if the exchange rate is not allowed to vary enough to trigger loss-stoppers, as with a target zone, then speculation becomes stabilizing and the exchange rates exhibits the behavior shown in Figure 1.3. If the exchange rate is allowed to move beyond some threshold level that triggers stop-loss trading, then the domestic currency can exhibit what the authors call 'crashes' – "a cascading wave of sale that drives the value of the domestic currency abruptly down." (Krugman and Miller, 1993: 294)

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[33] The target zone model with intra-marginal intervention implies a TT function has a less pronounced S-shape and is flatter compared to the basic model. It also implies a role for managed floating regimes, in which case the exchange rate changes along an MM line that is flatter than the FF line in Figure 1.3.

Thus, when the exchange rate moves beyond some threshold level, stop-loss traders quickly bid the exchange rate up or down. However, such sharp movements in exchange rates can be hard to reconcile with persistent movements away from fundamental levels that sometimes last for several years. To generate such persistent movements in exchange rates away from parity, in this model the stop-loss exits from the domestic currency would need to occur in the same direction for extended periods of time such as 3-4 years, which is implausible. Moreover, it is not clear in the model how policy authorities can affect the exchange rate once it moves beyond the bands and the cascading wave begins.

To sum up, target zone models provide a role for central bank intervention and parity announcement to affect exchange rate movements, however these models do not generate swings in exchange rates. As such, they do not constitute models that provide a role for central bank policy to affect exchange rate swings.

4.2 Portfolio Balance Models

In this class of models, the level of the exchange rate is determined by the relative supply of and demand for financial assets.[34] Individuals maximize their expected return by diversifying their portfolio between domestic and foreign assets. One major assumption of these models is that individuals are risk averse, which implies that domestic and foreign assets are imperfect substitutes. Individuals expect to be compensated for the risk of holding a relatively larger supply of domestic or foreign assets with a relatively higher expected rate of return of the respective asset.

[34] The portfolio balance model is originally due to Kouri (1976) and Branson (1977).

The model can be presented by the following wealth identity and asset demand functions from the perspective of the domestic economy:

$$W_t = M_t + B_t^H + s_t B_t^F \tag{23}$$

$$M_t = M_t\left(i_t, i_t^* + \Delta s_{t|t+1}^e\right) W_t \tag{24}$$

$$B_t^H = B_t^H\left(i_t, i_t^* + \Delta s_{t|t+1}^e\right) W_t \tag{25}$$

$$s_t B_t^F = B_t^F\left(i_t, i_t^* + \Delta s_{t|t+1}^e\right) W_t \tag{26}$$

where W_t is the net private financial wealth in the domestic economy at time t, M_t is the time-t domestic money supply, B_t^H is the value of domestic bonds held by domestic residents at time t, B_t^F is the value of foreign bonds denominated in foreign currency held by domestic residents at time t, s_t is the level of the exchange rate at time t, defined as before to be the domestic currency units it takes to buy one unit of a foreign currency, $\Delta s_{t|t+1}^e$ is the expected rate of depreciation of the domestic currency from time t to time $t+1$, given by $\Delta s_{t|t+1}^e = \frac{s_{t+1}^e - s_t}{s_t}$, and i_t and i_t^* is the time-t domestic and foreign interest rate, respectively. Thus, i_t is the rate of return on the domestic currency, whereas $i_t^* + \Delta s_{t|t+1}^e$ is the expected rate of return on the foreign currency expressed in domestic currency units. Similar set of equations hold for the foreign economy.

The assumption of imperfect substitutability between domestic and foreign assets implies the existence of a risk premium, ρ_t, defined as the expected excess return on domestic assets over foreign assets:

$$\rho_t = i_t - i_t^* - \Delta s_{t|t+1}^e \tag{27}$$

In the basic portfolio balance model, the risk premium is a positive function of the stock of domestic asset supplies and a negative function of the stock of foreign asset supplies, which are denoted by, B and B^*, respectively:[35]

$$\rho_t = g_t\left(B_t, B_t^*\right) \tag{28}$$

which, assuming a linear relationship and using (27) with REH, becomes:

$$i_t - i_t^* - \Delta s_{t+1} = \theta_1 B_t + \theta_2 B_t^* \tag{29}$$

where $\theta_1 > 0$ and $\theta_2 < 0$.

In the portfolio balance model the exchange rate is determined by the relative supply of domestic and foreign assets. Thus, in this model official intervention can influence the exchange rate by changing the relative supply of these assets, called the portfolio balance channel of official intervention. When intervention changes the relative supply of domestic and foreign assets, the exchange rate must change because risk-averse individuals have to be compensated with a higher expected rate of return on foreign (or domestic) denominated assets to continue holding the relatively larger stock of these assets. Assume, for example, that the central bank engages in foreign exchange intervention by selling domestic bonds and purchasing foreign bonds.[36] Now, if individuals are indifferent in holding domestic versus foreign bonds (i.e., the two assets are perfect substitutes), then they would simply be willing to hold the larger amount of

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[35] In the mean-variance optimization framework of the portfolio balance model, the risk premium is a function of the mean and variance of domestic and foreign assets. The logic of the effect of official intervention on the exchange rate, however, does not change. This version of the model is discussed in Chapter 2, Section 2.1.4, in the context of testing the effects of intervention on the exchange rate.

[36] This is an example of sterilized intervention, where following the intervention, the domestic money supply remains unchanged. For a more detailed discussion on sterilized intervention, see Chapter 2.

domestic bonds at the same expected rate of return. If, however, individuals are risk averse, which means that they now view domestic bonds as being riskier than foreign bonds due to their larger supply, then they will be willing to hold the larger stock of domestic bonds only if they are compensated for the higher risk by a higher expected rate of return compared to foreign bonds, which would necessitate a rise in the current exchange rate.[37]

To conclude, portfolio balance models provide a role for official intervention to affect the exchange rate, however, because they rely on REH to model expectations, they do not generate swings. By construction, these models do not provide any role for parity announcement to limit swings in exchange rates. Furthermore, as will be discussed in the next chapter, empirical tests of these models have produced very poor results. It appears that the assumption of REH is one factor that contributes to the poor empirical performance of these models.[38]

5 Conclusion

This chapter provided a survey of the theoretical exchange rate literature on exchange rate swings and the theoretical literature on the effects of official intervention and parity announcement. The major conclusion of the chapter is that there is no overlap

[37] From domestic investor's point of view, a higher current exchange rate implies a lower expected depreciation of the domestic currency against the foreign currency. This leads to a lower expected rate of return on the foreign currency, making domestic assets more attractive. From a foreign investor's point of view, a higher current exchange rate implies a higher expected rate of return on the domestic currency since a higher current exchange rate implies a higher expected future depreciation of the foreign currency against the domestic currency. Again, this makes domestics assets more attractive.

[38] Another factor is their specification of preferences that are based on the empirically-not-supported assumptions of risk aversion and expected utility theory. For a discussion of these issues refer to Frydman and Goldberg (2007).

between the two research areas – there is no exchange rate model that provides an explanation of swings and also a role for official intervention and parity announcement to affect exchange rate movements.

The first part discussed the REH bubble, behavioral and post-Keynesian approaches that, for the most part, explain exchange rate swings as movements away from levels based on macroeconomic fundamentals and/or arising from bubbles, irrationality and market psychology. The main argument that arises from the discussion of these models is that since macroeconomic fundamentals are not part of the explanations for exchange rate swings, these models do not provide a role for central bank intervention and parity announcement based on such fundamentals to affect swings in exchange rates.

The second part of the chapter discussed a different array of research in which economists have put aside the question of what drives swings in exchange rates and have concentrated on the policy question of what officials can do to limit these swings. The main point of the discussion of the two main models in the literature - the target zone and the portfolio balance models – is that although they offer some role for official intervention and parity announcement to influence exchange rate movements, because they rely on REH, they do no generate swings. Consequently, these models provide no insight into the ability of official intervention and parity announcement to limit the magnitude of exchange rate swings.

The main conclusion of this chapter is that there is need for a model that not only provides an explanation for exchange rate swings but also offers a role for official intervention aimed at pushing the exchange rate back to some parity level.

Figure 1.1: Spot German Mark/U.S. Dollar Exchange Rate and its PPP Level

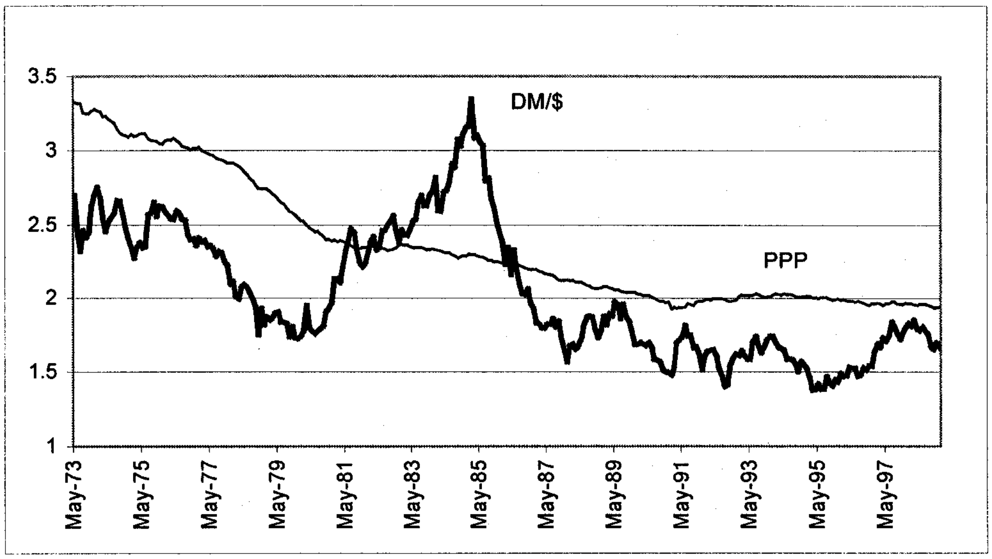


Figure 1.2: Spot Japanese Yen/U.S. Dollar Exchange Rate and its PPP Level

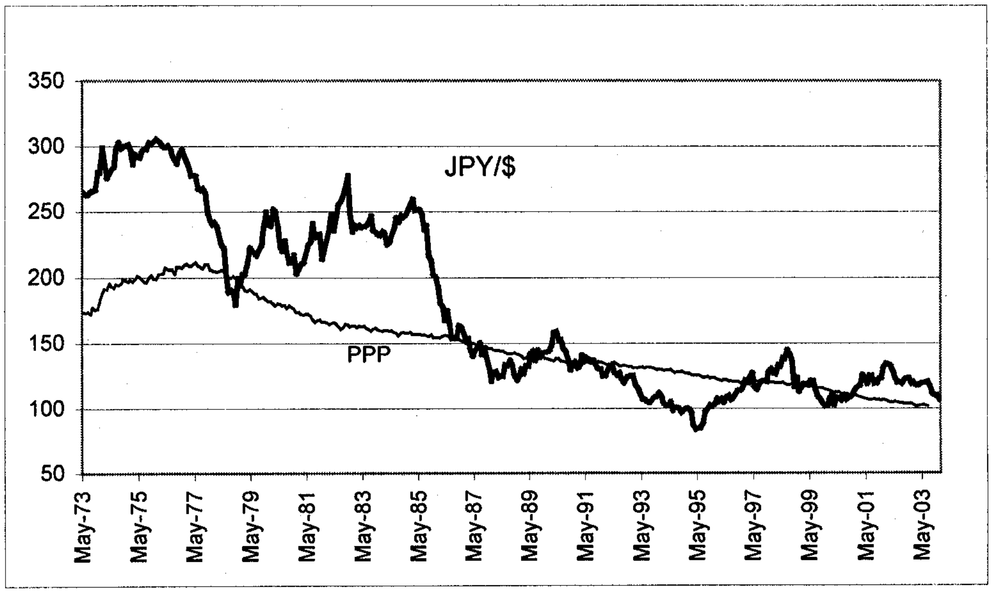
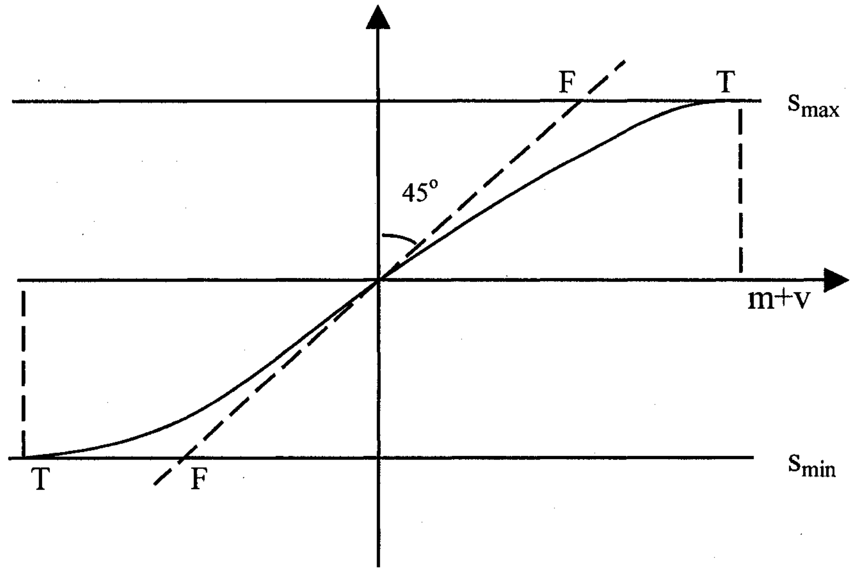


Figure 1.3: The Basic Target Zone Model



CHAPTER 2

RECONSIDERING THE EMPIRICAL EVIDENCE OF THE INEFFECTIVENESS OF OFFICIAL INTERVENTION

1 Introduction

The monetary authorities of many open economies have been regularly intervening in foreign exchange markets for years with the aim of limiting volatility in the exchange rate and/or pushing the exchange rate back to some desired level.

Whether official intervention has produced the intended results has been a popular research topic. Numerous studies have tested whether intervention succeeds in turning around the exchange rate in the few days, weeks or months following interventions. The major finding of studies investigating the effectiveness of official intervention is that such action has a significant but short-lasting effect on the exchange rate (up to 3 months). These studies are reviewed in Section 2.

In many countries official intervention has been accompanied by the announcement of some parity level by the central bank.[1] Such announcement of parity presumes that macroeconomic fundamentals matter for exchange rate movements. While studies estimating the conventional exchange rate models find that fundamentals do not matter for exchange rates, other studies provide strong evidence that they do. Among these are studies that test for the importance of news releases regarding macroeconomic

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[1] And the defense of this parity or bands around the parity.

fundamentals on exchange rates, which find strong evidence of exchange rate reaction to news. The importance of fundamentals for exchange rates is also supported by survey studies. These findings provide evidence that macroeconomic fundamentals are important for exchange rate movements, suggesting that, because exchange rate parities used by the authorities are based on fundamentals, perhaps the announcement of some parity by central banks may matter for short-run exchange rate movements. Furthermore, there are studies that have investigated the effects of official communication by authorities on their views about the stance of the exchange rate in relation to macroeconomic fundamentals. Findings indicate almost unanimously that such exchange rate communications have a significant effect on exchange rate movements. These findings imply that market participants care about central bank announcements and policy makers' views as to whether exchange rates are over- or undervalued in relation to the parity level they consider relevant. This suggests that market participants would also care about central bank announcements of a parity level.

The major conclusion from the survey of the empirical studies testing the effectiveness of official intervention and official communication is that such policy has a significant but short lasting effect on exchange rates. Studies have reached this conclusion by testing whether central bank intervention is effective in turning around the exchange rate. The finding that such central bank policy can move the exchange rate in the desired direction is important for my analysis. It implies that the central bank can inflict pain on traders who bet on the continuation of the exchange rate movement in the direction opposite to the one desired by policy officials. Since most central banks intervene in the foreign exchange market with the aim of pushing the exchange rate back to some parity level, official intervention that is successful in turning around the exchange rate will inflict pain on traders who bet on a movement away from such parity levels. As will be discussed in Chapter 3, this finding is important for the effectiveness of a new channel through which official intervention supporting some parity level can affect exchange rate movements. The implications of the results on the short-run effectiveness of official intervention for my model in Chapter 3 are discussed in Section 2.5 of the current chapter.

While the studies testing the effectiveness of official intervention provide valuable evidence on the short-run effectiveness of such exchange rate policy, they have missed an important question. That question is whether intervention and communication is effective in terms of limiting swings in exchange rates. Studies have mostly tested whether intervention has been effective in turning around the exchange rate over the few days, weeks or months following the intervention(s). There are only three studies that have investigated if intervention leads to more limited swings in exchange rates.[2] While they provide evidence that such policy can limit swings in exchange rates, I argue that they are flawed because they do not allow for individual creativity in choosing and revising forecasting strategies. These studies are discussed in more detail in Section 3.

2 The Effectiveness of Official Intervention: Empirical Evidence

The literature has explored three ways in which sterilized official intervention (defined below) may affect the exchange rate: 1) it may alter the relative supply of domestic and foreign assets (the portfolio-balance channel); 2) it may act to coordinate

[2] These are Kubelec (2004a,b) and Taylor (2004).

individual expectations (the coordination channel); or 3) it could affect expectations about future exchange rates, by signaling changes in monetary policy (the signaling channel). Official exchange rate communication, on the other hand, can influence the exchange rate through the signaling and coordination channels.

Official intervention is said to be *nonsterilized* if the sale or purchase of foreign currency by the authorities is allowed to change the monetary base, and it is *sterilized* if the change in the monetary base is offset by the sale or purchase of domestic securities.[3] There is a consensus among economists that nonsterilized intervention will have a significant and long-lasting effect on the behavior of the exchange rate through its direct effect on interest rates. For example, Fatum and Hutchison (1999: 54) state that "few doubt that unsterilized intervention may affect nominal exchange rates by changing interest rates on monetary aggregates." In fact the effectiveness of nonsterilized intervention has been supported by two studies that also test for the effectiveness of sterilized intervention.[4] Nevertheless, this remark is rather interesting given the major finding of the empirical studies on exchange rate determination that were discussed in Chapter 1. These studies failed to find a significant relationship between macroeconomic fundamentals and the exchange rate, and this conclusion led the majority of researchers to explain exchange rates as being detached from fundamentals and being driven by irrationality. According to these studies, because fundamental variables do not matter for exchange rates, although nonsterilized intervention affects interest rates, the change in

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[3] An example of sterilized in intervention would be the sale of foreign currency and purchase of domestic securities of the same value, in which case there is a change in the composition of domestic and foreign assets holdings of the central bank, but there is no change in the monetary base.

[4] These studies are Obstfeld (1983) and Kearney and MacDonald (1986).

interest rates would not influence exchange rate movements. Nevertheless, studies have assumed that nonsterilized intervention has an effect on exchange rates, and have concentrated on testing the effectiveness of sterilized intervention through one of the three channels listed above.

2.1 The Portfolio Balance Channel

The portfolio-balance model that I discussed in Chapter 1 implies that official intervention will affect the exchange rate through a *portfolio balance channel.* Tests of the portfolio balance channel have taken one of four forms: the direct demand approach, the indirect demand approach, the macroeconomic model approach, and the mean-variance optimization framework. Except for a few, studies have failed to provide support for this channel of intervention, suggesting that official intervention has no impact on exchange rates by changing the relative supply of domestic and foreign assets.[5]

2.1.1 The Direct Demand Approach. The direct demand approach involves testing the explanatory power of the portfolio balance model by using the structural asset demand equations given in Chapter 1. Good explanatory power of the expected returns on domestic and foreign assets is interpreted as evidence for the existence of the portfolio balance channel of official intervention. Recall from the discussion in Chapter 1 that in the portfolio balance model official intervention can influence the exchange rate by changing the relative supply of domestic and foreign assets. Because domestic and foreign assets are assumed to be imperfect substitutes, when intervention changes the relative supply of these assets, the expected rate of return on foreign (or domestic)

[5] For a review of studies discussed in this section as well as other studies, see Dominguez and Frankel (1993b), Edison (1993), Rogoff (1984), Taylor (1995) and Sarno and Taylor (2001, 2002).

denominated assets must rise for individuals to continue holding the relatively larger stock of these assets. This requires a move in the exchange rate.

Most studies that use this approach provide no support to the portfolio balance model, suggesting that official intervention, which does change relative asset supplies, has no significant effect on the exchange rate.

Frankel (1984), for example, estimates the structural asset demand equations of portfolio balance models for five currencies against the U.S. dollar on a monthly basis: the Canadian dollar, French frank, German mark, Japanese yen and British pound for mid-1970s to early-1980s. He finds that the asset and wealth variables in most of his regressions are either insignificant or significant but of the wrong sign.

Similar results are reported by Bisignano and Hoover (1982) for the U.S. dollar/Canadian dollar exchange rate between March 1973 and December 1978, and Lewis (1988) for Canada, Germany, Japan, the U.K. and the U.S. between January 1975 and December 1981. Asset supplies are found to enter the regressions generally insignificantly or with the wrong sign. The main problem with these studies is that asset supplies are not variable enough to explain the highly variable expected returns.

2.1.2 The Indirect Demand Approach. The indirect demand approach involves expressing the portfolio balance model in terms of a risk premium, and testing the following relationship between the risk premium and the stock of domestic and foreign asset supplies:[6]

$$i_t - i_t^* - \Delta s_{t|t+1}^e = \theta_1 B_t + \theta_2 B_t^* \qquad (1)$$

[6] See Chapter 1, Section 4.2.

The most common practice in estimating this equation is to invoke rational expectations, thereby implying a joint test of asset substitutability and rational expectations.[7] [8] Since official intervention through the portfolio balance channel affects the exchange rate by changing the relative supply of domestic and foreign assets, such a policy will have an effect on the exchange rate only if these assets are imperfect substitutes. Thus, studies testing for the portfolio balance channel by using this approach have generally done so in two stages. First they have performed the joint test of asset substitutability and rational expectations. Rejecting the null hypothesis implies that *possibly* domestic and foreign assets are imperfect substitutes. However this is not enough for arguing in favor of the portfolio balance channel because rejecting the null hypothesis could be due to the rejection of REH and not the rejection of asset substitutability. The existence of a portfolio balance channel is supported if in addition to rejecting the null hypothesis, results also provide coefficient estimates on bond holdings by domestic and foreign residents that are significantly different from zero ($\theta_1 > 0$ and $\theta_2 < 0$).

Studies that have tested for the effectiveness of official intervention using this approach have also generally failed to provide support for the portfolio balance model. Although the joint null hypothesis of asset substitutability and rational expectations has been regularly rejected, tests have failed to find significant coefficients on bond supplies.

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[7] Asset substitutability implies that domestic and foreign assets are perfect substitutes.

[8] There is a related literature that tests jointly for asset substitutability (or risk neutrality) and rational expectations by estimating this equation but in the context of market efficiency, rather than the effectiveness of official intervention. The joint null hypothesis of asset substitutability and rational expectations has been regularly rejected. For a review see Taylor and Sarno (2002). This finding in the literature has also been interpreted as irrationality driving exchange rates and irrelevance of exchange rate models.

Danker et. al (1987), for example, employ both the direct and inverted demand approaches using the monthly U.S. dollar exchange rate with respect to the Canadian dollar, German mark and Japanese yen between early- to mid-1970s and early-1980s. The authors reject the joint hypothesis that domestic and foreign assets are perfect substitutes and that expectations are rational for Canada and Germany. However, their risk premium equations fail to provide any support for the portfolio balance model with the Canadian dollar and provide limited support for the German mark: although most coefficients are of the correct sign, they are not always significant, and some coefficients are of the wrong sign.

Similarly, Loopesko (1984) strongly rejects the joint hypothesis of perfect asset substitutability and rational expectations, but she finds significant coefficients on bond supplies of the correct sign for only about half of the total cases and subsamples (thirteen out of twenty four) she considers in her study. The author estimates an equation for the risk premium for the daily U.S. dollar exchange rate vis-à-vis the British pound, Canadian dollar, French franc, German mark, Italian lira and Japanese yen from the mid- to late-1970s through late 1981 by including lagged values of the premium, the exchange rate and cumulative official intervention.

Frankel (1982a) reports results that fail to reject the null hypothesis of zero coefficients, and thus provide no support for the portfolio balance model. He uses monthly data on U.S. and Germany from January 1974 to October 1978 to estimate a variant of equation (1). A similar approach was adopted by Rogoff (1984) with a higher frequency (weekly) data on the Canadian dollar/U.S. dollar exchange rate for different subsamples between March 1973 and December 1980. Similarly to the earlier results by

Frankel (1982a), Rogoff fails to find statistically significant coefficients for asset supplies.

Ghosh (1992) adopts a different approach. He tests the portfolio balance effect by controlling for any signaling effects for the monthly U.S. dollar/ German mark exchange rate between October 1979 and November 1988. To do so, he first estimates a monetary model in which the current exchange rate is expressed as the present discounted value of money supply and income differentials. In this way he assumes that the spot exchange rate today is solely determined by the future values of these fundamental variables, which are known today, which is hard to justify. After estimating the monetary model, he allows for a risk premium based on variables in the portfolio balance model.[9] Since the monetary model captures any signaling effects, any additional explanatory power of the portfolio balance variables should be due to the portfolio balance channel.[10] Ghosh provides a statistically significant, but weak influence of intervention on the exchange rate through the portfolio balance channel. He states that: "it should be noted that very substantial intervention would be required to influence the exchange rate through portfolio balance effects... The portfolio balance channel of sterilized intervention may thus remain a theoretical curiosum rather than a practical policy tool." (Ghosh, 1992: 219)[11] Furthermore, because of the way in which Ghosh tests for the signaling channel, namely by expressing the current exchange rate as the present discounted value of money supply

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[9] The explanatory variables that Ghosh considers for the portfolio balance model are the total value of asset supplies and change in reserves corrected for valuation effects.

[10] Ghosh does not test for a specific time frame for the effectiveness of official intervention.

[11] Frankel (1985) also shows analytically that it would take a very large amount of intervention to affect the course of the exchange rate through a risk premium effect.

and income differentials, his results would also imply that non-sterilized intervention would not work either.

In sum, studies testing the portfolio balance channel of official intervention by utilizing the inverted demand approach provide no support to the hypothesis that central bank intervention can affect the exchange rate by changing the relative supplies of domestic and foreign assets. According to these studies, official intervention does not seem to influence the exchange rate through the portfolio balance channel.

2.1.3 The Macroeconomic Model Approach. A third way in which researchers have tested for the effectiveness of official intervention through the portfolio balance channel has been by estimating a fully specified macroeconomic model that incorporates portfolio balance equations. Studies that have used this approach to test for the effectiveness of official intervention have provided mixed results.

Obstfeld (1983), for example, has investigated the effectiveness of official intervention in Germany using monthly data between January 1975 and October 1981 by estimating a structural portfolio balance macroeconomic model. The author first estimates a portfolio balance model, and then simulates this empirical model to compare for the effectiveness of sterilized and nonsterilized intervention. The study concludes that sterilized intervention does not appear to have had an effect on the German mark/U.S. dollar exchange rate through the portfolio balance channel, but that "these findings leave open the possibility that sterilized foreign exchange market intervention has significant but short-lived exchange rate effects that disappear within a month." (Obstfeld, 1983: 185) Nonsterilized intervention, however, appears to have had a strong impact on the exchange rate. This result provides further support to the importance of macroeconomic fundamentals for exchange rate movements.

Kearney and MacDonald (1986) follow a similar approach for the U.K. using quarterly data between 1973 quarter 2 and 1983 quarter 4. In contrast to Obstfeld (1983), Kearney and MacDonald (1986) provide evidence that both sterilized and nonsterilized intervention, as proxied by the change in foreign exchange reserves, have had a statistically and qualitatively significant impact on exchange rates.[12] The finding on the effectiveness of nonsterilized intervention does once again provide evidence that macroeconomic fundamentals are important for exchange rates. Furthermore, Kearney and MacDonald (1986) also find that the effects of sterilized intervention on the exchange rate have lasted up to one year. This finding of a long lasting effect of official intervention on exchange rates supports the idea that such policy could lead to swings of smaller magnitude. This finding stands out distinctively compared to other studies that have tested any of the three channels through which sterilized intervention can affect the exchange rate. The reason is partly because the majority of studies have only looked at the short-term effectiveness of intervention, not testing for the effects of intervention on exchange rates beyond a few months. Another reason might be their use of foreign exchange reserves to proxy official intervention.[13] In contrast, Obstfeld (1983) and other studies have relied on some aggregate monetary data.

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[12] The authors mention that the difference in their results on sterilized intervention from those reported by Obstfeld (1983) to the less than perfect capital mobility in the U.K. in the period considered due to institutional arrangements.

[13] In my empirical analysis, I also use changes in foreign exchange reserves to proxy official intervention.

2.1.4 The Mean-Variance Optimization Framework. In the mean-variance optimization framework, the expected rate of return on foreign exchange is linked to asset supplies by imposing the constraint that the coefficients of an inverted asset-demand function are related to the variance covariance matrix. According to this approach, empirical evidence indicating the existence of a risk premium is interpreted as evidence of the effectiveness of official intervention through the portfolio balance channel.

Within this framework, individuals maximize a function of the mean and the variance of their final wealth, W_{t+1}, which depends on real returns and the portfolio allocation:[14]

$$W_{t+1} = W_t + W_t a_t r_{t+1}^* + W_t(1-a_t)r_{t+1} = W_t\left[a_t\left(r_{t+1}^* - r_{t+1}\right) + 1 + r_{t+1}\right] \quad (2)$$

where W_t is initial real wealth, a_t and $(1-a_t)$ are the portfolio shares of foreign and domestic assets at time t, respectively, and r_{t+1} and r_{t+1}^* stand for the domestic and foreign rates of real return in terms of the domestic currency from time t to $t+1$, respectively. Since the real rate of return is equal to the nominal rate of return less the inflation rate ($r_{t+1} = i_t - p_t$ and $r_{t+1}^* = i_t^* + \Delta s_{t|t+1}^e - p_t$), equation (2) can be rewritten as:

$$W_{t+1} = W_t\left[a_t\left(i_t^* - i_t + \Delta s_{t|t+1}^e\right) + 1 + i_t - p_t\right] \quad (3)$$

It is assumed that investors determine the portfolio shares on domestic and foreign assets by maximizing a function of the expected value and variance of final wealth, in which case equation (1) becomes:

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[14] See Frankel (1982b) and Dornbusch (1983).

$$i_t^* - i_t + \Delta s_{t|t+1}^e = \rho_t \Omega (a_t - \delta) \tag{4}$$

where Ω is the variance-covariance matrix of expected currency depreciation, and δ is the consumption share of foreign goods.

Rejecting the null hypothesis of no risk premium would imply that domestic and foreign assets are imperfect substitutes. This would be an indication that the portfolio balance channel does exist.

Studies using this approach have reported mixed findings. Frankel (1982b), for example, estimates equation (4) with monthly data for Canada, France, Germany, Japan, the U.K. and the U.S. from June 1973 to August 1980, and fails to reject the null hypothesis of no risk premium. Frankel and Engel (1984), on the other hand, use the same dataset but report results that fail to provide support for the model.[15]

By contrast, Dominguez and Frankel (1993a,c) provide evidence of a significant portfolio balance channel. They estimate a risk premium equation within a mean-variance optimization framework, similar to equation (4), and find a statistically significant portfolio effect on the U.S. dollar/ German mark exchange rate for different subsamples between November 1982 and December 1988. The findings of this study stand in contrast to the general findings of the empirical studies on the portfolio balance channel, which conclude that the effect of official intervention on the exchange rate through this channel is insignificant. One clear difference between their study and other studies is their use of actual intervention data to capture changes in asset supplies. [16] [17] Another distinguishing

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[15] Frankel and Engel (1984) allow for inflation risk.

[16] Previous studies have proxied changes in asset supplies by using some type of aggregate data, such as total government debt (Lewis, 1988), net private holdings of domestic bonds by domestic residents (Danker

factor of the studies by Dominguez and Frankel has been their use of survey data (from the Money Market Services International, MMS), instead of relying on REH for expectations.[18] This suggests that the assumption of REH might be a strong contributing factor to the failure to find significant effects of intervention on the exchange rate through the portfolio balance channel. I view results that are obtained by using survey data as more reliable because they capture market's expectations about the future exchange rate rather than deriving markets' exchange rate forecasts by using some rule that the researcher believes all market participants will follow.[19]

2.2 The Coordination Channel

The *coordination channel*, suggested by Sarno and Taylor (2001), and also discussed by Morris and Shin (2002) and Amato et.al. (2003), works by coordinating individual expectations, so that expectations converge on models that drive the exchange rate towards parity levels.

Morris and Shin (2002) and Amato et.al. (2003) develop a model with no specific reference to exchange rates that incorporates the signaling and the coordination channel. In this model individuals try to maximize their return by taking the appropriate action that is driven by two factors. One factor is the desire to match the price of an asset to

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et.al., 1987), or net private holdings of domestic bonds plus the monetary base (Rogoff, 1984). These data are likely to entail a high degree of measurement error.

[17] Loopesko (1984) also uses actual intervention data but her results provide support to the portfolio balance channel only for half of her sample.

[18] Survey data are four-week ahead surveys on a weekly basis starting October 24, 1984, and three-month ahead on a bi-weekly basis before that.

[19] In this dissertation I also utilize survey data to capture exchange rate expectations. The data are described in Chapter 4.

fundamentals, as conveyed by public and private information (the signaling channel). The other factor is the coordination motive, i.e. trying to guess the actions of other individuals: the smaller is the distance between an individual's own action and the average opinion of other individuals, the larger his return is. Morris and Shin (2002: 1-2) state that communication not only conveys information about macroeconomic fundamentals, but it also "serves as a focal point for the beliefs of the group as whole", and thus it "serves as a coordination device."

In the context of the foreign exchange market, this discussion on the coordination channel could be interpreted as official communication or parity announcement by the central bank coordinating exchange rate expectations towards the exchange rate level desired by policy authorities.

So far, no explicit theoretical or empirical work has been done on the coordination channel in the context of the foreign exchange market. Nevertheless, the findings on the signaling channel, discussed next, can be viewed as providing findings on the coordination channel as well. I discuss why that is the case below.

2.3 The Signaling Channel

The *signaling or expectations channel* was first considered by Mussa (1981). With this channel, intervention affects the exchange rate by providing the market with information about future monetary policy, future intervention policies, and/or information about relevant economic fundamentals. Credible information about the future level of the money stock, for example, will lead to a change in the expected future spot rate, which will bring about a change in the current rate.

It is interesting to note that the way in which the signaling channel is supposed to affect the exchange rate, namely by providing the market with information about future policies and macroeconomic fundamentals, is at odds with exchange rate studies that have concluded that fundamentals do not matter for exchange rates.[20] If it were in fact the case that fundamentals are not important for exchange rates, then one would expect that empirical studies would fail to provide any support for the signaling channel. This, however, is not the case. Although some studies fail to produce results of a significant signaling channel, most provide support for a significant effect of official intervention on exchange rates through this channel. This suggests that macroeconomic fundamentals do indeed matter for exchange rate movements.

Tests of the signaling channel fall in two general groups: testing whether intervention signals a change in monetary policy assuming that the latter will have an effect on exchange rate expectations, or testing the impact of intervention on exchange rate expectations. It should be noted that since both of these approaches are based on the effects of intervention on exchange rate expectations, results obtained by using either approach can be interpreted as evidence not only on the signaling channel but also on the coordination channel. None of the studies discussed in this section have interpreted their findings in terms of the coordination channel since it was only recently introduced. But it is possible that the effect of intervention on exchange rate expectations works through either or both of these channels.

<u>2.3.1 Intervention as Signaling Future Monetary Policy.</u> This approach assumes that monetary policy matters for exchange rates, and the argument is that if intervention

[20] See Chapter 1, Section 2.

does provide the right signals about future changes in monetary policy, then intervention will also matter for exchange rates. Therefore, studies that have used this approach have generally tested if there is high correlation between intervention and future monetary policy. They have interpreted their results of a significant relationship between intervention and future monetary policy as an indication that the signaling channel exists. Studies in this category in general provide support for the signaling channel by reporting a significant relationship between intervention and monetary policy. One study, Lewis (1995), identifies a short-term (up to 2 weeks) relationship between intervention and monetary policy variables (discussed below).

Fatum and Hutchison (1999) directly estimate the effect of U.S. daily intervention on changes in expected monetary policy, which is captured by changes in the one- and two-month federal funds futures rate between March 1989 and December 1993. They conclude that their "results suggest that it is difficult to identify a clear and effective "signaling" channel" (Fatum and Hutchison, 1999: 67). Watanabe (1994), on the other hand, provides evidence that official interventions by the Bank of Japan, measured by the yen value of the net purchases of foreign currencies, have been highly correlated with Japanese monetary policy, as captured by the discount rate and M2 plus certificates of deposit, between April 1973 and April 1992. The argument is that, because a reduction in the discount rate leads to a depreciation of the yen, such a policy should be negatively correlated with official intervention as defined above. Thus, this study supports the existence of a signaling channel of official intervention.

Lewis (1995) examines whether daily official intervention by the Federal Reserve helps predict future changes in monetary policy from 1985 to 1990, as captured by M1, monetary base, nonborrowed reserves and the federal funds rate. She also looks at reversed causality – whether changes in monetary policy help predict intervention. Her results provide support for significant effects within a 2-week period in both directions. Acknowledging the poor empirical support for the theoretical exchange rate models, she also investigates the effects of changes in monetary variables on the exchange rate. To that end, she examines the impulse response functions of the German mark/U.S. dollar and the Japanese yen/U.S. dollar exchange rates to the U.S. monetary variables.[21] Her findings suggest that changes in monetary policy variables have a significant effect on the exchange rate, however, except for M1, there is little contemporaneous effect.[22] These results provide evidence of a signaling channel and also suggest that, contrary to the findings of empirical studies on exchange rate determination that were discussed in Chapter 1, macroeconomic fundamentals are important for exchange rates movements.

Similarly, Kaminsky and Lewis (1996) strongly reject the hypothesis that U.S. intervention provides no information about future U.S. monetary policy, as proxied by the federal funds rate, M1 and nonborrowed reserves. They also find that from September 1985 to February 1990 U.S. official intervention had no independent effect on the U.S. dollar/German mark and U.S. dollar/Japanese yen exchange rates, and that exchange rates tend to move in the direction of actual monetary policy, even if this is opposite to the direction of official intervention.[23]

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[21] In a second set of regressions she controls for the foreign monetary variables.

[22] Controlling for foreign monetary variables, the effect of a positive shock to M1 is an immediate depreciation of the dollar and lasts for about 12 weeks. The effects of a positive shock to nonborrowed reserves lasts for about 20 weeks, and the effect of a positive shock to the federal funds rate becomes significant after 6 weeks.

[23] The first result is also supported by the game-theoretic framework developed by Reeves (1997).

2.3.2 Impact of Official Intervention on Exchange Rate Expectations. Studies analyzing the impact of official intervention on exchange rate expectations have produced mixed results. The main determining factor behind the difference in results seems to be the way in which they have measured exchange rate expectations. Studies using the forward rate fail to report a significant effect of intervention on exchange rate expectations. Studies that have used survey data, on the other hand, have reported significant effects. It has been established by many studies that the forward rate is a poor proxy for exchange rate expectations.[24] Moreover, as I argued before, I view the use survey data to capture exchange rate forecasts to be superior to assuming how market participants form their forecasts and capturing these forecasts by using a specific aggregate measure, such as the forward rate. Although there are some bias problems with forecasts from survey data, most researchers believe that even if there are biases in the forecast data they are not systematic. Therefore, the conclusion for this section is that official intervention seems to have a significant effect on exchange rate expectations when the latter are captured by survey forecasts.

Galati and Melick (1999) use the forward rate for exchange rate expectations and provide little support to the signaling channel. They analyze the effects of *perceived* intervention by the Federal Reserve and the Bank of Japan, based on Reuters reports, on the expected distribution of future Japanese yen/U.S. dollar exchange rate using daily data between September 1993 and April 1996. They estimate an equation that relates the moments of the distribution to the lagged values of the moments, lagged intervention and several lagged macroeconomic variables by instrumenting intervention with a reaction

[24] For review and references, see Sarno and Taylor (2001).

function for the Federal Reserve and the Bank of Japan. The results provide little evidence of a significant contemporaneous or subsequent effect of intervention on the expected exchange rate. Galati, Melick and Micu (2005) follow a similar approach and also find that official intervention by the Federal Reserve and the Bank of Japan had no statistically significant effect on the expected mean or higher moments of the daily Japanese yen/U.S. dollar exchange rate between September 1993 and April 2000.

Dominguez and Frankel (1993b) capture exchange rate expectations with survey data and find that exchange rate policy announcements and reports of intervention have significant effects on exchange rate expectations. They examine the effects of official intervention by the Federal Reserve and the Bundesbank on the bi-weekly, three-month ahead forecasts of the German mark/U.S. dollar exchange rate between November 1982 and October 1984. The authors estimate the following equation for exchange rate expectations, which captures the changes in the forecasted exchange rate during the day on which interventions take place and news reports of exchange rate policy get released:

$$\begin{aligned}\left(\hat{s}^e_{t,k} - \hat{s}^e_{t-j,k}\right) = \alpha_0 + \alpha_1\left(s_t - s_{t-j}\right) + \alpha_2\left(s_t - \hat{s}^e_{t-j,k}\right) + \\ \alpha_3 NEWS_t + \alpha_4 REPINT_t + \alpha_5 SECINT_t + \varepsilon_t\end{aligned} \tag{5}$$

where $\left(\hat{s}^e_{t,k} - \hat{s}^e_{t-j,k}\right)$ is the revision in the log survey forecast of the k-period ahead spot exchange rate from time $t-j$ to time t, s_{t-j} is the log of the spot exchange rate on the day of the last survey, the $NEWS_t$ is official news reports of exchange rate policy a time t, $REPINT_t$ is the reports of unilateral and coordinated interventions, and $SECINT_t$ is the official interventions that have not been reported in the press (i.e. secret interventions).[25] Findings indicate that exchange rate policy announcements and reported intervention have significant effects, while secret interventions have no effect on exchange rate expectations.

The findings by Dominguez and Frankel (1993b) of a significant signaling channel have also been supported by Dominguez and Frankel (1993c) with a similar strategy again for the German mark/U.S. dollar but from 1982 to1988. Another major finding of Dominguez and Frankel (1993b,c) is that the effectiveness of intervention is considerably enhanced if it is publicly announced.[26]

2.3.3 Summary of the Empirical Evidence on the Signaling Channel. Most of the empirical studies on the signaling channel conclude that official intervention has a significant influence on the exchange rate through this channel, either by signaling future monetary policy or by affecting exchange rate expectations. Since in this channel intervention affects the exchange rate by providing the market with information about future policies and macroeconomic fundamentals, these findings suggest that fundamental variables are important for exchange rate movements. But if macroeconomic fundamentals matter for exchange rates, then this implies that perhaps some parity announcement by central banks based on such fundamentals might have a significant effect on exchange rate movements.

[25] The official news reports of exchange rate policy are collected from the *Wall Street Journal*, the *Financial Times* (London) and the *New York Times*.

[26] This result has received general support in the literature. See Blinder (1998) and Bernanke (2004). See also the discussion on official exchange rate communication in Section 2.4.

2.4 General Studies on the Effectiveness of Official Intervention and Official Communication

Many studies have tested the effectiveness of official intervention without being able to distinguish between the different influence channels. Most of these studies consider some measure for intervention and test for its effects on the exchange rate. Thus, these studies only provide evidence as to whether intervention has been effective in turning around the exchange rate and if so, over what time frame. Few of the studies include some macroeconomic variables in their analysis and thus also provide evidence that macroeconomic fundamentals are important for exchange rates. The majority of the studies find that official intervention has a significant but short-lasting (up to 3 months) effect on exchange rates.

Some of the studies surveyed in this section have also tested for the effects of official communication on exchange rates and almost all of these have reported significant results (up to 40 days following interventions). This last result is especially important for my analysis, since it shows that views of monetary authorities on the stance of the exchange rate are important for the exchange rate. This further supports the idea presented above - that some parity announcement by central banks might also have a significant role in affecting exchange rate movements.

Humpage (1988) reports a significant effect of intervention on the exchange rate that lasts **one day**. He studies the effect of intervention by the Federal Reserve on the daily German mark/U.S. dollar and Japanese yen/U.S. dollar exchange rates for five sub-periods between August 1984 and August 1987. He regresses the spot exchange rate on lagged initial intervention, lagged subsequent intervention and a lag of the spot rate. An intervention is defined as initial intervention if there has been no intervention in the previous five business days. If there has been intervention in the previous five business days, then such intervention is identified as subsequent intervention. Initial intervention captures the news component of intervention, while subsequent intervention captures the effect of the intervention itself. Results suggest that official intervention can have an announcement effect on the exchange rate that lasts only one day. Moreover, the size and duration of an announcement effect seems to be bigger if the market associates the intervention with monetary and fiscal policy changes. This result provides further support to the importance of macroeconomic fundamentals for exchange rates. Subsequent intervention, on the other hand, did not appear to have any effect on the exchange rate.

Fatum and Hutchison (2003, 2006) use an event study approach and provide evidence in favor of short-term effectiveness (up to **15 days**). They argue in favor of an event study approach since interventions happen in clusters, which the authors call events.[27] The authors consider a direction criterion (whether immediately following the intervention event, the exchange rate moves in the direction intended by the intervention) and a smoothing criterion (whether following the intervention event, the intervention smoothes the exchange rate movement). They also introduce a 'reversal' criterion that allows them to analyze if cumulative intervention has been successful. The reversal criterion looks if the trend of the exchange rate has been reversed following the intervention event, i.e. whether the exchange rate has continued to move in the desired direction for a longer period than right after the intervention.

[27] An event is defined as a period of days with official intervention in the same direction that can possibly include days with no intervention. The end of an event is identified if afterwards there has been fifteen days with no intervention. The authors report no significant difference between the choice of a fifteen- as opposed to a five-day window.

Fatum and Hutchison (2003) analyze intervention by the Federal Reserve and the Bundesbank on the daily German mark/U.S. dollar exchange rate from September 1985 to December 1995 and provide evidence in favor of short-term effectiveness according to all three success criteria, i.e. following the interventions, the exchange rate immediately moved in the desired direction, the trend was reversed and movements were smoother.[28] These effects are seen with up to 15-day windows, but not with a 30-day window.[29]

Fatum and Hutchison (2006) perform a similar analysis in terms of the effectiveness of intervention by the Federal Reserve and the Bank of Japan on the daily Japanese yen/U.S. dollar exchange rate between April 1991 and December 2000. They find significant short-term effectiveness of official intervention according to the direction and reversal criteria for up to two weeks, but again no effect with a 30-day window.[30] Intervention has been effective independently of whether it has supported by changes in the interest rates (MP), and of being secret or not.

Dominguez and Frankel (1993b) examine the effects of central bank announcements about exchange rates and official interventions, reported and secret, and provide generally significant **contemporaneous effects** of announcements on exchange rates but mixed results for interventions.[31] [32] They analyze interventions by the Federal

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[28] Short term refers to the two-, five-, ten- and fifteen-day analysis of the exchange rate following the end of an episode.

[29] The authors comment that this is a limitation of the event-study approach, since with a 30-day window many intervention events are excluded due to overlaps.

[30] In both studies intervention is effective independently of whether it is being accompanied by monetary policy shifts.

[31] For variable definitions, see Section 2.3.2.

[32] Ito (2003) also reports such a significant same-day effect for the Japanese yen/U.S. dollar exchange rate for the period from April 1991 to March 2001.

Reserve and the Bundesbank for different subperiods on the change in the daily German mark/U.S. dollar exchange rate between January 1985 and December 1990, and the weekly German mark/U.S. dollar exchange rate between November 1982 and December 1988. For the daily change in the exchange rate, the authors report a statistically significant effect of central bank announcements about exchange rates for all subperiods and equation specifications.[33] The coefficients of reported and secret actual intervention, however, depend on the period and specification of the regression equation – sometimes they are significant and correctly signed, while sometimes they are insignificant, or even significant but incorrectly signed.

With weekly changes in the exchange rate, official exchange rate announcements and reported intervention have a significant contemporaneous effect on the exchange rate. When intervention is measured in other ways (intervention a day before the survey date, cumulative intervention between survey forecasts, and cumulative intervention from the beginning of the sample period), however, the coefficients on interventions and announcements turn out insignificant.

Fratzscher (2004, 2005) explores the effectiveness of daily official interventions (what he calls 'actual' interventions) and official communications (called 'oral' interventions) by policy makers in the U.S., Japan and the euro area by using a time series approach.[34] He focuses on the U.S. dollar/euro and Japanese yen/U.S. dollar

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[33] The authors run different equations testing different hypotheses, such as the effects of coordinated versus uncoordinated interventions, the effects of the magnitude of interventions versus the effects of intervention frequency.

[34] He regresses the change in the exchange rate on actual and oral interventions in Japan and U.S. for the yen/dollar exchange rate, and Europe and U.S. for the euro/dollar exchange rate and the corresponding interest differential.

exchange rates for the period from January 1990 through June 2003. In addition, Fratzscher (2005) also uses an event-study approach.

Fratzscher (2004) finds that both actual and oral interventions have a significant effect on the exchange rate in moving the exchange rate in the desired direction over the two- or three-day period following interventions.[35] He also finds that oral intervention policies may be effective even without the presence of actual intervention, and that their effect is generally independent of whether they move in the same or opposite directions with past or future monetary policy. This result suggests that parity announcement alone could affect the exchange rate.

The time series results by Fratzscher (2005) support his earlier results. In the event-study approach Fratzscher (2005) uses the success criteria by Fatum and Hutchison (2003, 2006) and also adds an 'event' criterion where intervention event is successful if the exchange rate moves in the desired direction during the intervention event.[36] His results indicate that actual intervention has been effective for up to **30 days**, while oral intervention has been effective for up to **40 days**:

> "communication and actual intervention events were successful and moved the G3 exchange rate in the desired direction in the five-day post-event period in 65% to 77% of the cases. This directional effect also proves highly persistent and shows a similar rate of "success" as many as **40 days** after the events... Oral interventions appear to be more successful during the events, while actual interventions have a somewhat higher success rate than oral interventions when they are of the "leaning-against-the-wind" type and attempt to reverse the previous exchange rate trend."
>
> Fratzscher (2005: 24)

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[35] Oral interventions are classified as being strengthening, weakening or ambiguous in terms of the value of the domestic currency.

[36] Fratzscher (2005) defines the end of an event after ten days with no intervention, as opposed to the fifteen days chosen by Fatum and Hutchison (2003, 2006). The author performs robustness checks for window lengths as short as five days and as long as one month, and does not find significantly different results.

Ramaswami and Samiei (2000) analyze the effects of intervention by the Federal Reserve and the Bank of Japan on the change in the daily Japanese yen/U.S. dollar exchange rate between 1995-1999 using an error correction model that includes interest rate differentials.[37] They find that out of 17 intervention episodes, 8 have led to a significant movement in the exchange rate in the desired direction within **two days** while for the rest of the episodes there has been no significant movement in any direction.[38]

Dominguez (2003) examines the effects of intervention operations in Germany, Japan and the U.S. on the German mark/U.S. dollar and Japanese yen/U.S, dollar exchange rates over the period 1990-2002. She provides evidence that intervention has been effective in turning around the exchange rate in the very short run (**4-hours and 8-hours**) and longer run (within **3 months** of the final intervention operation of the episode).[39]

Humpage (1999) and Beine, Benassy-Quere and Lecourt (2002) fail to report significant effects of intervention on exchange rates. Humpage (1999) uses different success criteria to assess the degree to which U.S. intervention has influenced the daily U.S. dollar/German mark and U.S. dollar/Japanese yen exchange rates from February 1987 to February 1990. The most general success criteria that Humpage uses is that intervention sale (purchase) of foreign exchange is associated either with an appreciation

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[37] The authors identify intervention by the Fed and the BoJ by compiling information from the press.

[38] The authors cluster individual interventions into episodes when they appear to be part of the same intervention process. They also find that the success of intervention depends on the type. For example, there have been total nine attempts by the BoJ to weaken the yen over the specific period, and only three have been successful. Also, coordinated interventions have been more successful that unilateral ones. This result has received a general support from studies in the field. The authors comment that intervention will have a lasting effect on the exchange rate because the exchange rate is non-stationary.

[39] Out of total 22 episodes of intervention, seven (ten) had a correctly signed significant 4-hour (8-hour) effect on the exchange rate. In fourteen episodes the exchange rate moved in the appropriate direction within three months of the final intervention of the episode.

(depreciation) of the dollar on the day the intervention was undertaken, or by a smaller appreciation (depreciation) of the dollar on the day of intervention compared to its appreciation (depreciation) from the morning of the previous day to the morning of the current day. He uses a logit estimation for the odds ratio of successful intervention by controlling for the amount and type of intervention, monetary policy and trade statistics. Humpage finds that the odds of a successful U.S. intervention increases with the amount of intervention, but U.S. sales (purchases) of foreign exchange were not associated with systematic dollar appreciation (depreciation).

Beine, Benassy-Quere and Lecourt (2002) investigate the effects of official intervention by the Federal Reserve, the Bundesbank and the Bank of Japan on the mean and variance of the daily U.S. dollar/German mark and U.S. dollar/Japanese yen exchange rates from 1985 to 1995. One of their main findings is that both exchange rates move in direction opposite to the one intended by official intervention. The authors perform causality tests to investigate possible leaning-against-the-wind effects where the central bank intervenes to oppose a particular direction of movement in the exchange rate. Their findings indicate that their "results do not systematically stem from reversed causality, although central banks clearly lean against the wind" (Beine, Benassy-Quere and Lecourt, 2002: 142).

It should be noted that all of the studies on the effects of intervention discussed so far have concentrated on developed countries. One of the major reasons for this is the lack of intervention data for developing economies. Another is that it is difficult to control for changes in central bank credibility and policy reaction functions (Guimarães and Karacadag, 2004). However, intervention is especially widespread in emerging countries because of the high premium due to low policy credibility, and the high pass-through from exchange rate movements to inflation (Calvo and Reinhart, 2002). There are a few studies that have investigated the effectiveness of intervention on Mexico and Turkey (Domac and Mendoza, 2004; Guimarães and Karacadag, 2004), and Chile (Tapia and Tokman, 2004). These studies do not differentiate between the different channels of influence and they report mixed findings.

Domac and Mendoza (2004) test for the effects of intervention on the mean and variance of the exchange rate against the U.S. dollar and conclude that in both Mexico (from August 1996 to June 2001) and Turkey (February 2001 to May 2002), foreign exchange *sales* have been effective in influencing the exchange rate, but not foreign exchange *purchases*. Guimarães and Karacadag (2004) estimate a first-difference equation for the exchange rate against the U.S. dollar and find a similar result for Mexico for the period from August 1996 to June 2003, whereas in Turkey intervention did not appear to have a significant effect on the exchange rate between March 2001 and October 2003.

Tapia and Tokman find that between January 1998 and February 2003 in Chile official intervention had a significant effect on the exchange rate during some subperiods, but not others. They also report that public announcement on *potential* intervention had a significant impact on the level and the trend of the exchange rate. This last result can be seen as supporting the effectiveness of official communication by central banks regarding exchange rates.

To sum up this section, the majority of studies that have tested the effectiveness of official intervention in developed countries with no specific channel of influence find that official intervention has been successful in moving the exchange rate in the desired direction as soon as in the day of the intervention and as late as 3 months following the intervention. Thus, one major conclusion from these studies is that official intervention has a significant short-term impact on exchange rate movements. The result of effective official intervention has received partial support for developing countries.

Some of the studies investigating the effectiveness of official intervention have also tested for the effects of official communication on exchange rates. All of these, including the ones on developing countries, have reported significant short-term results (up to 40 days following interventions). This result suggests that some parity announcement by central banks might also have a significant role in affecting exchange rate movements.

2.5 Evidence on the Effectiveness of Official Intervention: Summary and Implications

This section presented studies testing the effectiveness of official intervention through the portfolio balance, signaling and coordination channels.[40] The majority of studies investigating whether official intervention has a significant impact on exchange rates through the portfolio balance channel have produced results that do not support the significance of this channel. Studies on the signaling channel, on the other hand, have mostly concluded that official intervention has a significant effect on exchange rates by providing the market with information about future policies and macroeconomic fundamentals.

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[40] The effect of official communication on the exchange rate could work through the signaling or coordination channel.

Many studies have tested for the effects of intervention on exchange rates without a clear indication of a channel of influence and these have mostly reported significant short-term results (up to 3 months). Thus, the major conclusion that seems to arise from this literature is that official intervention has a significant but short lasting effect on exchange rates.

This finding on the ability of official intervention to turn around the exchange rate in the short run implies that the central bank can inflict pain on traders who bet on a movement away from announced parity levels. As will be discussed in Chapter 3, this finding is important for the effectiveness of a new channel through which official intervention can affect exchange rate movements, the *uncertainty premium* channel. It is also the case that the effectiveness of this new, uncertainty premium, channel is enhanced if intervention is accompanied by the announcement of some parity level. Usually, parity levels are based on macroeconomic fundamentals, such as PPP.[41] The importance of parity announcement for exchange rates is revealed by three major findings of empirical studies. First is the empirical finding of a significant effect of official communication by monetary authorities on exchange rates (up to 40 days). Furthermore, the supportive evidence on the signaling channel implies that macroeconomic fundamentals are important for exchange rates. And last but not least is the general support in the literature for the enhanced effectiveness of official intervention when it is publicly announced.

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[41] There are other measures for the benchmark exchange rate that have been proposed in the literature. Williamson (1985), for example, develops a measure for a 'fundamental equilibrium' exchange rate that generates a current account surplus or deficit equal to the underlying capital flow over the cycle, assuming that the country is pursuing internal balance (i.e. aiming to attain full employment level of output) and not restricting trade for balance of payments reasons. Kubelec (2004a, b) constructs a benchmark level for the exchange rate using data on relative money supplies (M1) and output levels. As will be discussed in Chapter 4, however, empirical studies have found that PPP acts as a long run anchor for exchange rates.

In addition to these findings, studies that test the importance of news releases regarding macroeconomic fundamentals on exchange rate forecasts report strong evidence of exchange rate reaction to news and thus provide further support for the role of parity announcement by central banks based on fundamentals to affect short-run exchange rate movements. These news releases are related to the surprise component of the announcements, since the expected part is already incorporated in exchange rate expectations. Dornbusch (1980) and Frenkel (1981), for example, derive measures of news by using statistical innovations in interest differentials and other macroeconomic variables. To capture the unexpected part of the news Edison (1997) and Andersen et. al. (2003) use survey data of expectations about the value of the fundamental variable to be released that is collected a week before the actual release by Money Market Services, International.[42]

Furthermore, survey results reported by Allen and Taylor (1990), Taylor and Allen (1992), Cheung and Chinn (2001) and Cheung, Chinn and Marsch (2004) clearly indicate the importance of macroeconomic fundamentals for market participants' exchange rate expectations. For example, Allen and Taylor (1990) and Taylor and Allen (1992) report survey results covering over 400 chief foreign exchange dealers in the London market in November 1989 with a 60% response rate. About 85% of the respondents judge fundamentals to be more important that chartist rules for expectations over a year and longer, with 30% relying exclusively on fundamentals.

In sum, the conclusion of significant short-term effects of official intervention and official communication on the exchange rate through the portfolio balance, signaling and

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[42] For other studies see references in Frankel and Rose (1995) and Edison (1997).

coordination channels and the findings and survey results indicating that macroeconomic fundamentals are important for exchange rates provides a role for official intervention and parity announcement to influence exchange rate movements.

3 The Effectiveness of Official Intervention in a New Perspective

The empirical studies on the effectiveness of official intervention through the different channels share one main characteristic - they have all investigated the effectiveness of intervention by looking at whether it has been successful in turning the exchange rate in the direction of intervention in the few days/weeks/months following the intervention. While it is true that monetary authorities care about the short-term trend in the exchange rate, they also care about long-term misalignments of the exchange rate from fundamental values. Survey results reported by Neely (2000b) display that seventeen out of nineteen reporting monetary authorities always or sometimes intervene to resist short-term trends in exchange rates, and twelve out of eighteen always or sometimes intervene to correct long-run misalignments of exchange rates from fundamental values.

To the best of my knowledge, only three papers have so far investigated whether intervention is effective in terms of limiting the magnitude of misalignment in exchange rates from benchmark levels, Kubelec (2004a, 2004b) and Taylor (2004). In the framework of a noise-trader model, Kubelec (2004a, 2004b) shows that intervention in the Japanese yen/U.S. dollar market from 1991 to 2003 has led to swings of smaller magnitude.

Kubelec (2004a,b) develops a noise-trader model in which when choosing a strategy, traders either pay a fixed cost to purchase a rule that is based on fundamentals, or use a chartist rule to extrapolate recent trends in exchange rates. Traders base their decision on an evolutionary fitness measure that is a weighted function of past realized profits and future expected profits from the chartist and the fundamentalist view (based on Brock and Hommes, 1998, 1999). Since this is just an extension of the Frankel and Froot noise-trader approach to exchange rates, swings in exchange rates here again arise because individuals switch to using the chartist rule as opposed to the fundamentalist rule.

In this model, chartists' profits rise as long as the exchange rate moves away from the 'fundamental', i.e. benchmark exchange rate. When the exchange rate reverts towards the benchmark level, market participants that continue to follow the chartist rule incur losses. Fundamentalists, on the other hand, endure losses when the exchange rate moves away from benchmark levels, and make profits when the exchange rate reverts towards the benchmark.

Kubelec models the effects of sterilized official intervention on the exchange rate through a risk premium as in the portfolio balance model. The argument here is that the risk premium affects realized profits, and thus the fitness measure, causing market participants to switch from the chartist rule to the fundamentalist rule. For example, if a central bank intervenes in the foreign exchange market to depreciate the domestic currency by purchasing foreign currency and selling the domestic currency, the supply of domestic currency rises relative to the supply of foreign currency. Now individuals will be willing to hold this larger supply of domestic currency only if they are compensated by a higher excess return on the domestic currency, i.e. by a risk premium, which leads to a depreciation of the domestic currency towards benchmark levels. The higher excess return on the domestic currency will increase the realized profits of individuals who followed the fundamentalist view and will thus induce more individuals to follow this view. This in turn will reduce "the persistence of exchange rate misalignments." (Kubelec, 2004a: 2)

Kubelec (2004a,b) tests the effects of official intervention by the Bank of Japan on the misalignments in the U.S. dollar/Japanese yen exchange rate from 1991 to 2003, where misalignments are measured as deviations from an equilibrium exchange rate based on fundamentals. For the equilibrium exchange rate he uses data on relative money supplies (M1) and output levels. Then he derives a series for the deviation of the exchange rate from its equilibrium level. His findings suggest that about 32% of the periods where traders use the fundamentalist strategy, the use of this strategy can be attributed to official interventions.[43]

Simulation results suggest that the size of intervention that is necessary to have a significant effect on the exchange rate in terms of moving the exchange rate in the desired direction decreases with the size of misalignment, and that misalignments would have been larger in the absence of intervention. One very interesting remark by Kubelec (2004a: 38) is: "the model identifies many interventions as having a significant effect on the path of the exchange rate, even in case where they do not seem to effect the trend in the short run."

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[43] The author arrives at this result by attributing one fundamentalist strategy to all fundamentalists in the market.

Taylor (2004) provides indirect evidence on the effectiveness of official intervention in terms of limiting the size of swings in the real exchange rate. Using a Markov-switching model, Taylor shows that intervention in the Deutche mark/U.S. dollar market during the period of 1985-1998 has increased the probability of stability when the rate is misaligned, and that this probability grows with the degree of misalignment. In this approach, the assumption is that market participants switch between a mean-reverting (stable) regime and an unstable regime, in which the exchange rate moves away from its fundamental equilibrium according to some specific rule. Taylor allows for transition probabilities between the two regimes to be affected by, among other factors, the degree of misalignment in the exchange rate and official intervention. He estimates a model that relates the transition probabilities to official intervention, the degree of misalignment in the exchange rate and other factors, and concludes that intervention increases the probability of switching from the unstable to the stable regime when it takes place at times when the real exchange rate is far from its equilibrium. The authors interpret these findings as indirect evidence on the coordination channel.

The studies by Kubelec (2004a,b) and Taylor (2004) provide evidence that official intervention is effective in limiting the magnitude of exchange rate swings. However, they do so by attributing two strategies – one fundamental, or stable, and one chartist, or unstable – to all market participants, with a fixed rule according to which individuals switch between strategies. As such, neither allows for different strategies among individuals, or for the creation of new strategies, thus ruling out any individual creativity related to the choice and revisions of forecasting strategies. In Chapter 3, I build on a model by Frydman and Goldberg (2007) that allows individuals to creatively cope with imperfect knowledge when formulating their forecasts of the future exchange rate and discuss its implications for central bank policy. Then in Chapter 6, I provide additional empirical evidence suggesting that official intervention coupled with parity announcement may lead to swings of smaller magnitude through the uncertainty premium channel.

4. Conclusion

This chapter discussed studies testing the effectiveness of official intervention. The majority of these studies have defined interventions to be effective if they are successful in turning around the exchange rate in the few days, weeks or months following interventions. As such, they have missed an important question, which is whether official intervention has been effective in limiting swings in exchange rates. I investigate this issue in Chapter 6.

The major finding of the studies testing for the effectiveness of official intervention is that intervention has a significant but a short-lasting effect on exchange rates (up to 3 months). Several of these studies have also analyzed the effects of official exchange rate communication by authorities and have concluded almost unanimously that such communications have a significant effect on exchange rate movements in the short run (up to 40 days). These findings combined with the strong evidence for the reaction of exchange rates to news regarding macroeconomic fundamentals suggest that parity announcement based on fundamentals and official intervention might be effective in limiting exchange rate swings. This result is important for my model that is presented in Chapter 3.

CHAPTER 3

LIMITING SWINGS IN EXCHANGE RATES: THE UNCERTAINTY PREMIUM CHANNEL

1 Introduction

In the preceding chapter I argued that the empirical literature on the effectiveness of central bank intervention and official communication by authorities on their views about the stance of the exchange rate in relation to macroeconomic fundamentals suggests that such policies have significant influence on short-run exchange rate movements. However, while these studies provide valuable evidence on the short-run effectiveness of exchange rate policy, they miss a key question: Does intervention and parity announcement provide a way for central banks to limit the magnitude of exchange rate swings away from benchmark levels? The empirical studies of Kubelec (2004a,b) and Taylor (2004) provide some evidence that this may be the case. However, Kubelec's (2004a,b) analysis is based on an exchange rate model in which swings away from historical benchmark levels occur because market participants irrationally rely on technical trading rules rather than macroeconomic fundamentals in forming their forecasts. As I discussed in Chapter 2, however, there is much evidence that market participants do care about fundamentals. Taylor (2004), for his part, provides no theoretical model at all.

In this chapter, I first sketch a model of the premium on foreign exchange developed in Frydman and Goldberg (2007). The Frydman and Goldberg model replaces the usual specification of preferences based on risk aversion and expected utility theory with preferences based on endogenous prospect theory. It also replaces REH with imperfect knowledge economics (IKE) representations of individual forecasting behavior.[1] Frydman and Goldberg show that these alternative assumptions lead to a new equilibrium condition for the foreign exchange market, which they call *uncertainty-adjusted uncovered interest parity* (UAUIP).

In this chapter I extend the Frydman and Goldberg model to allow for the possibility of intervention aimed at pushing the exchange rate to some announced or unannounced parity level. I then show that the Frydman and Goldberg model provides a new channel through which these policy tools can limit swings in exchange rates away from benchmark levels. This analysis, in turn, suggests a new way to test the efficacy of central bank intervention. The question is not whether central bank intervention can turn around the exchange rate over the next few days, but rather whether such policy can limit the magnitude of exchange rate swings. As was discussed in Chapter 2, for the most part, the literature has not examined this question. The Frydman and Goldberg premium model implies that in currency markets that are characterized with central bank intervention at unpredictable moments in time aimed at pushing the exchange rate back to some pre-announced or unannounced parity level, exchange rates will experience smaller swings

[1] IKE representations of forecasting behavior recognize that in making choices, individuals have to cope with imperfect knowledge. Consequently, individuals do not rely on one fixed forecasting strategy endlessly. To characterize an individual's forecasting behavior, an IKE model imposes only qualitative restrictions on how individuals may revise their forecasting strategies. Such IKE restrictions allow for myriad possible revisions of forecasting strategies at each point in time and yet they impose sufficient structure on the analysis to generate testable implications. See Section 3 in this chapter.

for the same swing in exchange rate expectations compared to currency markets without such policy intervention.

The remainder of the chapter is structured as follows. In section 2, I outline the Frydman and Goldberg model of the premium and discuss UAUIP. In Section 3, I discuss how the Frydman and Goldberg model is compatible with exchange rate swings away from historical benchmark levels. Then in section 4, I extend the Frydman and Goldberg premium model and show that it implies a new channel - the *uncertainty premium* channel - through which central bank policy can affect exchange rate swings. In this section I also discuss how the extended Frydman and Goldberg model informs us about the way in which one can re-examine exchange rate policy. Section 5 concludes the chapter.

2 The Frydman and Goldberg Model

It is useful to begin my sketch of the Frydman and Goldberg model with a discussion of how individuals speculate in the foreign exchange market and how they determine how much money to place at risk. I will then turn to the new equilibrium condition for the foreign exchange market - UAUIP.

2.1 Speculation in the Foreign Exchange Market

I assume that there are two countries, A (the domestic country) and B, and two types of non-monetary assets, A and B bonds, where these bonds are denominated in country-A currency (the domestic currency) and country-B currency, respectively. Both domestic and foreign individuals can issue A and B bonds, i.e., they can borrow domestic and foreign currency, respectively, without limit. The risk-free nominal returns on these bonds from time t to $t+1$ are denoted by i_t^A and i_t^B, respectively.

Consider how a country-A individual would take a *pure long position* in foreign exchange for one period, which requires no money down at time t.[2] He would borrow, say, one unit of domestic currency at time t at the rate i_t^A. He would then immediately sell this one unit of domestic currency at the spot rate, $\frac{1}{s_t}$, and lend $\frac{1}{s_t}$ units of foreign currency at the rate i_t^B, where the exchange rate, s_t, is defined as the price of foreign currency in terms of the domestic currency. At the end of the period, at time $t+1$, he would sell $\frac{1}{s_t}\left(1+i_t^B\right)$ units of foreign exchange at the spot rate, S_{t+1}. The nominal return on his pure long position would then be $\frac{S_{t+1}}{s_t}\left(1+i_t^B\right)-\left(1+i_t^A\right)$, the log approximation of which is given by:[3]

$$R_{t|t+1} = S_{t+1} - s_t + i_t^B - i_t^A \tag{1}$$

Similarly, to take a *pure short position* in foreign exchange, an individual would borrow foreign currency at time t at the rate i_t^B, purchase domestic currency at the rate s_t, lend out the domestic currency at the rate i_t^A and at the end of time $t+1$ convert the

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[2] Speculation of a country-B individual is identical to the speculation of a country-A individual.

[3] Note that lowercase letters denote realizations while uppercase letters denote random variables. Thus, for example, S_{t+1} denotes the future spot exchange rate, which is not known at time t, and is therefore a random variable. Similarly, $R_{t|t+1}$ is a random variable that stands for the unconditional distribution for the nominal excess return.

domestic currency back to foreign currency at the rate $\frac{1}{S_{t+1}}$. So, the log approximation for the nominal return on his pure short position would be given by:

$$-R_{t|t+1} = -\left(S_{t+1} - s_t + i_t^B - i_t^A\right) \quad (2)$$

An individual's speculative decision involves the choice of speculating in the foreign exchange market or staying out of the market. If he decides to speculate, he also has to decide on the amount of wealth he would want to place at risk, called the position size. Frydman and Goldberg model the speculative decision problem by assuming that an individual chooses his position size so as to maximize his utility. They use endogenous prospect theory that builds on the prospect theory by Kahneman and Tversky (1979) and Tversky and Kahneman (1992), and IKE representations of forecasts. One needs to represent forecasts because at time t an individual does not know what the future spot exchange rate will be, and thus, at time t, he formulates a forecast of the one-period-ahead real return on a pure long or short position in foreign exchange and chooses his utility-maximizing position size.[4]

As will be discussed in Section 2.3.2, to take an open position in the foreign exchange market, an individual requires some minimum positive return. An individual would take a long position in foreign exchange if he believes that the exchange rate would go up from time t to $t+1$, and he forecasts some positive return on the foreign currency, $\hat{R}_{t|t+1}^L = \hat{S}_{t|t+1}^L - s_t + i_t^B - i_t^A$ in excess of some minimum return, where $\hat{S}_{t|t+1}^L$

[4] The real return is, as usual, defined as the nominal return less the inflation rate, where individuals from country A are assumed to care only about the country-A inflation. See Section 2.2.1.

denotes the log level of his time-t forecast of the time $t+1$ spot rate.[5] Such an individual is called a bull. He would take a short position in foreign exchange if he believes that the exchange rate would fall from time t to $t+1$ and he forecasts some positive return on the domestic currency, $\hat{R}^S_{t|t+1} = s_t - \hat{S}^S_{t|t+1} + i^A_t - i^B_t$ in excess of some minimum return, where $\hat{S}^S_{t|t+1}$ denotes the log level of his time-t forecast of the time $t+1$ spot rate. An individual that believes that the exchange rate would fall is called a bear.

In the next section, I discuss prospect theory in the context of the foreign exchange market. This section is followed by endogenous prospect theory, which includes discussions on IKE representations of forecasts and the new equilibrium condition for the foreign exchange market, UAUIP.

2.2 Prospect Theory in the Context of the Foreign Exchange Market[6]

Prospect theory is an alternative way to model preferences of individuals to explain the often gross inconsistencies between the actual choices of individuals who are faced with risky or uncertain outcomes, and the predictions based on standard preferences with risk aversion. One of the key assumptions of prospect theory, called reference dependence, is that rather than the level of final wealth, individuals care about changes in

[5] Modeling forecasting behavior requires some representation of how individuals formulate and update their forecasts. Thus, a '^' denotes the representation of a forecast. The Frydman and Goldberg model emphasizes that there is a difference between the forecast of the market participant and the representation of that forecast by an economist.

[6] See Appendix A for the original formulation of prospect theory by Kahneman and Tversky (1979) and Tversky and Kahneman (1992).

wealth relative to some reference level of wealth, i.e. it is gains and losses that matter.[7] Another important assumption is loss aversion: wealth holders are assumed to be *more sensitive* to losses than to gains of the same size. Prospect theory also assumes diminishing sensitivity: that the utility function depends nonlinearly on the magnitudes of gains and losses and that the marginal value of gains and losses decreases with their size. To capture these assumptions, Tversky and Kahneman (1992) propose a particular parametric utility function. Because this utility function is specified in terms of gains and losses, we need to first define these in the context of the foreign exchange market.

2.2.1 Gains and Losses in the Foreign Exchange Market. Gains and losses for individuals that participate in the foreign exchange market are defined by the change in the individual's wealth from time t to $t+1$. If a country A individual starts with an initial non-monetary real wealth of W_t^i, then her time $t+1$ wealth, W_{t+1}^i, is equal to her initial wealth at time t plus her real returns from domestic and foreign bonds:

$$W_{t+1}^i = W_t\left[1 + a_t^i\left(S_{t|t+1}^i - s_t + i_t^B - p_t\right) + \left(1 - a_t^i\right)\left(i_t^A - p_t\right)\right] \qquad (3)$$

where the individual's wealth is given by her domestic and foreign bond holdings, $W_t^i = A_t^i + B_t^i$; a_t^i is an individual's share of B bonds at time t; p_t is the non-stochastic domestic rate of inflation; and $\left(1 - a_t^i\right)\left(i_t^A - p_t\right)$ and $a_t^i\left(S_{t|t+1}^i - s_t + i_t^B - p_t\right)$ represent the real returns from domestic and foreign bonds, respectively.[8]

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[7] This is as opposed to the assumption in expected utility theory that individuals care about the level of their final wealth. For a further discussion on the differences between expected utility theory and prospect theory, see Appendix A.

[8] Domestic individuals are assumed to use only domestic prices to deflate nominal values.

Substituting in for $R^i_{t|t+1} = S^i_{t|t+1} - s_t + i^B_t$ for an individual's one-period ahead nominal return on a pure long position in foreign exchange, and rearranging, the change in an individual's wealth from time t to $t+1$, ΔW^i_{t+1}, relative to some reference level of wealth, Γ^i_{t+1}, is given by:

$$\Delta W^i_{t|t+1} = W^i_{t+1} - \Gamma^i_{t+1} = W^i_t \left[a^i_t R^i_{t|t+1} + \left(1 + i^A_t - p_t\right)\right] - \Gamma^i_t \tag{4}$$

Frydman and Goldberg define Γ^i_t as the level of wealth that an individual would obtain if she were to stay out of the foreign exchange market at time t:[9]

$$\Gamma^i_t = W^i_t \left(1 + i^A_t - p_t\right) \tag{5}$$

Substituting (5) in (4) gives:

$$\Delta W^i_{t|t+1} = a^i_t W^i_t R^i_{t|t+1} \tag{6}$$

When $\Delta W^i_{t|t+1} > 0 \left(\Delta W^i_{t|t+1} < 0\right)$, an individual is said to experience a gain (loss). A positive realization of $R^i_{t|t+1}$, denoted by r^+_{t+1}, leads to a gain (loss) for an individual if she holds a long (short) position, in which case she is called a bull (bear). Recall that a bull (bear) is an individual who gains when the price of foreign exchange, i.e. the exchange rate, increases (falls). A negative realization of $R^i_{t|t+1}$, denoted by r^-_{t+1}, leads to the converse: a loss for a bull and a gain for a bear. Note also that holding a long (short) position implies that a domestic wealth holder holds her wealth in foreign (domestic)

[9] Barberis and Huang (2001) and Barberis, Huang and Santos (2001) also use this reference level. This definition provides for a final level of wealth that an individual obtains by investing her initial wealth on domestic bonds.

bonds, i.e. $a_t^i > 0 \left(a_t^i < 0\right)$.[10] To sum up, for a bull $a_t > 0, r^g = r_{t+1}^+$ and $r^l = r_{t+1}^-$ and for a bear $a_t < 0, r^g = -r_{t+1}^-$ and $r^l = -r_{t+1}^+$.[11]

2.2.2 The Original Tversky and Kahneman Utility Function. In the context of the foreign exchange market, Tversky and Kahneman's value function can be written as follows:

$$V(\Delta W) = \begin{cases} \left(W_t \left|a_t r^g\right|\right)^\alpha & \text{if } \Delta W > 0 \\ -\lambda\left(W_t \left|a_t r^l\right|\right)^\beta & \text{if } \Delta W < 0 \end{cases} \tag{7}$$

where W_t, as before, denotes an individual's non-monetary real wealth at time t; a_t is the share of foreign bonds; r^g *and* r^l denote a single gain and loss from speculation on a unit position; and α, β and λ are parameters, explained below.[12]

This value function embodies the experimental findings by Kahneman and Tversky on how individuals actually choose among gambles with uncertain outcomes. It embodies the experimental finding that individuals care about the changes in wealth rather than the level of wealth. The assumption of diminishing sensitivity is captured by the parameters α and β, where the decreasing marginal value of gains and losses with their size implies that both $\alpha < 1$ and $\beta < 1$. The finding of loss aversion (individuals

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[10] A domestic individual can hold a short position in foreign exchange if she holds A bonds in excess of her total wealth, i.e. $\left(1 - a_t^i\right) > 1$, which is possible by borrowing foreign exchange at i_t^B (i.e. by issuing B bonds), exchanging this foreign exchange at the spot rate for domestic currency and then using this domestic currency to buy A bonds.

[11] Note that for ease of notation, the subscript i is eliminated from this point on.

[12] The absolute value function ensures that the value function is relevant for both bulls and bears in the sense that both $W_t \left|a_t r^g\right|$ and $W_t \left|a_t r^l\right|$ are always positive.

being more sensitive to losses than gains of the same size) is captured by the loss aversion parameter λ. Under the assumption that $\alpha = \beta$, that Tversky and Kahneman (1992) as well as other researchers have used for practical purposes, $\lambda > 1$.[13]

The utility function given in (7) attaches a value to single outcomes. However, to represent an individual's preferences over prospects (or gambles) with different outcomes one needs to arrive at a weighted sum of the single outcomes comprising a gamble, i.e. the prospective utility of a gamble.[14]

2.2.3 The Prospective Utility of a Gamble. In the context of the foreign exchange market, the prospective utility of a gamble involving a long position of size $W_t |a_t|$, where $a_t > 0$, is given by:

$$PU_t^L = (a_t W_t)^\alpha \sum_k^{K^+} \hat{\pi}_{t|t+1,k}^+ \left(\hat{r}_{t|t+1,k}^+\right)^\alpha - \lambda (a_t W_t)^\beta \sum_k^{K^-} \hat{\pi}_{t|t+1,k}^- \left(-\hat{r}_{t|t+1,k}^-\right)^\beta \tag{8}$$

where $\hat{\pi}_{j,k}^+$ and $\hat{\pi}_{j,k}^-$ denote the weights that an individual attaches to the utility of each positive and negative outcome k, respectively, called *decision weights*;[15] K_j^+ is the set of outcomes comprised of potential gains; K_j^- is the set of outcomes comprised of potential losses, and $K_j = K_j^+ + K_j^-$ is the set of potential returns from choosing gamble j; $\hat{r}_{t|t+1,k}^+$ and $\hat{r}_{t|t+1,k}^-$ denote the positive and negative values of $\hat{R}_{t|t+1}$, respectively, which stands for the representation of an individual's forecast of R_{t+1}. Thus, the prospective

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[13] For more details on the three experimental findings and the value function, see Appendix A.

[14] For a more formal definition of a prospect, see Appendix A.

[15] Kahneman and Tversky (1979) present experimental evidence that these decision-weights are nonlinear functions of the true probabilities - individuals tend to overweight small probabilities and underweight moderate and high probabilities. For details, see Appendix A.

utility of a gamble is composed of the sum of the utilities of single losses and gains weighted by the decision weights.[16]

Recalling that for a bear $a_t < 0$ and that the set of potential gains (losses) consists of the negative (positive) values in $\hat{R}_{t|t+1}$, the prospective utility from a short position is given by

$$PU_t^S = \left(-a_t W_t\right)^{\alpha} \sum_{k}^{K^+} \hat{\pi}_{t|t+1,k}^{+} \left(-\hat{r}_{t|t+1,k}^{-}\right)^{\alpha} - \lambda \left(-a_t W_t\right)^{\beta} \sum_{k}^{K^-} \hat{\pi}_{t|t+1,k}^{-} \left(\hat{r}_{t|t+1,k}^{+}\right)^{\beta} \qquad (9)$$

<u>2.2.4 Applying Prospect Theory to Real World Markets.</u> Kahneman and Tversky's experimental evidence concerning the properties of their utility function is compelling. However, the application of prospect theory to model both individual behavior and aggregate outcomes in real markets is challenging. One problem is posed by the utility function being nonlinear in gains and losses.[17] What this nonlinearity means is that one cannot represent utility in terms of expected values for an individual. Furthermore, with heterogeneous forecasts, one cannot aggregate to obtain an equilibrium condition in terms of the aggregate expected values.

To circumvent these difficulties, economists have constrained the marginal value of gains and losses to be constant by assuming a linear utility function, that is, by setting

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[16] This is very similar to expected utility theory, which sets the expected utility of a gamble equal to the weighted sum of the utilities of single outcomes, with weights being equal to probabilities.

[17] For other issues related to the application of prospect theory to real markets, see Appendix A and Chapter 9 in Frydman and Goldberg (2007).

$\alpha = \beta = 1$.[18] This linear specification of the utility function, however, has a number of drawbacks. It is inconsistent with Kahneman and Tversky's experimental findings on how individuals make decisions under uncertainty. Furthermore, with a linear utility function, one does not get limits to speculation, which is necessary for a well-defined equilibrium condition. What this implies is that an individual would either stay out of the foreign exchange market when she believes that she will not be able to cover her potential losses, or she would want to hold a position of unlimited size whenever she perceives profit opportunities.[19] [20] To see why this is the case, let us reconsider the prospective utilities for a bull and a bear, as given by equations (8) and (9). Let us define

$$PG^L_{t|t+1} = \sum_k^{K^+} \hat{\pi}^+_{t|t+1,k} \left(\hat{r}^+_{t|t+1,k}\right)^\alpha, \quad PL^L_{t|t+1} = -\sum_k^{K^-} \hat{\pi}^-_{t|t+1,k} \left(-\hat{r}^-_{t|t+1,k}\right)^\beta \quad \text{and} \quad PR^L_{t|t+1} = PG^L_{t|t+1} + PL^L_{t|t+1}$$

respectively as the prospective gain, loss and return on a unit long position from time t to $t+1$; and similarly, $PG^S_{t|t+1} = \sum_k^{K^+} \hat{\pi}^+_{t|t+1,k} \left(-\hat{r}^-_{t|t+1,k}\right)^\alpha$, $PL^S_{t|t+1} = -\sum_k^{K^-} \hat{\pi}^-_{t|t+1,k} \left(\hat{r}^+_{t|t+1,k}\right)^\beta$ and $PR^S_{t|t+1} = PG^S_{t|t+1} + PL^S_{t|t+1}$ as the prospective gain, loss and return on a unit short position. Then if we constrain $\alpha = \beta = 1$, the prospective utilities for a bull and a bear become linear in both prospects and position size:

$$PU^L_t = (aW_t)\left[PR^L_{t|t+1} - (1-\lambda) PL^L_{t|t+1}\right] \tag{10}$$

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[18] Schmidt and Zank (2001) use a piece-wise linear utility specification where the utility function is linear in both gains and loses, but steeper in the region of losses. Although this solves the aggregation problem, it does not allow for diminishing sensitivity.

[19] As DeLong et.al. (1990a, b) have emphasized, to obtain a well defined equilibrium under the assumptions of heterogeneous forecasts and unlimited short selling one needs limits to speculation.

[20] In fact, as long as $\alpha = \beta$, even if these are not constrained to be equal to 1, there will be no limits to speculation (see Frydman and Goldberg, 2007).

$$PU_t^S = (aW_t)\left[PR_{t|t+1}^S - (1-\lambda)PL_{t|t+1}^S\right] \quad (11)$$

Accordingly, an individual would stay out of the market if her prospective return is less than her prospective loss on either a long or a short position, i.e. $PR_{t|t+1}^L < (1-\lambda)PL_{t|t+1}^L$ and $PR_{t|t+1}^S < (1-\lambda)PL_{t|t+1}^S$, because taking any open position would lead to a negative prospective utility. If her prospective return from taking a long (short) position is larger than her prospective loss, i.e. $PR_{t|t+1}^L > (1-\lambda)PL_{t|t+1}^L$ ($PR_{t|t+1}^S > (1-\lambda)PL_{t|t+1}^S$), however, then every unit increase in her long (short) position size would raise her prospective utility. Thus, she would not only decide to take a long (short) position, but she would want to take a long (short) position of unlimited size.[21]

Thus, to obtain a well-defined equilibrium, Barberis and Huang (2001), Barberis, Huang, and Santos (2001), as well as other behavioral-finance economists have relied on risk-averse preferences, despite the rejection of this assumption in the behavioral literature in favor of loss aversion.[22]

To apply prospect theory to the foreign exchange market, Frydman and Goldberg (2007) propose a utility function that embodies *endogenous loss aversion*, where the degree of loss aversion depends on the position size. In contrast to other behavioral-finance models, this alternative formulation of the utility function that is based on *endogenous prospect theory* does not violate any of Kahneman and Tversky's

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[21] This result is based on the assumption that the reference level of wealth that individuals consider relevant is the level of wealth they would receive if they stay out of the market, as defined in (5). However, even when reference levels are not defined in this way, in general when $\alpha = \beta$, there are no limits to speculation. See Frydman and Goldberg (2007).

[22] See Barberis and Thaler (2003).

experimental findings. The following section demonstrates how Frydman and Goldberg get limits to speculation by using the utility function that was defined in equation (7).

2.3 Endogenous Loss Aversion

2.3.1 Limits to Speculation. To illustrate how endogenous loss aversion leads to a well-defined equilibrium in the foreign exchange market, let us once more consider the utility function given in equation (7), which is rewritten below for convenience:[23]

$$V(\Delta W)=\begin{cases} \left(W_t \middle| a_t r^g \right|)^{\alpha} & \text{if } \Delta W>0 \\ -\lambda\left(W_t \middle| a_t r^l \right|)^{\beta} & \text{if } \Delta W<0 \end{cases}$$

Now let us once again consider the loss aversion parameter. Loss aversion is defined as the ratio of disutility from losses to the utility from gains *of the same magnitude*. Thus, to find the loss aversion parameter, one needs to express the utility function in gains and losses of the same magnitude. When $\alpha=\beta$, the utility function becomes $V(\Delta W)=\left(W_t \middle| a_t r^g \right|)^{\alpha}-\lambda\left(W_t \middle| a_t r^l \right|)^{\alpha}$. In this case, loss aversion is given by the parameter $\lambda>1$.[24] To derive the loss aversion parameter with the more general case when $\alpha \neq \beta$ holds, let us rewrite the utility function as:

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[23] Note that endogenous prospect theory is defined with the modified utility function that is discussed in Appendix A. The utility function discussed in this section is only used to demonstrate limits to speculation when the loss aversion parameter depends on the position size. For a discussion on why Frydman and Goldberg needed to modify this function, see below.

[24] The ratio of disutility from losses to the utility from gains *of the same magnitude* is equal to $\frac{\lambda\left(W_t \middle| a_t r^l \right|)^{\alpha}}{\left(W_t \middle| a_t r^g \right|)^{\alpha}}=\lambda$.

$$V(\Delta W) = \left(W_t \left|a_t r^g\right|\right)^{\alpha} - \lambda\left(W_t \left|a_t r^l\right|\right)^{\beta-\alpha}\left(W_t \left|a_t r^l\right|\right)^{\alpha} \quad (12)$$

In this case, the parameter of loss aversion is given by:

$$\Lambda = \lambda\left(W_t \left|a_t r^l\right|\right)^{\beta-\alpha} \quad (13)$$

As can be seen from equation (13), the degree of loss aversion is endogenous because it depends on the position size, a_t. When $\alpha < \beta$ holds, which is consistent with the experimental evidence of Kahneman and Tversky indicating that the curvature of the utility function in the domain of losses is greater than in the domain of gains, the degree of loss aversion increases with the speculative position size, $\frac{d\Lambda}{d\left|a_t\right|} > 0$.[25] What endogenous loss aversion implies is that, as an individual increases her position size, her disutility of losses relative to gains increases. Therefore, she limits her position size. This is the case because with endogenous loss aversion the prospective utility becomes concave in the position size, as opposed to the linear case when $\alpha = \beta$.

It should be noted that although the utility function given in (7) provides a utility-maximizing position size, and thus, limits to speculation, for a range of small values for the position size $W_t\left|a_t\right|$, it implies that individuals would prefer losses over gains. Therefore, Frydman and Goldberg propose a modified utility function that implies that individuals prefer gains over losses for any position size. This utility function is associated with prospective utilities that are linear in prospective gains and losses and nonlinear in position size. The linearity of the prospective utilities allows for aggregation

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[25] See Appendix A.

across heterogeneous individuals, i.e. bulls and bears. The nonlinearity of prospective utilities in the position size implies limits to speculation. This alternative formulation of the utility function is discussed in Appendix A. The next section discusses the utility-maximizing position size that follows from this modified utility function.

2.3.2 The Utility-Maximizing Position Size. Using the modified utility function, the utility-maximizing position size that individuals decide to hold in the foreign exchange market depends on their forecasted loss on a unit position and their degree of loss aversion:

$$a_t^L W_t = \frac{1}{\lambda_3}\left(\hat{r}_{t|t+1}^L - (1-\lambda_1)\hat{l}_{t|t+1}^L\right) \tag{14}$$

$$-a_t^S W_t = \frac{1}{\lambda_3}\left(\hat{r}_{t|t+1}^S - (1-\lambda_1)\hat{l}_{t|t+1}^S\right) \tag{15}$$

where L and S stand for 'long' and 'short' positions; as before, a_t is the share of B bonds at time t and W_t denotes non-monetary real wealth at time t; $\hat{r}_{t|t+1}$ and $\hat{l}_{t|t+1}$ are the forecasted return and loss, respectively, from a unit position size, defined below; and $\lambda_1 > 1$ and $\lambda_3 = \frac{\lambda_2(1+\alpha)}{\alpha} > 0$ represent the degree of loss aversion.[26] Note that the forecasted return on a unit position for a bull and a bear is respectively given by $\hat{r}_{t|t+1}^L = \hat{s}_{t|t+1}^L - s_t + i_t^B - i_t^A$ and $\hat{r}_{t|t+1}^S = -\left(\hat{s}_{t|t+1}^S - s_t + i_t^B - i_t^A\right)$. The forecasted loss on a unit

[26] The utility-maximizing position size for a bull and a bear given by equations (14) and (15) is obtained using the modified utility function that is discussed in Appendix A. These are obtained by differentiating the prospective utilities for a bull and a bear with respect to a_t and setting the resulting equations equal to zero.

position is given by the expectation of a negative return: $\hat{l}^{L}_{t|t+1} = E\left(\hat{r}^{L}_{t|t+1} < 0\right)$ and $\hat{l}^{S}_{t|t+1} = E\left(\hat{r}^{S}_{t|t+1} < 0\right)$ for bulls and bears, respectively.[27]

These expressions for the position size have important implications for an individual's speculative decision problem. They imply that an individual's assessment of the potential loss on a unit position and her degree of loss aversion may be so large that although she forecasts a positive return from speculation she nevertheless decides to stay out of the market. In other words, an individual requires some minimum return before she takes a long or short position in foreign exchange. The expressions for the utility-maximizing position size for a bull and a bear, given by equations (14) and (15), show that this minimum return, called the *uncertainty premium*, depends on the forecasted loss on a unit position, $\hat{l}_{t|t+1}$, and the parameter of loss aversion, λ_1:

$$\widehat{up}^{L}_{t|t+1} = \left(1-\lambda_1\right)\hat{l}^{L}_{t|t+1} > 0 \tag{16}$$

$$\widehat{up}^{S}_{t|t+1} = \left(1-\lambda_1\right)\hat{l}^{S}_{t|t+1} > 0 \tag{17}$$

Accordingly, an individual should stay out of the market, i.e. set $a_t = 0$, when her forecasted return from taking either a long or a short position is less than her uncertainty premium, i.e. $\hat{r}^{L}_{t|t+1} < \widehat{up}^{L}_{t|t+1}$ and $\hat{r}^{S}_{t|t+1} < \widehat{up}^{S}_{t|t+1}$.[28] Note that under risk neutral preferences, a positive expected return of any size would lead an individual to take an open position in foreign exchange. Because individuals are loss averse, however, they need some

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[27] The way in which Frydman and Goldberg model the individual forecast of losses on a unit position is discussed in Section 2.3.4.

[28] An individual that stays out of the foreign exchange market holds all of her wealth in domestic assets.

minimum positive return to compensate them for their aversion to losses. Thus, an individual would hold a long position in foreign exchange of size $a_t^L W_t$ only if the forecasted return from holding a long position is larger than her uncertainty premium, i.e. $\hat{r}^L_{t|t+1} > \widehat{up}^L_{t|t+1}$ (equations (14) and (16)). If, on the other hand, the forecasted return on a short position is greater than her uncertainty premium, i.e. $\hat{r}^S_{t|t+1} > \widehat{up}^S_{t|t+1}$, a market participant should hold a short position in foreign exchange of size $a_t^S W_t$ (equations (15) and (17)).

In general then, to take an open position in the foreign exchange market, each individual expects to receive a return in excess of her uncertainty premium, where this so-called *excess return* is given by $\hat{r}^L_{t|t+1} - \widehat{up}^L_{t|t+1}$ and $\hat{r}^S_{t|t+1} - \widehat{up}^S_{t|t+1}$ for bulls and bears, respectively.[29]

We are now ready to discuss the new equilibrium condition for the foreign exchange market implied by endogenous prospect theory, UAUIP.

2.3.3 UAUIP.[30] Equilibrium in the foreign exchange market is generally defined as the balance between the demand for and supply of foreign exchange. Under endogenous prospect theory such a balance is characterized by the equality between the expected returns on domestic and foreign assets once these returns are adjusted for

[29] Note that this definition of the excess return is different from its conventional use in the literature, where it represents the return on foreign bonds, $\hat{s}_{t|t+1} - s_t + i_t^B$, in excess of the return on domestic bonds, i_t^A, both in domestic currency units.

[30] UAUIP is derived in Appendix A.

market participants' greater sensitivity to losses.[31] This equality can be expressed as follows:

$$\hat{r}_{t|t+1} = \widehat{pr}_{t|t+1} \tag{18}$$

where[32]

$$\widehat{pr}_{t|t+1} = \widehat{up}_{t|t+1} + \lambda_3 IFP_t \tag{19}$$

$$\hat{r}_{t|t+1} = \frac{1}{2}\left(\hat{r}^L_{t|t+1} - \hat{r}^S_{t|t+1}\right) \tag{20}$$

[33]

$$\widehat{up}_{t|t+1} = \frac{1}{2}\left(\widehat{up}^L_{t|t+1} - \widehat{up}^S_{t|t+1}\right) = \frac{1}{2}(1-\lambda_1)\left(\hat{i}^L_{t|t+1} - \hat{i}^S_{t|t+1}\right) \tag{21}$$

$$IFP_t = \frac{B^A_t - A^B_t / s_t}{W_t} \tag{22}$$

In the last equation, B^A_t and A^B_t denote the total value of B and A bonds that are held by country-A and country-B wealth holders, respectively; $W_t = \sum_i W^i_t$ is the total

[31] It is interesting to consider the special case where all market participants are loss averse except for one individual who is risk neutral. Could that risk neutral individual make higher profits compared to others? Now if this individual could borrow an unlimited amount of domestic or foreign currency, which is the assumption of the model, then UIP would hold and her expected rate of return would be zero. If there is some constraint on the amount of money she could borrow, and this amount is small enough so that she could not affect the equilibrium exchange rate, then UAUIP would hold. If there is one aggregate forecasting strategy, which she knows, and the exchange rate moves according to this strategy, then she would receive the same return as all other market participants who are loss averse. If the exchange rate moves in the opposite direction, she would incur losses. In either case she would not be able to make higher profits compared to market participants who are loss averse.

[32] Equations (20) and (21) assume that bulls and bears share the total non-monetary wealth equally.

[33] The aggregate expected return is given by $\hat{r}_{t|t+1} = \frac{1}{2}\left(\hat{r}^L_{t|t+1} - \hat{r}^S_{t|t+1}\right)$ because the return on short positions is $-R_{t+1}$ (see equation (2)). In this case,

$$\hat{r}_{t|t+1} = \frac{1}{2}\left[\left(\hat{s}^L_{t|t+1} - s_t + i^B_t - i^A_t\right) + \left(\hat{s}^S_{t|t+1} - s_t + i^B_t - i^A_t\right)\right] = \frac{\hat{s}^L_{t|t+1} + \hat{s}^S_{t|t+1}}{2} - s_t + i^B_t - i^A_t = \hat{s}_{t|t+1} - s_t + i^B_t - i^A_t.$$

non-monetary wealth of individuals in the market in countries A and B; and IFP_t stands for the international financial position of country A vis-à-vis country B, expressed as a proportion of total market wealth. If $IFP_t > 0\,(IFP_t < 0)$, country A is a net creditor (debtor) to country B. Also note that a positive $B_t^A\left(A_t^B\right)$ represents the aggregate long (short) position held by individuals from country A (country B), net of any short (long) positions at time t. Thus, IFP_t is also the net supply of long positions.

UAUIP can be written as:

$$\hat{r}^L_{t|t+1} - \widehat{up}^L_{t|t+1} = \hat{r}^S_{t|t+1} - \widehat{up}^S_{t|t+1} + \lambda_3 IFP_t \tag{23}$$

As can be seen from this equation, in the aggregate, the side of the market that forecasts a larger excess return is determined by the sign of IFP_t. If, for example, $IFP_t > 0$, then in equilibrium, the forecasted return by bulls in excess of their uncertainty premium must be larger than that of bears in order to compensate them for their larger open position, i.e. $\left(\hat{r}^L_{t|t+1} - \widehat{up}^L_{t|t+1}\right) > \left(\hat{r}^S_{t|t+1} - \widehat{up}^S_{t|t+1}\right)$. This is the case because a positive IFP_t implies a net supply of long positions that bulls must hold. This larger supply of long positions implies that bulls' perceived exposure to potential losses is higher relative to that of bears. Therefore, bulls will be willing to hold this larger supply of long positions only if they forecast a higher excess return compared to bears.

We saw in this section that the market premium depends on the aggregate uncertainty premium of bulls and bears, which depend on bulls' and bears' forecast of the potential unit loss. Thus, to use UAUIP as an equilibrium condition for the premium, one needs to model the expected losses of bulls and bears.

2.3.4 The Uncertainty Premium and the Gap from the Historical Benchmark. Frydman and Goldberg (2007) model expected losses by using a behavioral insight from Keynes (1936). In discussing why an individual might prefer to hold cash instead of some interest-bearing asset, Keynes draws a connection between what he calls the fear of potential losses and the gap between the interest rate and its 'safe' historical benchmark level.[34] He argues that the decision of holding cash instead of some interest-bearing asset will be determined not by the absolute level of the interest rate, but by "the degree of its divergence from what is considered a fairly *safe* level of r [the interest rate]." (Keynes, 1936: 201)

Frydman and Goldberg apply this insight to the foreign exchange market, and model an individual's expected loss from holding an open position in the foreign exchange market to depend on her assessment of the gap from some historical benchmark. They capture this relationship by assuming that an individual's expected unit loss depends on the gap between the forecasted exchange rate and some historical benchmark level for the exchange rate, $\widehat{gap}_{t|t+1} = \hat{s}_{t|t+1} - \hat{s}_t^{HB}$. As will be explained further below, for a bull, an increase in the gap implies higher potential losses, whereas for a bear a higher gap implies lower potential losses. The *qualitative* nature of this implication follows from the IKE representations of forecasted returns and losses, which recognize that in making choices, individuals have to cope with imperfect knowledge.

In representing forecasts, Frydman and Goldberg allow for differences among information sets that individuals use as well as differences in forecasting strategies.

[34] A historical benchmark is a stable and slowly moving rate that provides a long run anchor for exchange rates. Independently of the way in which the benchmark is measured, it moves more slowly compared to exchange rates.

Furthermore, their representations also allow for a speculator to change her strategy if she believes that this would lead to higher profits. She can do so by switching to another existing strategy, or by inventing a new one. To model such revisions in forecasting strategies, Frydman and Goldberg use *qualitative* conditions. One set of such conditions, called the gap restrictions, implies that an individual's revised forecasting strategy must be consistent with a positive (negative) relationship between the magnitude of her potential loss and the gap from historical benchmark if she is a bull (bear). As such, IKE representations of forecasting behavior describe the *qualitative* properties that different forecasting strategies and/or their revisions have in common.

Thus, while the IKE assumption implies that when the gap increases, bulls' prospective loss and thus uncertainty premium increase, and bears' prospective loss and uncertainty premium decrease, it does not imply a specific quantitative relationship. In this dissertation, however, I am investigating whether the effect of the gap on the uncertainty premium could depend on the exchange rate regime. As I discuss in Sections 3.2 and 4 of this chapter, it is possible that the weight attached to the gap from historical benchmark is on the average higher for markets that are characterized by central bank intervention aimed at pushing the exchange rate towards some parity level. Furthermore, in Chapter 6 I test for the magnitude of this effect across different exchange rate regimes. Therefore, I assume that the relationship between the gap and the premium is stable over time, and use the following functions for bulls and bears, respectively:[35] [36]

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[35] In Chapters 5 and 6, I discuss the possibility of $\hat{\sigma}$ to be varying with the gap from the historical benchmark.

[36] Note that the historical benchmark levels for bulls and bears are aggregates of individual benchmarks. Individual benchmarks are likely to differ from each other due to imperfect knowledge, which encompasses

$$\widehat{up}^{L}_{t|t+1} = (1-\lambda_1)\hat{i}^{L}_{t|t+1} = \theta^{L} + \hat{\sigma}^{L}\left(\hat{s}^{L}_{t|t+1} - \hat{s}^{HB,L}_{t}\right) \tag{24}$$

$$\widehat{up}^{S}_{t|t+1} = (1-\lambda_1)\hat{i}^{S}_{t|t+1} = \theta^{S} - \hat{\sigma}^{S}\left(\hat{s}^{S}_{t|t+1} - \hat{s}^{HB,S}_{t}\right) \tag{25}$$

where $\hat{s}^{L}_{t|t+1}$ and $\hat{s}^{S}_{t|t+1}$ denote the log levels of the bulls' and bears' time t forecast of the time $t+1$ spot rate, respectively; $\hat{s}^{HB,L}_{t}$ and $\hat{s}^{HB,S}_{t}$ stand respectively for the bulls' and bears' assessment of the historical benchmark at time t, around which bulls and bears believe the exchange rate swings revolve; $\hat{\sigma}^{L} > 0$ and $\hat{\sigma}^{S} > 0$ are parameters that reflect the importance that bulls and bears, respectively, attach to the gap from the historical benchmark; and $\theta^{L} > 0$ and $\theta^{S} > 0$ are constant parameters that are large enough to ensure that $\widehat{up}^{L}_{t|t+1}$ and $\widehat{up}^{S}_{t|t+1}$ are positive.[37]

In the aggregate, the uncertainty premium is given by:

$$\widehat{up}_{t|t+1} = \frac{1}{2}\left(\widehat{up}^{L}_{t|t+1} - \widehat{up}^{S}_{t|t+1}\right) = \theta + \hat{\sigma}\left(\hat{s}_{t|t+1} - \hat{s}^{HB}_{t}\right) \tag{26}$$

where $\hat{\sigma} = \frac{1}{2}\left(\hat{\sigma}^{L} + \hat{\sigma}^{S}\right)$ denotes the aggregate of bulls' and bears' weight attached to the gap from the historical benchmark; $\hat{s}_{t|t+1} = \frac{1}{2}\left(\hat{s}^{L}_{t|t+1} + \hat{s}^{S}_{t|t+1}\right)$ stands for the bulls' and bears' aggregate time t forecast of the time $t+1$ exchange rate; $\hat{s}^{HB}_{t} = \frac{1}{2}\left(\hat{s}^{HB,L}_{t} + \hat{s}^{HB,S}_{t}\right)$ stands

the difference in variables that individuals deem important for benchmark levels, as well as the different ways in which they incorporate new information about such variables.

[37] The parameters θ^{L} and θ^{S} become important when $\hat{s}^{L}_{t|t+1} < \hat{s}^{HB,L}_{t}$ and/or $\hat{s}^{S}_{t|t+1} > \hat{s}^{HB,S}_{t}$.

for the aggregate of bulls' and bears' assessment of the historical benchmark; and $\theta = \frac{1}{2}\left(\theta^L + \theta^S\right)$.

Let us now discuss the implications of equations (24)-(26). Market participants are assumed to know that the exchange rate experiences long swings – it has a tendency to move away from benchmark levels for extended periods of time only to be followed by sustained countermovements back. The problem that individuals face is that they do not know exactly when such swings in exchange rates away from benchmark levels end and the countermovement begins. A bull in the market believes that the future exchange rate will be further from the benchmark than the current spot exchange rate. A bear, on the other hand, believes that the future exchange rate will be closer to the benchmark than the current exchange rate. Suppose, for example, that the exchange rate is above the historical benchmark and that $\widehat{gap}_{t|t+1} = \hat{s}_{t|t+1} - \hat{s}_t^{HB} > 0$. Bulls believe that the exchange rate will continue moving away, while bears believe that it will revert back to the historical benchmark. Now suppose that both bulls and bears increase their forecast of the future exchange rate, i.e. both $\hat{s}^L_{t|t+1}$ and $\hat{s}^S_{t|t+1}$ rise, while their assessment of the historical benchmark remains unchanged. [38] [39] The increase in $\hat{s}^L_{t|t+1}$ leads to a larger gap from the

[38] Note that in general, it is possible that an increase in $\hat{s}_{t|t+1}$ is associated with an increase in $\hat{s}^L_{t|t+1}$ and a fall in $\hat{s}^S_{t|t+1}$, which means that both bulls and bears would increase their assessment of potential losses, leading to an increase in both $\widehat{up}^L_{t|t+1}$ and $\widehat{up}^S_{t|t+1}$. Thus, the aggregate uncertainty premium could, in general, rise or fall. Frydman and Goldberg derive what they call relative gap conditions, under which the aggregate uncertainty premium would still rise with an increase in the gap. These relative gap conditions state that "if the bulls revise their assessment of the gap by a greater (smaller) magnitude compared with the bears, then they would also tend to revise their forecasts of the unit loss by a greater (smaller) magnitude." Frydman and Goldberg (2007, Ch. 12, pg. 10)

benchmark and this rise leads our bulls to become more concerned about the potential loss of continuing to bet on a continuation of the swing away, which would result if the exchange rate were to revert back to its benchmark level. Therefore bulls require a higher uncertainty premium to speculate in the currency market, i.e. a $\widehat{up}^{L}_{t|t+1}$ rises (equation (24)). Bears, on the other hand, become less concerned about potential losses, which would result if the exchange rate were to continue moving away from the historical benchmark. Therefore, bears require a lower premium, i.e. $\widehat{up}^{S}_{t|t+1}$ falls (equation (25)). This increase in $\widehat{up}^{L}_{t|t+1}$ and fall in $\widehat{up}^{S}_{t|t+1}$ leads to a higher uncertainty premium in the aggregate.[40] [41]

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[39] Note that in general, a market participant is a bear as long as she forecasts the exchange rate to be lower than the current spot exchange rate, $\hat{s}^{S}_{t|t+1} < s_t$. Thus, a bear increasing her forecast of the future spot exchange rate in general implies that she forecasts a smaller fall in the exchange rate, compared to her previous forecast. It is, however, possible that an individual is a bear even when $\hat{s}^{S}_{t|t+1} > s_t$. That would be the case if the interest rate differential, $i^B_t - i^A_t$, is more negative than $\hat{s}^{S}_{t|t+1} - s_t$, which would still imply a positive expected return on a short position. Such a case, however, would not change any of the basic arguments.

[40] Recall that $\widehat{up}_{t|t+1} = \widehat{up}^{L}_{t|t+1} - \widehat{up}^{S}_{t|t+1}$.

[41] Note that this result does not depend on the sign of the gap, i.e. even if $\widehat{gap}_{t|t+1} = \hat{s}_{t|t+1} - \hat{s}^{HB}_t < 0$, as bulls and bears increase their forecast of the future exchange rate towards the benchmark, the aggregate uncertainty premium would rise. To see why this is the case, let us first work out the case with $\widehat{gap}_{t|t+1} < 0$ and both $\hat{s}^{L}_{t|t+1}$ and $\hat{s}^{S}_{t|t+1}$ decreasing further below the benchmark. In this case, bears become more concerned about an eventual countermovement, while bulls become less concerned. Thus, $\widehat{up}^{L}_{t|t+1}$ falls while $\widehat{up}^{S}_{t|t+1}$ rises. In the aggregate, then, as $\hat{s}_{t|t+1}$ falls, so does the aggregate uncertainty premium. Now if $\widehat{gap}_{t|t+1} < 0$ and both bulls and bears increase their forecast of the future exchange rate towards the benchmark, then the uncertainty premium for bulls and bears changes in the opposite way. Bears become less concerned about an eventual countermovement, while bulls become more concerned. Thus, $\widehat{up}^{L}_{t|t+1}$ rises while $\widehat{up}^{S}_{t|t+1}$ falls. In the aggregate, then, as $\hat{s}_{t|t+1}$ increases, so does the aggregate uncertainty premium.

Now that we modeled forecasted losses by bulls and bears, we are ready to discuss how UAUIP serves as an equilibrium condition for the premium on foreign exchange.

2.3.5 UAUIP as an Equilibrium Condition. To illustrate how UAUIP serves as an equilibrium condition for the premium, let us rewrite UAUIP by substituting for $\hat{r}_{t|t+1} = \hat{s}_{t|t+1} - s_t + i_t^B - i_t^A$ and $\widehat{pr}_{t|t+1} = \widehat{up}_{t|t+1} + \lambda_3 IFP_t$ in (18):

$$\hat{s}_{t|t+1} - s_t + i_t^B - i_t^A = \hat{\sigma}\left(\hat{s}_{t|t+1} - \hat{s}_t^{HB}\right) + \lambda_3 IFP_t + \theta \qquad (27)$$

Now suppose that initially the equilibrium condition holds, and that $\widehat{gap}_{t|t+1} = \hat{s}_{t|t+1} - \hat{s}_t^{HB} > 0$. Also suppose that both bulls and bears in the market increase their forecast of the future exchange rate, i.e. $\hat{s}_{t|t+1}^L$ and $\hat{s}_{t|t+1}^S$ both rise. Assume further that $\hat{s}_t^{HB}$, i_t^A and i_t^B remain unchanged. As $\hat{s}_{t|t+1}^L$ rises away from $\hat{s}_t^{HB}$, bulls' forecasted excess return rises (recall that $\hat{r}_{t|t+1}^L = \hat{s}_{t|t+1}^L - s_t + i_t^B - i_t^A$), which causes them to want to increase their position size. If bulls' expected losses do not change then, bulls increase their long position (see equation (14) above). Simultaneously, however, the rise in $\hat{s}_{t|t+1}$ leads to a larger gap from the benchmark and this rise leads our bulls to become more concerned about the potential loss of continuing to bet on a continuation of the swing away, which would result if the exchange rate were to revert back to its benchmark level. Therefore bulls require a higher uncertainty premium to speculate in the currency market, i.e. a $\widehat{up}_{t|t+1}^L$ rises (equation (24)). This higher premium restrains bulls' desire to increase their long positions. For bears, on the other hand, the increase in $\hat{s}_{t|t+1}^S$ implies a lower expected return (recall that $\hat{r}^{S}_{t|t+1} = -\left(\hat{s}^{S}_{t|t+1} - s_t + i^{B}_t - i^{A}_t\right)$), which leads them to reduce their position size (see equation (15) above). At the same time, bears become less concerned about potential losses, which would result if the exchange rate were to continue moving away from the historical benchmark. Therefore, they require a lower premium, i.e. $\widehat{up}^{S}_{t|t+1}$ falls (equation (17)). This lower premium restrains bears' desire to decrease their short positions.

In the aggregate, the expected excess return, $\hat{r}_{t|t+1} = \frac{1}{2}\left(\hat{r}^{L}_{t|t+1} - \hat{r}^{S}_{t|t+1}\right)$, rises, and so does the premium, $\widehat{up}_{t|t+1} = \frac{1}{2}\left(\widehat{up}^{L}_{t|t+1} - \widehat{up}^{S}_{t|t+1}\right)$. Assuming that the increase in the premium does not completely reduce market participants' willingness to take open positions, the rise in the exchange rate forecast creates excess demand for foreign exchange, which bids up the spot exchange rate to restore equilibrium in the foreign exchange market.[42]

3 UAUIP and Swings in Exchange Rates

With the gap restrictions that were discussed in the previous section, UAUIP gives rise to a model of the premium. To model the exchange rate, however, one needs to also model exchange rate expectations, the interest rates, the historical benchmark, and the international financial position. Frydman and Goldberg (2007) develop such an IKE model, which I briefly discuss in this section.[43] Before moving on, let me point out that the focus of this dissertation is not on the genesis of swings. For my purposes, it does not

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[42] This implies that $\hat{\sigma} < 1$, in which case the increase in $\hat{r}_{t|t+1}$ is larger than the rise in $\widehat{up}_{t|t+1}$. Therefore, s_t rises to restore equilibrium in the market.

[43] See Chapter 14 in Frydman and Goldberg (2007).

matter how swings in exchange rates arise. Independently of the way in which swings may arise, the Frydman and Goldberg model of the premium implies that swings in the exchange rate toward or away from historical benchmarks should be associated with swings in the aggregate premium on foreign exchange. This is the relationship on which my dissertation builds.

However, it is worthwhile to discuss the basic idea behind Frydman and Goldberg's IKE model of exchange rate swings model. The dominant view in the literature is that swings in exchange rates are driven by bubbles, irrationality, or market psychology (discussed in Chapter 1). However, in Frydman and Goldberg's IKE model, exchange rate swings arise without assuming irrationality. Moreover, such behavior can occur even if all market participants base their forecasts solely on macroeconomic fundamentals.[44]

3.1 What Drives Exchange Rate Forecasts Away from Benchmark Levels?

Recall from the discussion in Chapter 1 that the flexible-price and sticky-price monetary models rely on REH, and thus they fail to provide an explanation for long swings in exchange rates. In exchange rate models that do generate long swings - the REH bubble model and behavioral models – swings occur because as exchange rate expectations move persistently away from historical benchmarks, the exchange rate follows. With IKE, swings in exchange rates are also driven by exchange rate expectations. To see how swings in exchange rates occur in the IKE model, consider the following representation of the aggregate forecast for the future exchange rate:

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[44] For the IKE model of swings, refer to Chapter 14 in Frydman and Goldberg (2007).

$$\hat{s}_{t|t+1} = \hat{\delta}_t' x_t + \hat{\gamma} s_t \quad (28)$$

where $\hat{s}_{t|t+1}$ depends on a set of causal variables, x_t, called the autonomous component, and an endogenous component that depends on the level of the spot exchange rate.

The influence of the causal variables on the exchange rate forecast, $\hat{\delta}_t$, is not constrained either in terms of algebraic sign or magnitude. Moreover, this influence might be changing over time.[45] The effect of the spot exchange rate on exchange rate forecasts is captured by the parameter $0 < \hat{\gamma} < 1$, which, for simplicity, is assumed to be invariant over time.

According to this specification of the exchange rate forecast, a change in the aggregate forecast of the future exchange rate can occur either because of new realizations of causal variables or the exchange rate, or because of changes in the parameters, $\hat{\delta}_t$, attached to each causal variable. This latter change could involve a change in the set of causal variables in x_t, so that the absence of a causal variable at time t, for example, would be represented by $\hat{\delta}_t = 0$ for that specific variable.

In this model, there is no constraint on either the set of causal variables that might be deemed important by market participants, or how these variables might matter for them. In forming their forecasts, market participants may be looking at many factors, including the historical benchmark as well as other macroeconomic fundamentals, such as interest rates and current account deficit. The variables individuals deem important might change over time, as might the way in which these variables matter for them.

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[45] Allowing the $\hat{\delta}$ parameters to change over time leads to a piece-wise linear specification of forecasting behavior.

What role does such a representation of the aggregate forecast for the future exchange rate play in terms of exchange rate swings? According to the specification in (28), when market participants are presumed to have imperfect knowledge and the policy environment does not change, swings in exchange rates away from benchmark levels can arise due to new realizations of the causal variables with no change in the forecasting strategy, i.e. changes in x_t. In the conventional flexible-price and sticky-price monetary models, such new realizations in causal variables do not generate swings in real exchange rates.[46] The reason is that these models assume that the structural parameters of the economy and the parameters that individuals use in their forecasting strategies are the same. In other words, they do not allow for diversity in forecasting strategies across individuals. Therefore, in these models, representations of individuals' forecasts on the exchange rate are tied to PPP. This implies that the real exchange rate equals its PPP level.

IKE, on the other hand, recognizes that individuals use diverse forecasting strategies. Therefore, with IKE, the aggregate of individual forecasts of the exchange rate will not be captured by the REH representation. This implies that, in general, the real exchange rate will not equal its PPP level, and the nominal exchange rate will not equal to its PPP level.[47] Thus, with IKE, if causal variables, which could be comprised exclusively of macroeconomic fundamentals, are moving in a way that causes individuals

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[46] Recall from the discussion in Chapter 1 that in the flexible-price model swings in nominal exchange rates can occur if there is a change in relative price levels. These models, however, have not been able to generate swings in real exchange rates.

[47] Note that the relationship between the PPP levels of the nominal and real exchange rates is given by $\hat{s}^{PPP} = \hat{q}^{PPP} + p_t$. Thus, swings in the real exchange rate will, in general, imply swings in the nominal exchange rate.

to formulate their forecasts in a direction pushing the exchange rate persistently away from historical benchmark levels, then there will be swings in exchange rates away from benchmark levels.[48]

Exchange rate swings could also occur due to revisions of forecasting strategies, which is captured by the change in $\hat{\delta}_t$, when revisions of the $\hat{\delta}_t$ parameters is either reinforcing or conservative. Revisions of forecasting strategies are said to be conservative or reinforcing if they lead to a new forecast that is not too different from or reinforces the forecast that an individual would have formed if she had not revised her forecasting strategy. These conservative revisions in forecasting strategies appeal to a major finding in the psychology literature - that individuals are generally slow in revising their beliefs and strategies when faced with new evidence.

In sum, in contrast to the REH bubble and behavioral models which explain swings as arising due to bubbles, irrationality, or market psychology, in the IKE swings model exchange rate swings can occur even if all market participants base their forecasts solely on macroeconomic fundamentals.

3.2 What Does UAUIP Imply About the Magnitude of Swings?

Independently of how exchange rate swings arise and what drives exchange rate expectations, UAUIP, coupled with gap restrictions, implies that the exchange rate moves less than one-for-one with exchange rate expectations. This is in contrast to the bubble and behavioral models in which the exchange rate moves one-for-one with exchange rate

[48] This result is *not* derived by assuming that the trend in the causal variables remains unchanged. See Frydman and Goldberg (2007).

expectations. To illustrate why this is the case, let us first consider the equilibrium condition for the foreign exchange market on which standard monetary models rely, the uncovered interest parity (UIP):

$$\hat{s}_{t|t+1} - s_t + i_t^B = i_t^A \tag{29}$$

where all variables are defined as before.

The UIP condition states that the foreign exchange market is in equilibrium when the expected returns on domestic and foreign assets are equal. It can be easily seen from this equation that if there is, say, an increase in the expected exchange rate for the next period, *ceteris paribus*, then the spot exchange rate would change one-for-one with the change in exchange rate expectations in order to maintain equilibrium in the foreign exchange market.

Now recall that UAUIP is based on the premise that to speculate in the foreign exchange market, individuals require an uncertainty premium as a compensation for exposing themselves to risk, where this uncertainty premium is a positive function of the gap between the expected exchange rate and its historical benchmark level as perceived by market participants.

Also recall that according to UAUIP, equilibrium in the foreign exchange market occurs when the aggregate *uncertainty-adjusted* forecasted returns on domestic and foreign assets are equal:

$$\hat{s}_{t|t+1} - s_t + i_t^B - i_t^A = \hat{\sigma}\left(\hat{s}_{t|t+1} - \hat{s}_t^{HB}\right) + \lambda_3 IFP_t + \theta \tag{30}$$

or, alternatively:

$$\widehat{pr}_{t|t+1} = \hat{\sigma}\left(\hat{s}_{t|t+1} - \hat{s}_t^{HB}\right) + \lambda_3 IFP_t + \theta \tag{31}$$

UAUIP implies that, when there is a change in exchange rate expectations, the exchange rate will move less that one-for-one. To see why this is the case, suppose that $\widehat{gap}_{t|t+1} = \hat{s}_{t|t+1} - \hat{s}_t^{HB} > 0$. Now suppose that both bulls and bears in the market increase their forecast of the future exchange rate, i.e. $\hat{s}_{t|t+1}^L$ and $\hat{s}_{t|t+1}^S$ both rise. Market participants are assumed to know about the long swings behavior of exchange rates in the long run, and that the exchange rate eventually comes back to its benchmark. So, as before, the bulls in the market become more concerned about the possibility of a countermovement back to the benchmark and they ask for an uncertainty premium as a compensation for exposing themselves to risk. The farther away the exchange rate gets from the historical benchmark, bulls become even more concerned and ask for an even higher uncertainty premium. This leads them to limit their position size. Bears, on the other hand, become more confident that a countermovement would occur and lower their uncertainty premium. In the aggregate, the uncertainty premium rises, limiting individuals' willingness to put more money at risk. Therefore in the premium model, as expectations rise, the exchange rate rises less than one-for-one.

Furthermore, with UAUIP, the degree of responsiveness of the exchange rate, s_t, to a change in expectations, $\hat{s}_{t|t+1}$, depends on the size of the weight attached to the gap from the historical benchmark, $\hat{\sigma}$: the larger (smaller) is $\hat{\sigma}$, the smaller (bigger) is the movement in s_t that will be required to restore equilibrium in the market.[49] In other words, following a change in $\hat{s}_{t|t+1}$, in markets where $\hat{\sigma}$ is small we will observe larger

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[49] This can also be seen from $\frac{ds_t}{d\hat{s}_{t|t+1}} = (1 - \hat{\sigma})$.

movements in s_t either away from or towards benchmark levels compared to markets where $\hat{\sigma}$ is large. This implies that for a given change in the expected exchange rate, markets where $\hat{\sigma}$ is small will experience exchange rate swings of a larger magnitude compared to markets in which $\hat{\sigma}$ is large.

This suggests that if policy officials can lead individuals to increase the weight they attach to the benchmark level in forming their assessments of the riskiness of foreign exchange speculation, this would lead to an aggregate uncertainty premium that is more sensitive to changes in the forecasted exchange rate, and thus, *ceteris paribus*, to smaller swings in the exchange rate. This leads to a key theoretical result suggesting that there may be a channel through which official intervention aimed at pushing the exchange rate back to some announced or unannounced parity level can limit the magnitude of exchange rate swings.[50]

A key premise behind this result is the positive relationship between the uncertainty premium and the gap between the exchange rate and its historical benchmark level. Frydman and Goldberg (2007) have tested for the positive relationship between the gap and the market premium as given in equation (31) for the British pound/U.S. dollar, Japanese yen/U.S. dollar and German mark/U.S. dollar exchange rates between December 1982 and February 1997. They provide strong evidence that as the gap from PPP rises, so does the premium.[51] In Chapter 5, I extend their analysis to twenty-four

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[50] This idea was first proposed by Frydman and Goldberg (2004). They suggest a *reference-rate proposal*, which consists of a central bank announcement of an official estimate, a reference rate, of some benchmark parity at regular intervals and official intervention aimed at pushing the exchange rate back to parity at any point in time.

[51] Results by Frydman and Goldberg are discussed in more detail in Chapter 5.

exchange rates against the dollar. My results also provide support for a positive relationship between the gap and the premium.

4 Official Intervention, Parity Announcement and the Uncertainty Premium

The Frydman and Goldberg premium model suggests that official intervention to push the exchange rate back to some announced or unannounced parity may work to limit the magnitude of exchange rate swings by inducing individuals to increase the weight they attach to the benchmark level in forming their forecasts. Why would such a policy cause the market to attach a higher weight to the benchmark? Recall the discussion on UAUIP as an equilibrium condition for the premium. As the market increases their forecast of the future exchange rate away from the historical benchmark from above, the uncertainty premium rises.[52] This is the case because bulls become more concerned about an eventual countermovement. They forecast higher potential losses and ask for a higher uncertainty premium to take open positions, which limits their willingness to put more money at risk. Bears, on the other hand, become more confident that a countermovement will occur, thus lowering their forecasted potential losses, and asking for a lower uncertainty premium. In the aggregate, as the forecasted future exchange rate increases away from the benchmark from above, the uncertainty premium rises.

In this dissertation, I suppose that, if the central bank were to intervene to push the exchange rate back to some parity level at unpredictable moments in time, then market participants would raise their assessment of the potential losses from betting on

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[52] Assume that both $\hat{s}^{L}_{t|t+1}$ and $\hat{s}^{S}_{t|t+1}$ rise. See Section 2.3.4 above.

movements away from the central bank's parity level.[53] To see why this is the case, suppose again that bulls in the market raise their expectation of the future exchange rate away from historical benchmark levels from above. Now bulls are already concerned about betting on a further movement away from benchmark levels because they know that historically, while long swings can continue for extended periods of time, eventually the swing ends and the exchange rate comes back to the benchmark. If in addition to this, they have to worry about a loss that might arise from central bank intervention, it is reasonable to suppose that they would further increase their forecast of the potential loss. As was discussed in Chapter 2, there is empirical evidence that central bank intervention does have a short run influence on exchange rates in the desired direction, and so they can lead to actual losses for bulls in the market. Consequently, bulls' concern about countermovements may become heightened when the central bank is working to push the exchange rate back to its benchmark. If that is the case, then bulls would ask for an even higher uncertainty premium, as compared to the case with no central bank intervention, which will further temper their desire to risk more capital. Bears, on the other hand are likely to feel even more convinced of an eventual countermovement and thus ask for an even lower uncertainty premium. In the aggregate, the uncertainty premium would be even higher compared to the case with no central bank intervention, inducing a smaller increase in the spot exchange rate. Thus, it is possible that with central bank intervention, as the exchange rate moves away from the benchmark level from above, the uncertainty premium rises even faster and so we get a smaller swing in the exchange rate for the

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[53] Because the central bank does not defend the official parity or any bands around the parity, even if such parity is announced, intervention aimed at pushing the exchange rate back to such a pre-announced benchmark level would be hard to predict in advance.

same swing in exchange rate expectations. This suggests a new channel through which central bank intervention aimed at pushing the exchange rate back to some parity can affect swings exchange rates: *the uncertainty premium channel.*

4.1 Central Bank Intervention and Parity Announcement: The Uncertainty Premium Channel

I propose to capture the policy of intervention to support some parity level as an additional term in the equation for the uncertainty premium:[54]

$$\widehat{up}_{t|t+1} = \theta + \hat{\sigma}_1 \left(\hat{s}_{t|t+1} - \hat{s}_t^{HB} \right) + \hat{\sigma}_2 \left(\hat{s}_{t|t+1} - \hat{s}_t^{HB_{CB}} \right) \quad (32)$$

where $\hat{\sigma}_1$ is the weight market participants attach to the gap between the forecasted exchange rate and their assessment of the benchmark level, $\hat{s}_t^{HB}$, and $\hat{\sigma}_2$ is the weight individuals attach to the gap between the forecasted exchange rate and the official benchmark level, $\hat{s}_t^{HB_{CB}}$.

The second term in equation (32) captures the idea discussed above that, with central bank intervention to push the exchange rate to some parity level, the aggregate uncertainty premium may be higher compared to markets with no such policy because bulls would face higher potential losses while bears would face lower potential losses.[55] It is perhaps the case that such a policy would be more effective if the central bank announces their official assessment of the benchmark level. Recall our discussion in Chapter 2 on official exchange rate communication and the reaction of the exchange rate

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[54] In equation (32), θ is large enough so that $\widehat{up}_{t|t+1} > 0$ holds.

[55] When $\hat{s}_{t|t+1}$ rises further away from historical benchmark from above.

to news announcements. The major conclusion was that such announcements have a significant effect on exchange rate movements, suggesting that a parity announcement by the central bank would also matter for exchange rates. However, this does not have to be the case. Even if the central bank does not announce its official benchmark level, as long as market participants believe that intervention is aimed at pushing the exchange rate to some parity, they would still attach a higher weight to the gap in assessing potential losses. In that case they would perhaps somehow infer what benchmark the central bank is using, or they would simply attach a higher weight to their individual assessment of the benchmark level.

There are several things to be noted about the specification of the uncertainty premium given in (32). First, note that the sign of the two gap terms does not matter in terms of the effect of the forecasted future spot exchange rate on the uncertainty premium. As before, as the forecasted exchange rate rises, the uncertainty premium increases as well. Suppose, for example, that $\left(\hat{s}_{t|t+1} - \hat{s}_t^{HB}\right) < 0$, which implies that the aggregate forecast of the future exchange rate is below market participants' own assessment of the benchmark, i.e. $\hat{s}_{t|t+1} < \hat{s}_t^{HB}$; and $\left(\hat{s}_{t|t+1} - \hat{s}_t^{HB_{CB}}\right) > 0$, which implies that the aggregate forecast of the future exchange rate is above the official benchmark, i.e. $\hat{s}_{t|t+1} > \hat{s}_t^{HB_{CB}}$. Now suppose that the market forecasts a higher future exchange rate, i.e. $\hat{s}_{t|t+1}$ rises. In this case, both gap terms, $\left(\hat{s}_{t|t+1} - \hat{s}_t^{HB}\right)$ and $\left(\hat{s}_{t|t+1} - \hat{s}_t^{HB_{CB}}\right)$, would increase, leading to a higher uncertainty premium. This effect of the forecasted future exchange rate on the uncertainty premium can be easily seen if equation (32) is rewritten as:

$$\widehat{up}_{t|t+1} = \left(\hat{\sigma}_1 + \hat{\sigma}_2\right)\hat{s}_{t|t+1} - \hat{\sigma}_1\hat{s}_t^{HB} - \hat{\sigma}_2\hat{s}_t^{HB_{CB}} + \theta \qquad (33)$$

What this implies is that the relationship between the two historical benchmarks does not play a role in the model. It is possible that the individual assessment of the benchmark is equal or different from the official parity. Perhaps when the central bank does not announce its official estimate of the benchmark, the market participants would basically assume that official estimate is the same as their own assessment of the benchmark. In that case, the uncertainty premium equation given in (32) would become:

$$\widehat{up}_{t|t+1} = \theta + \left(\hat{\sigma}_1 + \hat{\sigma}_2\right)\left(\hat{s}_{t|t+1} - \hat{s}_t^{HB}\right) \tag{34}$$

In a way, a specification such as the one given in (32) allows for two different benchmark levels, however it does not constrain them to be different from each other. In terms of the effect of the forecasted future exchange rate on the uncertainty premium, it does not matter if the two benchmarks are the same. What really matters here is that market participants are aware of the long swings nature of the exchange rate and bulls, say, already face some potential losses when they increase their forecast for the exchange rate away from historical benchmark levels. And now the central bank steps into this environment with a policy to push the exchange rate back to the benchmark level. Thus, in addition to the long swings nature of exchange rates, now there is an additional force that will push the exchange rate back to parity. So now the question is, how do market participants react to such a policy?

As was discussed before, even without any central bank intervention, when the gap from benchmark levels increases, bulls increase their assessment of potential losses because they become more concerned about an eventual countermovement. It is possible then, that for the same gap from historical benchmark levels, bulls increase their assessment of potential losses even more when there is central bank intervention aimed at pushing the exchange rate back to parity. If that is the case, it would suggest that the total weight attached to the gap from historical benchmark would be higher with central bank policy compared to the case with no such policy, i.e. $\hat{\sigma}_1 + \hat{\sigma}_2 > \hat{\sigma}$. However, whether $\hat{\sigma}_1 + \hat{\sigma}_2 > \hat{\sigma}$ holds would for one thing depend on whether the weight attached to the gap from $\hat{s}_t^{HB}$ would differ with and without central bank intervention. Note that the specification in (32) allows for the weight attached to the gap from $\hat{s}_t^{HB}$ to be different depending on central bank policy, i.e. it could be that $\hat{\sigma}_1 \neq \hat{\sigma}$. If the market attaches the same weight to the gap from their assessment of the benchmark level, i.e. if $\hat{\sigma}_1 = \hat{\sigma}$, and in addition they attach some weight to the official parity, i.e. $\hat{\sigma}_2 > 0$ holds, then $\hat{\sigma}_1 + \hat{\sigma}_2 > \hat{\sigma}$ would hold. However, it is possible that market participants lower the weight they attach to their own assessment of the benchmark level, $\hat{\sigma}_1$, while increasing the weight they attach to the official parity, $\hat{\sigma}_2$. What determines the relative magnitudes of $\hat{\sigma}_1$ and $\hat{\sigma}_2$ is an open question. It could be the degree of access to credible information that individuals use to form their own assessment of the historical benchmark, where easier or cheaper access might lead to higher weight attached to one's own forecast of the gap, i.e. a higher $\hat{\sigma}_1$ compared to $\hat{\sigma}_2$. More limited or more costly access, on the other hand, might lead to higher weigh attached to the official forecast of the gap. Or perhaps they attach a higher weight to the official parity just because it is the relevant benchmark for central bank intervention. In that case it is possible that the magnitude of $\hat{\sigma}_2$ depends on central bank credibility, where the weight is higher with a more credible central bank.[56] At the end, however, whether the total weight that the market attaches to the gap from the historical benchmark with central bank intervention ($\hat{\sigma}_1 + \hat{\sigma}_2$) is higher compared to the case with no central bank intervention ($\hat{\sigma}$) is an empirical question, which I investigate in Chapter 6.[57]

4.2 A New Way for Testing the Effectiveness of Central Bank Policy

If it is the case that the weight attached to the gap from historical benchmark is higher with central bank intervention aimed at pushing the exchange rate back to some announced or unannounced parity level, then such policy could lead to a smaller swing in the exchange rate *for the same swing in exchange rate expectations* compared to markets with no such policy. Thus, by testing whether the weight attached to the gap is larger in markets that involve central bank intervention, I can indirectly test for the effectiveness of such policy in limiting exchange rate swings.[58] What this means is that I do not directly test whether intervention leads to swings of smaller magnitude by developing some measure for the magnitude of swings as Kubelec (2004a,b) does. One of the problems with such an analysis is that countries with different exchange rate regimes experience different shocks. Therefore, even if official intervention has been effective in leading to swings of smaller magnitude, this might not appear to be the case. For

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[56] I owe this point to Sudesh Mujumdar.

[57] Note that if the two central banks are intervening to push the exchange rate in opposite directions, then it is possible that the effect on the exchange rate is nullified. In that sense, the model assumes that either only one of the central banks is pursuing a policy to affect the exchange rate, or if they both are, then the policy intervention is in the same direction.

[58] Note that central bank policy would influence exchange rate swings by affecting the weight attached to the gap from PPP, as well as exchange rate expectations through its effect on macroeconomic fundamentals such as interest rates and prices. Such a policy could, however, also have a direct effect on the premium. Such a possibility is discussed in Chapter 6 under future research avenues.

example, consider two countries – one with a freely floating exchange rate regime (country A) and another that has adopted a regime that involves central bank intervention aimed at reducing exchange rate swings with or without an official announcement of a parity (country B). Now, it is possible that although intervention policy in country B is effective in terms of limiting the magnitude of exchange rate swings, swings in the currency of this country still appear to be larger than the swings for the currency of country A just because country B has experienced bigger shocks. Recall that in the IKE swings model, one way in which changes in exchange rate forecasts, and thus, swings in exchange rates could arise is due to new realizations of causal variables. In that context, swings in the exchange rate for country B may be larger because of larger changes in the causal variables, despite the fact that intervention is working to limit swings. Thus, the way in which I test for the effectiveness of official intervention allows me to control for the change in the causal variables and compare the relative effects of central bank intervention on exchange rate swings for the same change in exchange rate expectations.

As a last note, it is important to emphasize that the Frydman and Goldberg premium model leads to a new way to test the influence of intervention aimed at pushing the exchange rate back to some parity on exchange rate movements. The question is not whether central bank intervention can turn around the exchange rate over the next few days, but rather whether such policy can limit the magnitude of swings. For the most part, the literature has not examined this question. The premium model implies that in currency markets where the central bank is intervening at unpredictable moments in time to push the exchange rate back to some pre-announced or unannounced parity level, exchange rates will experience smaller swings for the same swing in exchange rate expectations compared to currency markets without such policy intervention. The model also provides a new way to test for this implication without deriving a measure for the magnitude of exchange rate swings and as such, it differs from other studies. It implies that in markets characterized with central bank intervention the aggregate weight attached to the gap from historical benchmarks will be larger compared to markets without such policy. Thus, by testing whether the aggregate weight is larger for countries that have been pursuing some kind of an exchange rate regime that involves central bank intervention aimed at pushing the exchange rate to some parity level compared to freely floating exchange rates, one can test if these markets have experienced smaller swings in exchange rates for the same swing in exchange rate expectations. If that is the case, this would be an indication that such policy interventions have been successful in limiting exchange rate swings.

In Chapter 6, I provide some empirical evidence that suggests that markets that involve some central bank policies aimed at influencing exchange rates are associated with a larger weight attached to the gap compared to free floats, thus with more limited swings in exchange rates.

5 Conclusion

In this chapter I built on the Frydman and Goldberg (2007) premium model and showed that this model provides rationale for a new channel through which central bank intervention can limit swings in exchange rates. This uncertainty premium channel is based on the insight that when speculating in the foreign exchange market, individuals require an uncertainty premium as a compensation for exposing themselves to risk. The uncertainty premium depends positively on the gap between the forecasted exchange rate and its historical benchmark level. This relationship is the key premise on which the uncertainty premium channel builds - when there is central bank intervention aimed at pushing the exchange rate back to some parity, market participants would presumably care more about the gap from the benchmark level because such policy leads to higher potential losses. These higher potential losses limit individuals' willingness to put additional money at risk, and therefore lead to a smaller swing in exchange rates for the same swing in exchange rate expectations. In Chapters 5 and 6 I respectively test for the positive relationship between the market premium and the gap from the historical benchmark, and whether central banks can utilize this link for limiting exchange rate swings. In the next chapter I discuss the methodology and data for testing these implications.

CHAPTER 4

DATA AND METHODOLOGY

1 Introduction

The previous chapter discussed two testable implications of the premium model. The first is the positive relationship between the gap from the historical benchmark and the market premium. The other implication is that central bank intervention supporting some parity level can lead to a larger weight attached to the gap from the historical benchmark, and thus, smaller swings in exchange rates. These implications follow from UAUIP and the gap restrictions, relating the market premium to the gap between the forecasted exchange rate for the next period and its historical benchmark level and the international financial position of the domestic economy vis-à-vis the foreign economy as a percentage of total market wealth:

$$\widehat{pr}_{t|t+1} = \hat{\sigma}\left(\hat{s}_{t|t+1} - \hat{s}_t^{HB}\right) + \lambda_3 IFP_t + \theta \quad (1)$$

In terms of the specification that I proposed in the last chapter that captures the announcement of a parity by the central bank, equation (1) becomes:

$$\widehat{pr}_{t|t+1} = \hat{\sigma}_1\left(\hat{s}_{t|t+1} - \hat{s}_t^{HB}\right) + \hat{\sigma}_2\left(\hat{s}_{t|t+1} - \hat{s}_t^{HB_{CB}}\right) + \lambda_3 IFP_t + \theta \quad (2)$$

Testing the predictions of the premium model requires a measure for the equilibrium premium, the markets' exchange rate forecasts, the historical benchmark(s) and the international financial position.

To obtain a measure of the markets' exchange rate forecasts, I use a novel dataset provided by Forecasts Unlimited, Inc. This data set consists of survey data of market participants' one-month ahead exchange rate forecasts for twenty-four currencies, including developed and developing countries from August 1986 through September 2000.[1]

Survey data on market participants' forecasts concerning future exchange rates have been used fairly extensively in the literature. Although there are some bias problems with forecasts from survey data, most researchers believe that even if there are biases in the forecast data they are not systematic.

Survey data provide the researcher with the markets' forecasts of the exchange rates and thus eliminate the need for coming up with measures regarding these forecasts by using some economic model. Moreover, in particular to my analysis, survey data also allow me to follow an approach in which I can control for different shocks in exchange rate expectations that different countries might experience. One prediction of the premium model is that *for a given swing in exchange rate expectations*, countries with exchange rate regimes that involve central bank intervention supporting some parity level should experience swings of smaller magnitude compared to countries that have a freely floating exchange rate. As was discussed in section 4 of chapter 3, different shocks to

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[1] Although the survey provides forecast data for over 40 countries, due to several reasons that are discussed below, about half of these have been excluded from the analysis. The sample runs through September 2000 because the one-month ahead forecasts have been discontinued afterwards.

different markets might make a successful policy appear unsuccessful.[2] I discuss the survey data in greater detail in Section 2.

To construct a series for the gap from the historical benchmark, one also needs to have a measure for the historical benchmark, which is a stable and slowly moving rate that provides a long run anchor for exchange rates. Recall that the effect of the forecast of the future exchange rate on the uncertainty premium does not depend on the two benchmark levels, $\hat{s}_t^{HB}$ and $\hat{s}_t^{HB_{CB}}$, being different or the same (Section 4 of Chapter 3). Therefore, I use one measure for both the individual and the official historical benchmark levels, which I discuss in Section 3.

Data on bilateral financial positions between countries as a percentage of total market wealth (IFP_t in the equations above) are not available due to the lack of data on total market wealth. Therefore, the effect of this variable on the market premium will be captured by the error term. However, there is evidence that when bilateral asset supplies change, they change more slowly compared to the forecasted future exchange rate.[3] Assuming that the total market wealth changes slowly as well, then it might be reasonable to suppose that the covariance between this variable and the gap is small, and thus the estimate of the weight attached to the gap from historical benchmarks will not be greatly affected.

Testing the second prediction of the model - that central bank intervention aimed at pushing the exchange rate back to some parity level could lead to a larger weight

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[2] Successful policy refers to central bank intervention leading to more limited swings compared to the case where such policy is missing.

[3] In fact, if asset supplies were changing faster, the portfolio balance models would have performed better empirically. See Chapters 1 and 2. Also see Frydman and Goldberg (2007).

attached to the gap from historical benchmark, i.e. a higher $\hat{\sigma}$ compared to freely floating regimes - requires classifying currencies according to the exchange rate regime. One of the crucial things here is to be able to classify countries according to the exchange rate regime that they actually adopt (de facto regime) instead of the exchange rate regime that the authorities claim to pursue (de jure regime). This is important because it appears that there are significant differences between the two – many countries that claim to be pursuing a freely floating regime in actuality follow an intermediate regime, called the 'fear of floating' due to Calvo and Reinhart (2002). However, classifying exchange rate regimes requires that some assumptions about the behavior of exchange rates and other variables under different regimes be made. And of course, different assumptions imply different classifications. In section 4, I discuss three classifications in detail – Bubula and Ötker-Robe (2002), Levy-Yeyati and Sturzenegger (2002) and Reinhart and Rogoff (2004), none of which are free of shortcomings.

One way to deal with the problem of classifying exchange rate regimes is to use central bank intervention data to classify regimes according to the degree to which central banks are involved in determining the movements of the exchange rate. Unfortunately central banks do not make such data publicly available.[4] Therefore, I use the change in international reserves to proxy official intervention as a way to rank countries in terms of the degree to which they are pursuing a free float. Then I use estimates for the weight attached to the gap for each regime and test if the market attaches a larger weight to the gap in assessing potential losses during regimes with greater intervention. If that is the case, we would expect to observe smaller exchange rate swings in these markets.

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[4] The actual data on daily official intervention was released in the early 1990s for the US, followed later by Germany and Japan.

The use of changes in official reserves as a proxy for official intervention has been criticized by some researchers on the grounds that the two are not well correlated.[5] These criticisms are discussed in detail in Section 5, where I argue that the major shortcomings of changes in reserves as a proxy for official intervention do not pertain to my analysis.

2 The Market Premium

Recall from Chapter 3 that in equilibrium, the market premium is equal to the expected return on foreign exchange:

$$\widehat{pr}_{t|t+1} = \hat{s}_{t|t+1} - \left(s_t + i_t^A - i_t^B\right) \tag{3}$$

The term in the parentheses is the forward exchange rate in the current period, $fw_{t|t+1} = s_t + i_t^A - i_t^B$. Therefore, to calculate the market premium I use data on exchange rate forecasts and the forward exchange rate. The forward rate data come from Global Insight - DRI Money Market and Fixed Income Database (DRIFACS) and JP Morgan. Forward exchange rate data are further discussed in the next section in conjunction with exchange rate forecasts.

2.1 Exchange Rate Forecasts

My exchange rate forecast data come from the Consensus Forecast historical monthly database provided by Forecasts Unlimited, Inc[6] for forty-seven currencies dating

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[5] For example, see Neely (2000a) and Bubula and Ötker-Robe (2002).

[6] The Consensus Forecasts is the current name of the Currency Forecasters' Digest of White Plains, NY.

back to August 1986 for many of them.[7] The number of currencies in my sample is twenty-four due to several reasons that are discussed below.

Survey respondents are about forty in number and include multinational firms, forecasting firms and banks.[8] The Consensus Forecast reports one-, three-, six- and twelve-month horizon consensus forecasts of various exchange rates vis-à-vis the U.S. dollar, calculated as the harmonic mean.[9] Every month, it also reports the spot exchange rate and the one-, three-, six- and twelve-month forward exchange rates. Since the one-month surveys that I use in my analysis were discontinued in October 2000, my sample runs from August 1986 to September 2000 for most countries.

2.1.1 Issues Concerning the Survey Data. There are several difficulties with using this dataset. As was discussed above, I need to use the forward exchange rate to calculate the market premium. In the ideal case, one would have the aggregate for the spot and forward exchange rates that survey participants have used when forming their forecasts. Unfortunately, the survey does not include a question on the spot or forward exchange rates that survey participants have used when forming their forecasts. Moreover, the spot and forward exchange rates that the Consensus Forecast provides are on a date that is 3-7 days later than the date on which the forecasts were actually made. The survey is send to participants on the third Thursday of the month with the following Monday as the

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[7] Several sources, like the MMSI (Money Market Services International), provide forecasts for several major currencies. However, since the model predicts a different weight attached to the gap from PPP for different exchange rate regimes, it makes more sense to use survey data that covers a mix of countries that freely float and manage their exchange rates.

[8] See Appendix B for a list of current survey respondents.

[9] The harmonic mean is a measure of central tendency that attaches less weight to outliers. It is calculated as $\bar{x} = \left(\sum_i^N w_i \frac{1}{x_i} \right)^{-1}$ where x_i are individual forecasts, $w_i = \frac{1}{N}$, $\sum_i^N w_i = 1$, and N is the number of forecasts.

deadline for response. The issue is generally published on the fourth Thursday of the month, and the spot and forward exchange rates that are reported in the issue belong to that day. Therefore, depending on when survey respondents responded to the survey (the third Thursday or Friday, or the fourth Monday of the month), there is a 3-7 day lag between the forecasted and the spot and forward exchange rates. Such a lag is problematic because the spot exchange rate can experience sharp movements from day to day, or even from minute to minute, leading to similar changes in the forward exchange rate.

To address this problem, I construct a data set that consists of daily spot and forward exchange rates for each date at which surveys were conducted. However, there is another issue that complicates the analysis: the date on which forecasts are actually formulated is unfortunately not reported. The survey is usually sent to participants on the third Thursday of the month with the following Monday as the deadline for response. Thus, forecasts could have been formulated on that Thursday, or the following Friday or Monday. However, Forecasts Unlimited, Inc has told me that the majority of responses are received either on Friday or on Monday. I have thus taken the average of the spot and forward exchange rates for these two days. The daily data on spot and forward rates are from DRIFACS and JP Morgan.[10]

Another issue regarding the survey data is related to missing observations for some of the currencies. The source of some missing observations is the way in which the survey was conducted. In the early years, the number of currencies that were surveyed

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[10] For several currencies for which daily spot and forward rates could not be found for the whole period from DRIFACS or JP Morgan, data has been compiled from past issues of the Financial Times. I have tried to exploit every possibility to expand the sample size to as many currencies and years as possible.

was twenty-four and for some 'minor' currencies the survey was conducted every other month on a rotating basis with other 'minor' currencies. Such missing observations are encountered for some of the sample period for the Czech koruna, Polish zloty, Turkish lira, Indonesian rupee, Korean won, Malaysian ringgit, Phillipine peso, Singapore dollar and Thai baht. Another reason for missing observations is lost issues. The survey was initially owned by its current owner, but was sold to the Financial Times for a short period of time, before it was again acquired back by Forecasts Unlimited, Inc. In this process of changing ownership, several of the printed issues were lost. Because printed issues were the only source I was provided with, I had no way of recovering these missing observations.

Missing observations that arise due to some self-selection process can lead to biased estimates. Since none of the missing observations in my series are on a self-selection basis, however, they would only lead to an efficiency loss due to lower sample size. With a large enough sample size, this may not be an issue. However, given that the sample size for some of the currencies in my sample is already small, the efficiency loss caused by missing observations could be significant. Therefore, I interpolated the missing observations using the cubic spline method in SAS. This method overcomes some of the disadvantages of other interpolation methods, such as linear or polynomial interpolation.[11]

2.1.2 Sample Size. As was mentioned in the beginning of this section, the survey data are available for over forty countries, but my sample size is only twenty-four due to

[11] Linear interpolation is not very precise, and the error is proportional to the square of the distance between the data points. The error in polynomial interpolation is proportional to higher powers of the distance between the data points, and thus it is better than linear interpolation, however this method is not very precise at the end points of the series.

several reasons. First, I exclude the countries that are part of the Economic and Monetary Union (EMU), i.e. are on the euro[12] and Denmark, that is part of the second Exchange Rate Mechanism.[13] The reason for excluding these countries is that up to 1999, their currencies have been fixed with respect to the German mark, and as is shown in Figure 4.1 for the French frank and the Danish krone, their dollar exchange rates behave very similarly to the German mark/U.S. dollar exchange rate. Including these countries in the sample would have given more weight to the German mark or later the euro within the analysis.

The coverage for three countries, China, Israel and Egypt, is 12 months or less. I thus exclude these countries from my analysis. Such a small number of observations is insufficient to derive meaningful statistical relationships.

The lack of daily spot and forward exchange rate data for another eight currencies has reduced the sample further to twenty-six.[14] Furthermore, Taiwan was excluded from the sample because of the lack of exchange rate regime classification. Hong Kong was excluded because it is a currency board, and the model does not have much to say about such hard pegs. With these two exclusions, the number of currencies in my sample ends up being twenty-four.

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[12] These countries are Belgium, Finland, France, Greece, Ireland, Italy, the Netherlands, Portugal and Spain.

[13] Countries that are part of the second Exchange Rate Mechanism have tied their currencies with respect to the euro.

[14] These currencies belong to the following countries: Argentina, Chile, Ecuador, India, Russia, South Africa and Ukraine.

3 The Historical Benchmark

A historical benchmark is a stable and slowly moving rate that provides a long run anchor for exchange rates. Market participants might have different views of the benchmark depending on what models or information they use. Unfortunately, the survey data does not collect information on individual forecasts of the historical benchmark level, or on any historical benchmark that survey participants might have used when formulating their forecasts of the future exchange rate. Thus, to calculate the gap, we need to come up with a measure for the benchmark exchange rate. One factor that reduces the issues posed by the unavailability of individual data on historical benchmarks is that although individual assessments of the benchmark might differ, the range over which these individual assessments differ should be smaller than the range over which the exchange rate varies. Thus, the use of a single measure for the historical benchmark as assessed by individuals themselves should not cause much concern.

Furthermore, as I argued before, the relationship between the individual assessment of the historical benchmark and the official historical benchmark is not important for my analysis. It is also the case that exchange rate forecasts are much more variable than the historical benchmark, suggesting that results would not depend on the use of one or two benchmark levels. Therefore, using a single measure for both historical benchmarks simplifies my analysis without causing any obvious loss of generality.

One benchmark level that is often used in open-economy macroeconomics is the purchasing power parity (PPP) exchange rate. As Sarno and Taylor (2001: 51) put it, "estimates of PPP exchange rates are important for practical purposes such as determining the degree of misalignment of the nominal exchange rate and the appropriate policy response, the setting of exchange rate parities, and the international comparison of national income levels." But does PPP act as a historical benchmark?

3.1 PPP as a Long Run Anchor for Exchange Rates: Evidence[15]

Studies that have tested whether in the long run the real exchange rate has a tendency to revert to its mean provide considerable evidence that PPP serves as a long run anchor for exchange rates and that long swings in nominal exchange rates revolve around PPP.

Corbae and Oiliaris (1988), Kim (1990) and Cheung and Lai (1993) use cointegration analysis, where rejecting the null hypothesis of no cointegration provides evidence of mean reversion towards PPP. Corbae and Oiliaris (1988) use monthly averages for the exchange rates of the Canadian dollar, French frank, German mark, Italian lira, Japanese yen and British pound vis-à-vis the U.S. dollar between July 1973 and September 1986. They fail to reject the null hypothesis of no cointegration for all five currencies. Kim (1990) uses the Canadian dollar, French frank, Italian lira, Japanese yen and British pound vis-à-vis the U.S. dollar between 1900 and 1987. The author concludes that PPP seems to provide a long run anchor in general, but not for all currencies and all specifications. Cheung and Lai (1993) analyze the same currencies as Kim (1990) for the 1914-1989 period and conclude that all five exchange rates mean-revert towards PPP.

Edison and Klovland (1987) and Lothian and Taylor (1996) test for PPP using long span data and provide evidence supporting PPP as a long run anchor for the exchange rate. Edison and Klovland (1987) estimate an error-correction model for the

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[15] For review articles see Rogoff (1996) and Taylor and Taylor (2004).

Norwegian krone/British pound exchange rate between 1874-1971, whereas Lothian and Taylor (1996) use the U.S. dollar/British pound and French franc/British pound exchange rates between 1971-1990.

Taylor and Sarno (1998) uses panel data for the G5 exchange rates vis-à-vis the U.S. dollar and provides supporting evidence for PPP as a long run anchor.[16] Taylor, Peel and Sarno (2001) allow for nonlinear adjustment and provide evidence that PPP provides such an anchor for the German mark, British pound, French franc and Japanese yen vis-à-vis the U.S. dollar between January 1973 and December 1996.

These findings suggest that PPP might be a relevant benchmark for exchange rates. So, to measure the historical benchmark in the foreign exchange market, I construct a PPP series.

3.2 The Historical Benchmark in the Premium Model: Constructing the PPP Series

To calculate the PPP series I use the following approach. I first calculate the average of the spot exchange rate for the whole period for which forecasts are available for the particular currency. This average constitutes the PPP exchange rate for the first period, i.e.

$$s_1^{PPP} = \frac{\sum_{t=1}^{N} s_{t|t+1}}{N} \qquad (4)$$

Then I use inflation rates for the two countries to expand the time series for the PPP exchange rate to the whole period, so that

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[16] G-5 countries include France, Germany, Japan, the U.K and the U.S.

$$s_{t+1}^{PPP} = s_t^{PPP} \frac{(1+\pi_{t+1})}{(1+\pi_{t+1}^*)} \quad \text{for } t = 1,\ldots,N-1 \tag{5}$$

where π_{t+1} and π_{t+1}^* denote the inflation rate in the U.S. and the other country, respectively, from t to $t+1$, as based on the consumer price indices (CPI's) for the two countries.[17]

Another way of constructing the historical benchmark levels would be to use the Big Mac PPP for a specific year instead of the average for the spot exchange rate, and then expand the series by using the CPI data for the two countries.[18] I have not used this measure since the Big Mac PPP index is not available for some of the countries in my sample. However, both measures produce the same results by construction – using PPP as described in the text generates a series that is identical to the Big Mac PPP series scaled by some constant factor. Figure 4.2 plots the relative PPP (according to my approach), the relative Big Mac PPP and the spot exchange rate for the Japanese yen vis-à-vis the U.S. dollar. As can be seen from this figure, the two measures for the historical benchmark move in the same way, but are located at different levels.

Note that by using the approach described above I obtain series for *relative* PPP.[19] Relative PPP implies that the change in the nominal exchange rate is equal to the change in the relative price of the two countries. *Absolute* PPP, on the other hand, implies that

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[17] The CPI data come from IMF's International Financial Statistics.

[18] The Big Mac purchasing power parity exchange rates are reported in *The Economist* magazine in the April issue of every year.

[19] Note that equation (5) follows from relative PPP: $\frac{s_{t+1}}{s_t} = \frac{P_{t+1}/P_t}{P_{t+1}^*/P_t^*}$, defining $\pi_{t+1} = \frac{P_{t+1}-P_t}{P_t} = \frac{P_{t+1}}{P_t} - 1$ as the inflation rate, we get $\frac{s_{t+1}}{s_t} = \frac{1+\pi_{t+1}}{1+\pi_{t+1}^*}$, which can also be rewritten as $s_{t+1} = s_t \frac{(1+\pi_{t+1})}{(1+\pi_{t+1}^*)}$.

the nominal exchange rate is equal to the price ratios of the two countries. The only difference between the two series over time is, however, the level at which the historical benchmark is located. What is important for my analysis is to capture the movements in the exchange rate, thus it is not important at what *level* the benchmark is located. That is the case because for my analysis what matters is the way in which the gap moves, not whether it is positive or negative.

By using PPP as a measure for both the individual and the official historical benchmark levels I am assuming that the two have a tendency to move together, which seems to be a reasonable assumption. In this case, the uncertainty premium becomes

$$\widehat{up}_{t|t+1} = \theta + \left(\hat{\sigma}_1 + \hat{\sigma}_2\right)\left(\hat{s}_{t|t+1} - \hat{s}_t^{PPP}\right) \qquad (6)$$

4 Exchange Rate Regime Classification

As I mentioned in the introduction, there can be significant differences between the exchange rate regime that authorities claim to pursue (de jure regime) and the regime that they actually adopt (de facto regime). The de jure regime classification is provided by the IMF from 1975 through 1998 and it is based on member countries' own official statements. As was later argued by many studies, however, many countries do not actually adopt the regime they report to the IMF.[20] To improve upon that classification, the IMF officially adopted a new classification scheme in January 1999, which relies on

[20] For example, by analyzing exchange rates, reserves and interest rates, Calvo and Reinhart (2002) report that many countries that announce a floating exchange rate actually manage – what they call a 'fear of floating'. Of course, this and other studies that use different approaches to find the 'true' exchange rate policy have their drawbacks, as is discussed below.

exchange rate behavior and information from IMF country reports and other sources.[21] Bubula and Ötker-Robe (2002) have extended the coverage of the IMF de facto classifications back to 1990 on an annual and monthly basis.

There have been several other attempts at identifying de facto regime classifications, such as the Levy-Yeyati and Sturzenegger (2002) and Reinhart and Rogoff (2004) classifications. All three classifications - Bubula and Ötker-Robe (2002), Levy-Yeyati and Sturzenegger (2002) Reinhart and Rogoff (2004) - employ different approaches.

But before discussing each of the three classifications in more detail, it is useful to discuss how I would use these classifications to test if central bank intervention aimed at pushing the exchange rate back to some announced or unannounced parity, without the obligation to defend a parity or bands around the parity, leads to swings of smaller magnitude. None of the classifications in the literature has such a category simply because no country is pursuing such an exchange rate regime. Thus, I use the available classifications to classify regimes as 'managed regimes' to the extend that they involve central bank intervention aimed at reducing misalignments in exchange rates with or without the announcement of a parity. Accordingly, irrevocably fixed exchange rates such as a currency board or a monetary union are excluded from the analysis. Intermediate regimes, such as other conventional fixed pegs and crawling pegs or bands are included in the managed regime group, although under these regimes there is an obligation by the central bank to defend a parity or bands around it.[22] In most managed

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[21] International Monetary Fund (2003).

[22] For definitions of these regimes, see Table 4.1.

floating regimes central banks likely have some notion for misalignments and try to prevent these by intervening in the market without announcing a specific parity. Therefore, managed floating regimes are also included in the managed regimes group.

In the following three sections I discuss each classification in more detail. Then in Section 4.5, I compare the three classifications.

4.1 The Bubula and Ötker-Robe (2002) (or IMF De-Facto) Classification

The classification by Bubula and Ötker-Robe (2002) spans from 1990 through 2001. This classification uses information obtained through bilateral consultation discussions, and regular contacts with IMF country desk economists as the primary source in identifying regimes, and combines these with other sources of information, including press reports, news articles, other relevant papers, as well as an analysis of observed exchange rates and reserves behavior.

Each country is assigned to one of the following thirteen categories: formal dollarization, currency union, currency board, conventional fixed peg to a single currency, conventional fixed peg to a currency basket, horizontal band, forward looking crawling peg, forward looking crawling band, backward looking crawling peg, backward looking crawling band, tightly managed floating, managed floating and independently floating. The definitions of these regimes are provided in Table 4.1.

A country is classified as having a conventional fixed peg with respect to a specific currency if the exchange rate is observed to be within a narrow band of 2% for at least 4 months, and this classification is supported by country information. It is a conventional peg with respect to a basket if this is the de jure classification and it is also what the country information indicates, unless the country clearly pegs to a single currency (as indicated by an analysis of the exchange rate).

A gradual depreciation of the currency by small amounts according to a formula with or without formal or unannounced bands is classified as a crawling peg (with or without bands). If there are announced bands but there is heavy intramarginal intervention within some detected narrow inner band, the regime is classified as a fixed or crawling peg.[23] Based on information contained in the documents, distinction is made between forward and backward looking crawls.

The country is identified as a managed float in three cases: if the announced regime is a fixed peg but the official exchange rate is subject to frequent devaluations within very short time periods, or when the country has multiple exchange rates and most transactions are done using the parallel market-determined rate; or if intervention is aimed at countering the long term trend of the exchange rate.[24] [25] This way of classifying managed floating regimes is somewhat troublesome because it does not necessarily indicate central bank intervention aimed as reducing misalignments in exchange rates. Therefore, we should interpret results for managed floating regimes with some caution. In tightly managed floating regimes intervention achieves a stable exchange rate by very tight monitoring, where such stable rates have not been clearly identified as any of the

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[23] Intervention is measured by balance of payments position, international reserves, and parallel market developments.

[24] The official exchange rate is the exchange rate that is set by the Central Bank and is used by banks and other financial institutions. In some countries, an exchange rate market has developed parallel to the official rate (sometimes called the black market rate).

[25] In general, if parallel rate is used in most transactions, this is the rate used for classification purposes.

above discussed regimes. If intervention is aimed at preventing excessive exchange rate volatility only, it is classified as a free float.

One big advantage of this classification involves the use of country information besides data on exchange rates and other indicators. The use of exchange rate behavior alone could lead to erroneously assigning a fixed exchange rate regime if the exchange rate has been stable due to stable fundamentals or the lack of shocks to the economy. The shorter the time period for which the exchange rate behavior is analyzed, the more serious this problem becomes.

One shortcoming of this classification involves possible biased inference because some countries may not be disclosing all information. Another is that it only goes back to 1990. More importantly, however, the classifications of managed and tightly managed regimes seem to be the 'leftover' category of regimes that could not be incorporated anywhere else.

For my analysis, I include the following exchange rate regimes under the group of managed regimes: conventional fixed pegs to a single currency or to a currency basket, crawling pegs, horizontal and crawling bands, tightly managed and managed floating regimes. This leaves out hard pegs such as formal dollarization, currency union and currency board.

4.2 The Levy-Yeyati and Sturzenegger (2002) Classification

Levy-Yeyati and Sturzenegger (2002) provide annual series for 183 countries for 1974-2000. They use K-means cluster analysis to classify countries in one of four exchange rate regimes: flexible, dirty float, crawling peg and fixed.[26]

The authors utilize the behavior of three variables: changes in the official nominal exchange rate, volatility of exchange rate changes and volatility of international reserves. Changes in the official nominal exchange rate are calculated as the average of the absolute monthly percentage change in the nominal exchange rate during a calendar year. Volatility of exchange rate changes is given by the standard deviation of the monthly percentage changes in the exchange rate. Lastly, the volatility of international reserves is calculated as the average of the absolute monthly change in net dollar international reserves relative to the monetary base in the previous month, where net dollar reserves are given by foreign assets less foreign liabilities and government deposits at the Central Bank.[27]

The authors distinguish between flexible regime, dirty float, crawling peg and fixed regime as given by Table 4.2. Flexible regimes involve little intervention (i.e. low volatility in reserves) and large fluctuations in the exchange rate (i.e. high volatility in exchange rates and exchange rate changes). In a fixed exchange rate regime, on the other

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[26] Cluster analysis is a technique that allocates observations in homogeneous groups according to some rule. K-means cluster analysis allocates observations according to their distance to the center of the cluster (centroid) – an observation is assigned to the cluster with the nearest centroid. The number of groups is pre-specified by the researcher, and the centroids are iteratively estimated by the program itself.

[27] The argument here is that a given percentage change in reserves in countries with low monetization implies a larger relative intervention in foreign exchange markets. However, this might not necessarily be the case. A specific change in reserves would imply larger relative intervention with a relatively smaller volume of the foreign exchange market, and low monetization does not necessarily imply a smaller foreign exchange market. A better measure would be the sum of exports and imports, see Section 5 below.

hand, the volatility of reserves is high and exchange rates do not change much. A crawling peg is characterized by high volatility in reserves and small changes in the exchange rate in fixed increments (i.e. high changes in the exchange rate and low volatility of exchange rate changes). In dirty floats there is foreign exchange intervention that is aimed at smoothing exchange rate fluctuations, where both changes in the exchange rate and the volatility of exchange rate changes still remain high. Combinations of low change in the exchange rate, low volatility of exchange rate changes and low volatility of reserves are marked as 'inconclusive'.

One shortcoming of the Levy-Yeyati and Sturzenegger classification is that series are annual, and therefore, they cannot capture changes in the exchange rate regime *during* the year. Thus, it might attribute an exchange rate regime that might have lasted only a few months to the whole year. For example, when the exchange rate was *fixed* in Argentina in April 1991, owing to the high exchange rate volatility in the first three months, year 1991 is specified as a dirty float. Similarly, a high sample variance may be due to a one-time large devaluation under a pegged regime and may not indicate greater exchange rate flexibility.[28]

Another shortcoming is related to the heavy reliance on exchange rate behavior to classify regimes. As was stated above, using movements in exchange rates to classify regimes could pose problems since, for example, an exchange rate may remain fairly constant over some time due to the absence of shocks, which would be mistaken for some pegged or intermediate regime. Since the authors use the annual average of some measures of monthly exchange rate behavior, this could be a significant problem in terms

[28] The reliance on exchange rate behavior to classify regimes may also lead to an endogeneity problem in terms of my analysis. See Section 4.4 below.

of regime classifications. Additionally, unlike the other two classifications, Levy-Yeyati and Sturzenegger use official exchange rates, which can mislead results in the presence of an extensively used parallel market.[29] Moreover, their classification ends up with many inconclusive periods.[30] Also note that Levy-Yeyati and Sturzenegger do not distinguish between hard and other conventional ('soft') fixed regimes. It only has a broad 'fix' category characterized by high volatility of reserves and stable exchange rates, which could be the case in hard as well as soft fixes. There is one currency in my sample that is classified as a fix, the New Zealand dollar (NZD). I do estimate a gap weight for the NZD, however, I also check to see whether results are sensitive to the estimate for the NZD. In general terms, in my analysis, I include the crawling peg and dirty float exchange rate regimes under the group of managed regimes.

4.3 The Reinhart and Rogoff (2004) Classification

Reinhart and Rogoff (2004) provide annual and monthly database for 153 countries over the period of 1946-2001. This classification relies solely on the behavior of the exchange rate to classify countries in one of the following ten exchange rate regimes: no legal tender, currency board, peg (to a single currency), (horizontal) band, crawling peg, crawling band, moving band (which allows for both a sustained

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[29] Reinhart and Rogoff (2004) analyze the use of parallel and dual markets and argue that they are more important than is usually thought.

[30] To be exact, there are 716 unidentified years, either due to the lack of some data or because of low change in the exchange rate combined with low volatility of exchange rate changes and low volatility of reserves.

depreciation and appreciation), managed floating, freely floating, and freely *falling*.[31] The freely falling category includes countries for which the officially announced regime is not statistically verified and that experience annual inflation rates higher than 40%.[32] The argument here is that countries experiencing macroeconomic instability often have very high inflation rates, which may be reflected in high and frequent exchange rate depreciation, and thus such macroeconomic disturbances can be incorrectly attributed to the exchange rate regime. It might therefore be problematic to classify such regimes as floating, intermediate or pegged. The authors do, however, provide a secondary classification for the freely falling category as well, classifying the currency into one of the nine exchange rate regimes, which I have used in my analysis.

The Reinhart and Rogoff classification is depicted in Figure 4.3. A country is classified as a peg if no dual or multiple exchange rate exists, and the absolute percentage change in the exchange rate is zero for 4 consecutive months or more, or if the probability that the monthly exchange rate remains within a 1% band over a rolling 5-year period is greater than 80% and no drift is present.

If the probability that the monthly exchange rate remains within a 2% band over a rolling 5-year period is greater than 80% and a positive drift is present, the country is classified as a crawling peg; if the exchange rate goes through periods of both appreciation and depreciation, it is a moving band. A country is classified as a band also

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[31] This classification relies mainly on movements in dual and parallel market exchange rates if they differ substantially from the official rate.

[32] The countries in my sample that fall in the freely falling category for some period are Brazil (02/99-08/99), Indonesia (04/98-03/99), Korea (12/97-06/98) and Turkey (05/98-09/00).

if a band is announced and there is a unified exchange market, and the regime is not being identified as a de facto peg.

If a country cannot be classified as any of the other regimes, it is either a managed or a free float. Reinhart and Rogoff define a ratio $\frac{\varepsilon}{P(\varepsilon < 1\%)}$, where ε is the mean absolute monthly percentage change in the exchange rate over a rolling 5-year period, and $P(\varepsilon < 1\%)$ gives the likelihood of small changes in ε. Then they get a frequency distribution by pooling the observations for all most transparent floaters, and test the freely floating as the null hypothesis vs. managed floating.[33] In that case, if $\frac{\varepsilon}{P(\varepsilon < 1\%)}$ for a particular country for a particular period falls inside the 99% confidence interval, it is characterized as freely floating. If, on the other hand, $\frac{\varepsilon}{P(\varepsilon < 1\%)}$ falls in the lower 1% tail, then the country is characterized as managed floating. As such, the classification of managed floating does not necessarily imply active or frequent foreign exchange market intervention, just that the index does not behave like the indices for the free floaters. Thus, similarly to the Bubula and Ötker-Robe classification, one might question how appropriate it is to include this managed floating category under managed regimes. Furthermore, this classification does not identify the regime as being a managed float with respect to a specific currency. Beyond that, this approach poses another difficulty. Since the classification relies solely on exchange rate behavior, it is quite possible that an

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[33] Most transparent floaters include the US dollar/DM-euro, US dollar/yen, US dollar/UK pound, US dollar/Australian dollar, and US dollar/New Zealand dollar exchange rates. It is rather strange that authors would include the New Zealand dollar among most transparent floaters when their classification actually identifies the currency as a managed float.

exchange rate regime that is truly managed floating could be classified as a free float if it has experienced large shocks, or that a truly floating regime could be classified as a managed float if it has not experienced large shocks.[34] Thus, even if central bank intervention has been effective in limiting exchange rate swings by leading to a larger weight on the gap from PPP, this might not appear to be the case if the country has experienced large shocks. This country would erroneously be classified as a free float and this would affect the average weight for managed and freely floating groups. If it is in fact the case that central bank intervention leads to a larger weight on the gap from PPP, then such an erroneous classification would bias the average weight for free floaters in the upward direction relative to the average weight for managed regimes.

To circumvent the problem of attributing the stability in fundamentals or lack of significant shocks to the economy to exchange rate stability, Reinhart and Rogoff authors use a rolling 5-year window. As such, their classification might be seen as more reliable that the Levy-Yeyati and Sturzenegger classification. But although this approach reduces the significance of this problem, one can hardly argue that it eliminates it altogether.

One certain advantage of this classification is the time period it spans: 1946-2001.

4.4 Comparing the Classifications

As was discussed above, all three classifications have some shortcomings. The Bubula and Ötker-Robe (2002) or IMF de facto classification combines quantitative analysis with country reports, which is a big advantage over the other two classifications. However, this classification only goes back to 1990, which limits its usefulness for

[34] Similarly to the Levy-Yeyati and Sturzenegger classification, the reliance on exchange rate behavior to classify regimes may also lead to an endogeneity problem in terms of my analysis. See Section 4.4 below.

empirical analysis. The Levy-Yeyati and Sturzenegger (2002) classification, on the other hand, is on an annual basis, and as such may classify the whole year as a particular regime while this regime may have started, say, in March. The classification provided by Reinhart and Rogoff (2004) is on monthly basis and goes back to 1946, which is a big advantage. However, their main reliance on quantitative measures may result in incorrect inferences about regime classifications.

One major problem related to the Reinhart and Rogoff and the Levy-Yeyati and Sturzengger classifications is their main reliance on exchange rate behavior to classify regimes. Such an approach raises the concern of first using exchange rate volatility to classify exchange rates into different regimes and then using these exchange rate regimes to test for long run misalignments in the exchange rates – the endogeneity problem. If one were relying on some measure for exchange rate swings to test if central bank intervention is effective in limiting the magnitude of swings in exchange rates, this would be a major problem. One would almost guarantee obtaining smaller swings in exchange rates under exchange rate regimes involving such policy, since by construction, under these regimes the exchange rate is less volatile. But is this a problem in terms of testing whether managed regimes attach a higher weight to the gap compared to freely floating regimes? Exchange rate volatility could affect results by influencing the market premium, since smaller changes in exchange rates lead to a higher premium.[35] Thus, for the same change in exchange rate expectations, to get larger changes in the premium, one would need a higher gap weight. Thus, if endogeneity is a problem, it would likely bias results in favor of getting a higher gap weight under managed regimes. Note that for the Bubula

[35] Recall that the market premium is calculated as $\widehat{pr}_{t|t+1} = \hat{s}_{t|t+1} - \left(s_t + i_t^A - i_t^B\right)$.

and Ötker-Robe classification, that would probably be less of a problem, if any, since its primary source in identifying regimes is country reports and information, and exchange rate behavior is only supplementary.

The differences between the three classifications are evident in Table 4.3, which provides the different regime classifications for the 24 currencies in the sample.[36] A currency that is identified as a managed or free float in one study could be identified as some type of intermediate regime in another.[37] [38] For example, the Turkish lira (TRL) is classified as a crawling peg by Bubula and Ötker-Robe, while the other two classifications state the TRL to be a free float. Even more strikingly, the NZD is classified as a free float by Bubula and Ötker-Robe, managed float by Reinhart and Rogoff, and a fix by Levy-Yeyati and Sturzenegger! It is also worth noting that the classifications differ mainly in determining the exchange rate regimes adopted in developing countries.

Since there is no way of telling which classification is closer to the 'true' exchange rate regimes adopted by the different countries in the sample, in the next two chapters I run empirical tests using all three classifications.

Given the major shortcomings of these exchange rate classifications, most notably their reliance on the behavior of the exchange rates, in the next section I discuss an

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[36] One common problem with all classifications is that they do not allow for effects of intervention by other countries that negates the need for exchange market action by the country under consideration.

[37] See Maier (2005) for a comparison of the classifications provided by Levy-Yeyati and Sturzenegger (2002) and Reinhart and Rogoff (2004).

[38] The cut-off months for the exchange rate regimes of the different currencies are based on the Reinhart and Rogoff classification with no specific purpose.

alternative way of classifying exchange rate regimes by using data on reserves as proxy for central bank intervention.

5 Reserves Data as Proxy for Official Intervention

If data on central bank intervention were available, one could use these data to classify regimes according to the degree to which central banks are involved in determining the movements of the exchange rate. Unfortunately central banks do not make such data publicly available. Therefore, many researchers have used different measures to try to capture the degree of official intervention in foreign exchange markets. As was mentioned above, Levy-Yeyati and Sturzenegger (2002) have used central banks' net foreign assets less government deposits at the central bank.[39] Calvo and Reinhart (2002) and Bofinger and Wollmershäuser (2001) have used total reserves minus gold.[40] This is the sum of foreign exchange, reserve position in the IMF and the U.S. dollar value of special drawing rights (SDR) holdings by monetary authorities.[41] Both of these measures include foreign assets that are not part of central bank intervention, namely reserve positions with the IMF and SDRs. Moreover, the first measure also includes gold holdings.

The IFS also provides data on foreign exchange reserves, which include monetary authorities' claims on nonresidents in the form of foreign assets, such as banknotes, bank

[39] Net foreign assets are obtained by subtracting line 16c from line 11, and government deposits at the central bank are given in line 16d in the International Financial Statistics (IFS) database.

[40] Which corresponds to line 1 l.d in IFS.

[41] SDRs are reserve assets created by the IMF to supplement existing reserves. These are allocated to member countries that participate in the IMF's Operations Division for SDRs and Administered Accounts proportionately to their quotas. SDRs can be used for many transactions such as settling financial obligations, purchasing foreign currency, or extending loans.

deposits, treasury bills, and government securities.[42] Since these data do not include gold, reserve positions in the IMF and SDRs, they could be considered a better proxy for official intervention. Since the exchange rates that I consider in my analysis are all with respect to the U.S. dollar, foreign exchange reserves in terms of U.S. dollars alone would be a better proxy for official intervention in the dollar market. However, such data are not available for all countries in my sample. Nevertheless, it might be reasonable to assume that for the most part the difference between the two series is not significant since the majority of foreign exchange held by central banks throughout the world is likely denominated in U.S. dollars. Therefore, to proxy official intervention, I use the change in foreign exchange reserves.

Since a particular change in reserves can imply a different degree of intervention for different countries depending on the size of the foreign exchange market, the reserves data need to be normalized. Unfortunately, historical data on the size of the foreign exchange market are not available for most countries.[43] There are several different measures that have been used in the literature, such as reserves of the previous period (Calvo and Reinhart, 2002), the monetary base (Levy-Yeyati and Sturzenegger, 2002), or the sum of exports and imports (Bofinger and Wollmershäuser, 2001). Since the sum of exports and imports provides a measure for the amount of foreign exchange traded in a

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[42] Line 1d.d in the IFS.

[43] Such data is provided by the Bank for International Settlements (BIS) Triennial Central Bank Survey, which started in 1989 with 21 countries and expanded to 52 countries in 2004.

specific period of time, I view this as the best proxy for the size of the foreign exchange market that is available for every country in my sample.[44]

Several economists have argued that changes in reserves are not a good proxy for foreign exchange intervention. They have argued that international reserves are not well correlated with official intervention since they may change due to reasons that are unrelated to official intervention, such as fluctuations in valuations and accrual of interest earnings. Moreover, changes in international reserves may not capture all transactions that are in fact official interventions, such as the Japanese hidden reserves, or the use of open market operations and interest rate changes to affect exchange rate behavior.[45]

However, many of these arguments are not very important for my analysis. This is because I use foreign exchange holdings measured *in U.S. dollars* and thus, to the extent that most reserves are held in dollars, there are no valuation effects in my data. Moreover, my objective is to examine the *relative effects* of intervention across countries. Therefore, fluctuations in valuations, or the accrual of interest earnings as well as the use of other policy tools besides the purchase and sale of foreign exchange to affect exchange rate behavior (as long as the use of such policy tools is proportionate across countries), may not play a crucial role for my results. This would be the case because all of these would affect changes in reserves in the same way for all countries. Thus, the relative effects of intervention across countries would be based on changes in reserves that are not due to these factors but due to different degrees of intervention. Therefore, one can view the use

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[44] The capital account provides trade in financial assets, which makes up about 97% of the total volume of the foreign exchange market. As such, it would be a better measure for the amount of foreign exchange traded in a country. However, these data are not available for several countries in my sample.

[45] Japanese hidden reserves are official foreign exchange deposits with commercial banks. See Dominguez and Frankel (1993b) and Bubula and Ötker-Robe (2002).

of change in foreign exchange reserves to be a good measure of the relative degree of central bank intervention across countries.

As a last note, I would like to emphasize that classifying exchange rate regimes according to the degree to which central banks are involved in determining the movements of the exchange rate by using changes in reserves as a proxy for intervention overcomes the major issues from which the exchange rate regimes discussed in the previous section suffer. Data on reserves, exports and imports are widely available and thus, this approach does not impose period constraints on the sample. Most importantly, however, it does not rely on exchange rate behavior, and as such could perhaps be seen as a more reliable way of classifying exchange rate regimes. Nevertheless, one should keeping mind that the exchange rate regime classifications and the changes in reserves imply different ways in which one can test the prediction of the premium model that official intervention could limit swings in exchange rates by leading to a higher gap weight. By using exchange rate regime classifications, I group countries under two groups – freely floating and managed regimes – and test if the average gap weight is larger for the second group. I cannot perform the same analysis by using changes in reserves unless I come up with a measure of how much intervention would classify a country as a managed regime versus a free float. Changed in reserves, however, allow me to test whether more intervention leads to a larger weight attached to the gap from PPP.

6 Conclusion

This chapter discussed the methodology and data for testing the two implications of the premium model. One is that the market premium and the gap from PPP are positively related. The other implication is that in markets characterized by central bank intervention aimed at pushing the exchange rate back to some announced or unannounced parity level at unpredictable moments in time, the aggregate weight attached to the gap in assessing potential losses will be larger compared to markets without such policy. Such a finding would indicate smaller swings in exchange rates. The next chapter provides supporting evidence on the positive link between the gap and the premium. Whether policy officials can make use of this positive link between the gap and the premium in limiting exchange rate swings is the topic of Chapter 6.

Table 4.1: Exchange Rate Regime Classification by Bubula and Ötker-Robe (2002)

General category	Exchange rate regime	Explanation
Hard pegs	Formal dollarization	The country uses the currency of another country as the legal tender.
	Currency unions	The countries that are part of a monetary or currency union use the same currency as the legal tender.
	Currency boards	The country commits legally to exchange domestic currency for a particular foreign currency at a fixed rate. In that case the domestic currency is fully backed by foreign assets.
Intermediate regimes	Conventional fixed pegs vis-à-vis another currency or a currency basket	The country pegs its currency to another currency or a basket of currencies at a fixed rate, which may be adjusted although relatively infrequently. The exchange rate may fluctuate within a narrow margin of less than ±1% around the central rate, or the maximum and minimum values of the exchange rate remain within the margin of 2% for at least three months.
	Crawling pegs: forward and backward looking	The rate vis-à-vis a single currency or a basket of currencies is periodically adjusted in small amounts at a fixed rate or in response to changes in selected indicators. A crawling peg is classified as backward looking when the crawl is determined by past inflation differentials, and it is forward looking when the crawl is determined by projected inflation differentials.
	Horizontal bands	The currency is allowed to fluctuate within margins of at least ±1 percent around a fixed central rate.
	Crawling bands: forward and backward looking	The currency is allowed to fluctuate within margins of at least ±1 percent around a fixed central rate, which is periodically adjusted in small amounts at a fixed rate or in response to changes in selected indicators. The backward versus forward looking distinction is made similarly to the crawling peg.
Floats	Managed floating: tightly or other	Authorities intervene in the foreign exchange market to counter the long-term trend of the exchange rate without a pre-specified path or target. In tightly managed floating intervention achieves a stable exchange rate by very tight monitoring, again without a clear exchange rate path. Under "other managed floating" intervention is more ad-hoc.
	Free floating	The exchange rate is determined by the market. Intervention is aimed at reducing fluctuations in exchange rates rather than at establishing a level for the exchange rate.

Source: Bubula and Ötker-Robe (2002).

Table 4.2: Exchange Rate Regime Classification by Levy-Yeyati and Sturzenegger (2002)

	Changes in the exchange rate	Volatility of exchange rate changes	Volatility of international reserves
Flexible regime	high	high	low
Dirty float	high	high	high
Crawling peg	high	low	high
Fixed regime	low	low	high
Inconclusive	low	low	low

Source: Levy-Yeyati and Sturzenegger (2002).

Table 4.3: Exchange Rate Regime Classifications by Bubula and Ötker-Robe (2002) (BOR), Levy-Yeyati and Sturzenegger (2002) (LYS) and Reinhart and Rogoff (2004) (RR)[46]

	Time Period	BOR	LYS	RR
AUD	11/86-09/00	free float	float	free float
BRL	02/99-09/00	*free float*	*crawling peg/fix*	*managed float*
CAD	08/86-09/00	*managed/free float*	*float*	*moving band*
CHF	08/86-09/00	free float	float	free float
COP	02/98-09/99	*crawling band*	*float*	*crawling band*
CZK	04/98-09/00	free float	float	free float
DEM	08/86-09/00	free float	float	free float
EUR	01/99-09/00	free float	float	free float
GBP	08/86-09/92	*horizontal band*	*float*	*free float*
GBP	09/92-09/00	*free float*	*float*	*managed float*
HUF	04/98-09/00	free float	-	free float
IDR	04/98-09/00	*free float*	*intermediate/crawling peg*	*free float*
JPY	08/86-09/00	free float	float	free float
KRW	12/93-11/97	*tightly managed*	*fix/intermediate/cr.peg*	*crawling peg*
KRW	12/97-09/00	*free/managed float*	*crawling peg/fix*	*free float*
MXN	12/94-03/96	*free float*	*intermediate*	*free float*
MXN	04/96-09/00	*free float*	*intermediate/float*	*managed float*
MYR	03/93-07/97	*managed/tightly mng*	*intermediate/fix/float*	*moving band*
NOK	11/86-09/00	*free float*	*float*	*managed float*
NZD	02/93-09/00	*free float*	*fix*	*managed float*
PEN	04/99-09/00	*managed/tightly mng*	*float/crawling peg*	*peg*
PHP	12/97-05/99	*managed/free/managed*	*float*	*managed float*
PLN	04/98-09/00	*crawling band*	*float*	*managed float*
SGD	01/88-11/98	*tightly mng/managed*	-	*moving band*
SGD	12/98-08/00	managed/tightly managed	-	managed float
THB	06/98-09/00	*managed float*	*crawling peg/float*	*managed float*
TRL	05/98-09/00	*crawling peg*	*fix/float*	*free float*
VEB	04/99-08/00	*crawling band*	*crawling peg*	*crawling band*

The cut-off months for the exchange rate regimes of the different currencies are based on the Reinhart and Rogoff classification with no specific purpose. Note that some currencies appear more than once (GBP, KRW and SGD) due to different exchange rate regimes being adopted during the sample period.

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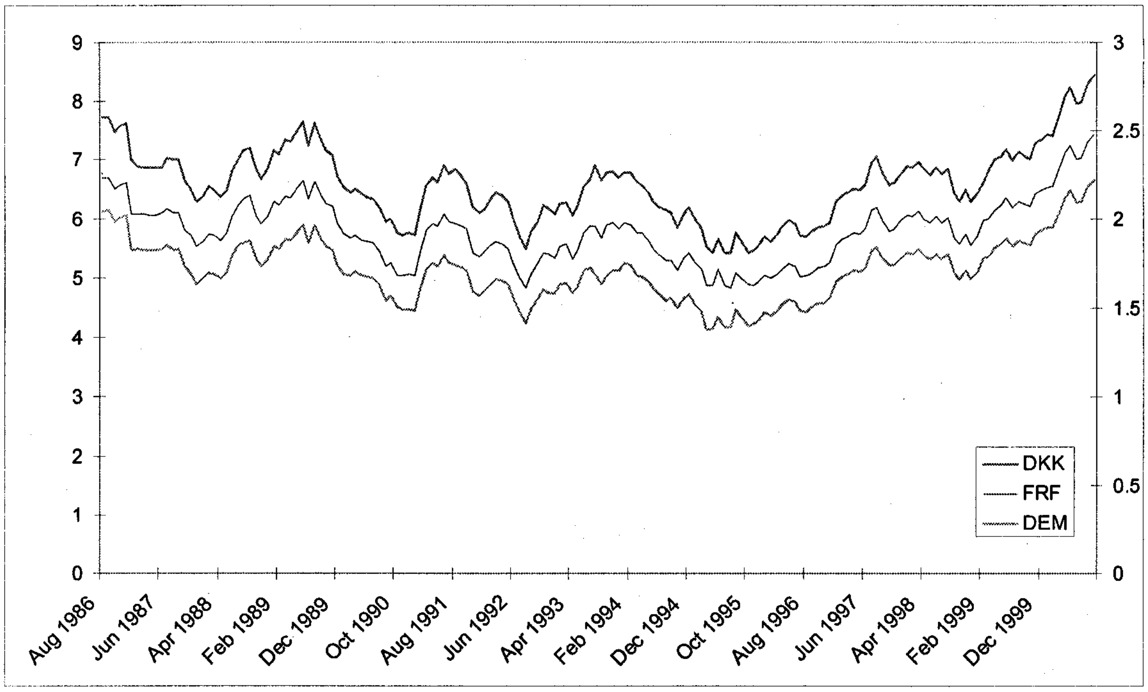
[46] AUD: Australian dollar, BRL: Brazilian real, CAD: Canadian dollar, CHF: Swiss franc, COP: Chilean peso, CZK: Czech koruna, DEM: German mark, EUR: euro, GBP: British pound, HUF: Hungarian forint, IDR: Indonesian rupee, JPY: Japanese yen, KRW: Korean won, MXN: Mexican peso, MYR: Malaysian ringgit, NOK: Norwegian krone, NZD: New Zealand dollar, PEN: Peruvian sol, PHP: Philippine peso, PLN: Polish zloty, SGD: Singapore dollar, THB: Thai baht, TRL: Turkish lira, VEB:Venezuelan Bolivar.

Figure 4.1: Danish krone/U.S. dollar, French frank/U.S. dollar and German mark/U.S. dollar exchange rates (in the order of appearance) (August 1986-September 2000)



The Danish krone and French frank are plotted on the primary axis, and the German mark is plotted on the secondary axis.

Figure 4.2: PPP and Spot Exchange Rates of the Japanese Yen vis-à-vis the U.S. Dollar (August 1986-September 2000)

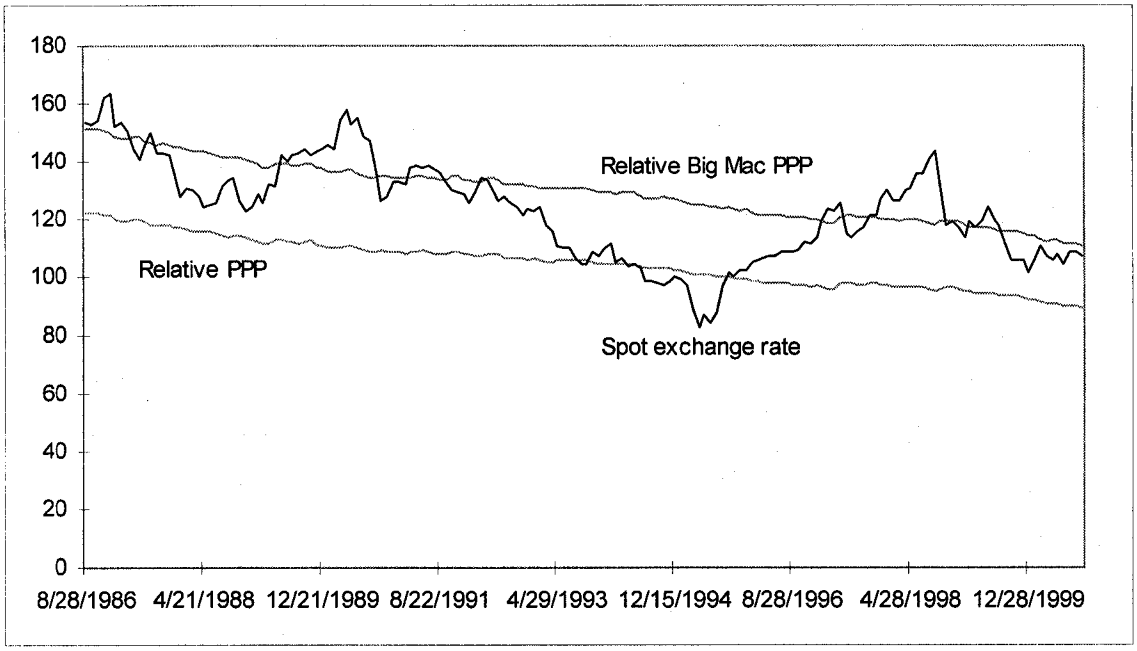
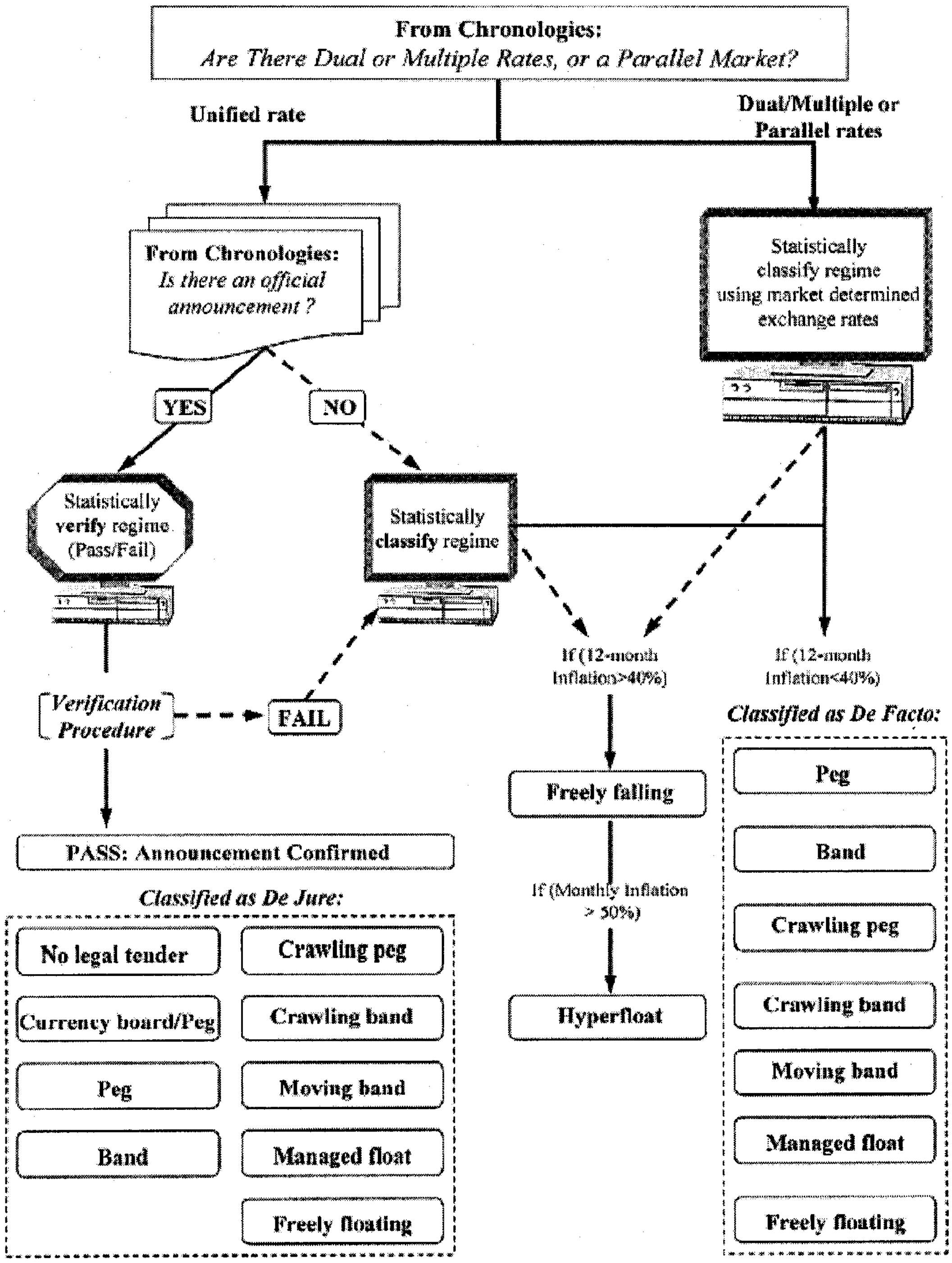


Figure 4.3: The Reinhart and Rogoff (2004) Natural Exchange Rate Classification Algorithm



Source: Reinhart and Rogoff (2004).

CHAPTER 5

THE MARKET PREMIUM AND THE GAP FROM PPP: EVIDENCE FROM 24 CURRENCIES

1 Introduction

In this chapter I test for a positive relationship between the market premium and the gap from PPP. As was mentioned previously, Frydman and Goldberg (2007) have tested this relationship for the Japanese yen, German mark and British pound vis-à-vis the U.S. dollar. I also test for these currencies, but with a different data set for exchange rate expectations and with a different time frame. Furthermore, I extend the analysis of Frydman and Goldberg (2007) to 24 currencies. Thus, my results help generalize the empirical findings on the positive relationship between the market premium and the gap from PPP. Furthermore, my series are based not on individual currencies but on exchange rate regimes. Recall the implication of the premium model that the weight attached to the gap from historical benchmark might be higher with some central bank policy supporting a parity compared to the gap weight under freely floating regimes. If this is in fact the case, then it would not be appropriate to estimate one gap weigh for a period that spans two different exchange rate regimes.

In estimating the relationship between the market premium and the gap from PPP, I follow two different approaches: contingency table analysis (Section 2) and regression analysis based on an autoregressive distributive lag model (Section 3). The contingency table analysis enables me to capture the *qualitative* relationship between the gap and the premium, which is important because the *quantitative* relationship could be changing over time. The autoregressive distributive lag model takes the nonstationarity of the series into account and allows one to make inference on the significance level of parameter estimates.

As was mentioned in Chapter 4, the exchange rate regime classifications by Reinhart and Rogoff (2004), Bubula and Ötker-Robe (2002) and Levy-Yeyati and Sturzenegger (2002) arrive at different classifications with different time periods. For comparison purposes, I provide the results for all three classifications.

The main finding that emerges from the empirical analysis is that there is general support for the positive link between the gap and the premium. The contingency table analysis results provide suggestive evidence that the gap and the premium move in the same direction for 61-77% of the exchange rate regimes in my sample, depending on the regime classification. The results from the autoregressive distributive lag model, on the other hand, provide strong support for the positive relationship between the gap and the premium in the short run, as the premium model predicts. All three classifications provide similar results.

2 Contingency Table Analysis

2.1 What is a Contingency Table Analysis (CTA)?

CTA is a very simple non-parametric technique that allows one to test the qualitative relationship in the data without imposing a quantitative relationship. For some of the currencies, the sample size is about 170 observations, which spans roughly 14 years. One would not expect the quantitative relationship between two variables to remain unchanged for such a long period of time. It is unlikely that individuals would follow a fixed rule for 14 years in assessing potential losses from taking open positions in the foreign exchange market. So, one would think that the relationship between the gap and the premium would be nonlinear. It is possible that individuals care about the gap from PPP more when the gap is large, and less when it is small. And how they measure the gap from PPP could change over time too. A CTA allows the quantitative relationship between the gap and the premium to vary over time but still picks up whether there is this qualitative relationship, which is the key prediction of the model.

A contingency table reports the number of observations for which two variables move in the same direction (in our case, the number of observations for which the gap and the premium either increases together of decreases together), and the number of observations for which these variables move in opposite directions. For example, consider the case for Australia as given in Table 5.1. In this table the on-diagonal elements capture the number of observations for which the gap and the premium move in the same direction over a month: there are 53 months during which the gap and the premium both increased and there are 55 months for which both of these variables fell. The off-diagonal elements capture the number of observations for which the gap and the premium move in opposite directions: there are 28 months for which the premium fell as the gap increased, and 31 months for which as the gap fell the premium increased.

The prediction of the premium model is that the gap and the premium should move in the same direction. Continuing with the same example, for Australia, the total number of observations for which the gap and the premium moved in the same direction is 108, whereas the total number of observations for which the gap and the premium moved in opposite directions is 59.

A CTA also reports a χ^2 statistic that one can use to test whether the number of observations for which the two variables move in the same direction is significantly different from the number of observations for which they move in opposite directions. In the case for Australia, the χ^2 statistic is equal to 14.41. The use of this statistic is, however, conditional upon non-autocorrelated error terms in the series that is being investigated. Tests reveal that the individual currency series in my sample exhibit autocorrelation, in which case the CTA is not distributed as χ^2. Therefore, we cannot comment on the significance level of the test, so we can only use it as a suggestive statistic. Thus, as an additional indication of the degree to which the premium and the gap are likely to move in the same direction, I report the ratio of the number of observations for which the gap and the premium move in the same direction to the number of observations for which they move in opposite directions. For Australia, for example, this ratio is 1.8. I also provide the percentage of observations for which the gap and the premium move together, which for Australia is found to be 64.7%.

2.2 CTA Results

Tables 5.2a, 5.2b and 5.2c at the end of the chapter report the contingency table results using the Reinhart and Rogoff (2004), Bubula and Ötker-Robe (2002) and Levy-Yeyati and Sturzenegger (2002) classifications, respectively. In this part of the analysis I use the exchange rate regime classifications only to determine the sample period for each currency.

For all three classifications, the CTA results provide general support for the positive relationship between the premium and the gap from PPP (summarized in Table 5.3). For all three classifications, the ratio of the number of observations that move in the same direction (SD) to the ones that move in opposite directions (OD) is greater than 1 for 17, which for the Reinhart and Rogoff classification makes up 61% of the total 28 regimes. For the Bubula and Ötker-Robe and Levy-Yeyati and Sturzenegger classifications, these percentages are 65% (out of total 26 regimes) and 77% (out of total 22 regimes).

How do my results for the Japanese yen, German mark and British pound vis-à-vis the U.S. dollar compare to the findings of Frydman and Goldberg (2007) where their analysis is based on a different survey and a sample period from December 1982 through February 1997? I analyze all three currencies between August 1986 and September 2000 for the Reinhart and Rogoff and Levy-Yeyati and Sturzenegger, and between January 1990 and September 2000 for the Bubula and Ötker-Robe classification. My results are weaker for the Japanese yen and the German mark, but stronger for the British pound. For the Japanese yen, the ratio of the number of observations for which the gap and premium move in the same direction to the number of observations for which they move in opposite directions, which Frydman and Goldberg call the success rate, is 1.2 (1.5) for the period of 01/90-09/00 (08/86-09/00). Frydman and Goldberg find the success rate for the Japanese yen to be 1.83. For the German mark I find the success rate to be 0.9 (1.1) for the period 01/90-09/00 (08/86-09/00), whereas Frydman and Goldberg report it to be 1.66. For the British pound, my results indicate a success rate of 1.4 (1.5) between 08/86-09/00 (01/90-09/00), versus the 1.27 reported by Frydman and Goldberg. The difference in results is likely due to the different forecast data that was used, and perhaps also due to the different time span that was analyzed.

In sum, the CTA results provide evidence that the gap and the premium move in the same direction for about 61-77% of the exchange rate regimes in my sample. However, since we cannot use the Chi-square statistic to test for the significance of the positive relationship between the gap and the premium, these results should be viewed only as suggestive evidence (or descriptive statistics).

3 Autoregressive Distributive Lag Model

3.1 What is an Autoregressive Distributive Lag (ADL) Model?

The non-stationarity of time series data poses problems for statistical inference since the sample mean and variance of such series are not constant over time, and successive observations are highly interdependent. As is well known, differencing non-stationary (unit root) time series data helps since it yields stationary series, thus allowing one to make inference on the significance level of parameter estimates. However, such an approach ignores the long run relationship between the variables, which implies a misspecification of the model.

One approach that avoids such a misspecification, which Frydman and Goldberg (2007) and other researchers have used to deal with unit root data, is to estimate an autoregressive distributive lag model.[1] In terms of the premium model, an ADL specification of order one is given by:[2] [3]

$$\widehat{pr}_t = b_0 + b_{11}\widehat{pr}_{t-1} + b_{20}\widehat{gap}_t + b_{21}\widehat{gap}_{t-1} + \varepsilon_t \tag{1}$$

Equation (1) can also be written in an error-correction form:[4]

$$\Delta\widehat{pr}_t = \alpha_0 + \alpha_1\Delta\widehat{gap}_t + \alpha_2 ECT_{t-1} + \varepsilon_t \tag{2}$$

where the error correction term (ECT) is given by:

$$ECT_{t-1} = \beta_1\widehat{gap}_{t-1} + \beta_0 - \widehat{pr}_{t-1} \tag{3}$$

and $\alpha_0 = b_0 - (1-b_{11})\beta_0$, $\alpha_1 = b_{20}$, $\alpha_2 = (1-b_{11})$, $\beta_1 = \dfrac{b_{20}+b_{21}}{1-b_{11}}$.

The ADL model, as stated in equation (2), allows for a distinction between the short run and the long run effects of the gap on the premium. The first difference terms in equation (2), $\Delta\widehat{gap}_t$ and $\Delta\widehat{pr}_t$, capture the contemporaneous (short run) relationship between the gap and the premium. A contemporaneous relationship captures the effect of changes in causal variables from one time period to the next on the dependent variable between the same time periods. The ECT provides a relationship between the gap and the premium in their levels, as captured by β_1. This relationship can be viewed as a long run

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[1] See Hendry and Juselius (2000).

[2] Ignoring the IFP_t term – see Section 1 in Chapter 4.

[3] For most series, one or two lags were enough to obtain stationary and normally distributed errors. For very few series, three lags were necessary. Appendix C provides the ADL model with two and three lags. For several series, normality was not attained and therefore the significance tests related to these series are valid only asymptotically.

[4] By subtracting $\widehat{pr}_{t-1}$ from both sides, adding and subtracting $b_{20}\widehat{gap}_{t-1}$ on the right side and rearranging.

relationship, because when $\alpha_2 > 0$, over time the market has a tendency to move towards this relationship between the gap and the premium.[5] A long run relationship is defined as the state of the economy where all variables have had time to adjust to their steady state levels.

How do these short run and long run components of the ADL model relate to the prediction of the premium model? Recall that the premium model implies that as the gap rises from one time period to the next, the premium rises as well. Thus, it implies a contemporaneous relationship between the gap and the premium in their levels. Does the ADL model capture such a relationship? Note that in the error correction form, as given in (2), the parameter α_1 captures the effect of the change in the gap from time $t-1$ to t on the change in the premium from $t-1$ to t. Also note that $\alpha_1 = b_{20}$, where, according to the ADL specification as given in equation (1), the parameter b_{20} captures the effect of the gap on the premium in their levels. Thus, the prediction of the premium model is that $\alpha_1 > 0$.

If we were to expect the gap and the premium to be positively related in the long run as well then it should be the case that $\beta_1 > 0$. For this to hold in the long run, however, there needs to be a stable relationship between the gap and the premium. In estimating the ADL model, I assume that the relationship between the gap and the premium is stable for the length of the sample period on a particular regime. This, however, may not be the case. It is possible that the weight attached to the gap from PPP

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[5] Suppose, for example, that the ECT in some period is positive, implying that the premium that market participants expect is lower than the level implied by the gap variable. In this case, the premium will tend to rise over time, where the magnitude of the rise is determined by α_2.

changes over time even during a particular regime. That would be the case if the gap weight depends, for example, on the magnitude of the gap. It is possible that individuals attach more importance to the gap in forming their forecasts the farther the exchange rate is from PPP. That could be the case because as the exchange rate forecast increases further and further away from PPP from above, bulls in the market would get more and more concerned about an eventual countermovement. Thus, they would put a larger weight on the gap from PPP in assessing their potential losses. In fact, Kubelec (2004a,b) reports that official intervention is more successful in moving the exchange rate in the desired direction when misalignments from benchmark levels are larger. This finding is in line with my argument that the weight attached to the gap could be higher when the gap is larger. Thus, if the gap weight changes over time, we should not expect to see a long run relationship between the gap and the premium. Therefore, results on the long run relationship between the gap and the premium should be interpreted with caution.

I estimate the ADL model in two steps. First, I estimate equation (1) to obtain estimates of the b_0, b_{11}, b_{20} and b_{21} coefficients, which I then use to construct the ECT. Then I estimate the error-correction form of the ADL model as given in equation (2).

3.2 ADL Results

Tables 5.4a, 5.4b and 5.4c report the results obtained from the ADL model for the Reinhart and Rogoff (2004), Bubula and Ötker-Robe (2002) and Levy-Yeyati and Sturzenegger (2002) classifications, respectively.[6] The contemporaneous effect of

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[6] Results are arranged in two groups according to the exchange rate regime: freely floating regimes and regimes that involve some central bank intervention, called the managed regimes. That is because I will use the ADL results by these groups to perform the analysis in Chapter 6.

changes in the gap on the market premium, α_1, is found to be positive for most currencies with all three classifications. For the Reinhart and Rogoff classification, of the 27 regimes, α_1 is positive for 22 (82%), of which 15 (56% of 27) are significantly positive.[7] For the classifications of Bubula and Ötker-Robe and Levy-Yeyati and Sturzenegger, results are stronger. For the Bubula and Ötker-Robe classification, of the 26 regimes, α_1 is positive for 23 (92%), of which 14 (56% of 25) are significantly positive. For the classification by Levy-Yeyati and Sturzenegger, α_1 is positive for 17 out of 21 regimes (81%), and 14 of the estimates are significantly positive (67% of 21). For all three classifications, none of the negative estimates are significant. Also note that for several currencies, which are denoted in the tables, the significance tests are only valid asymptotically because the normality assumption was violated. In other words, these tests would be valid if the sample size were to approach infinity.[8] Thus, they can only be treated as suggestive. It is also the case that for several regimes, assumptions such as heteroscedasticity were violated, implying that significance tests are not valid.

The findings on the long run relationship between the gap and the premium in levels, as captured by β_1, are not as supportive to the model as previous results. For all three classifications the findings are mixed – there are both positive and negative estimates for β_1. For the Reinhart and Rogoff classification the estimate for β_1 is positive

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[7] Note that compared to the CTA results, one regime are missing, the Mexican peso between 12/94-03/96. The reason is that I could not obtain unbiased estimates for these, as revealed by the Reset test, which is used to test for omitted variables or nonlinearity in the model. The same holds for the Bubula and Ötker-Robe classification with the British pound between 10/90-08/92, and the Levy-Yeyati and Sturzenegger classification with the Mexican peso between 01/95-12/96.

[8] Due to the Central Limit theorem that states that any distribution would approach a normal one in the limit.

for 48% of regimes (13 out of 27), and significantly so for only 19% (5 out of 27). For 52% of regimes (14 out of 27) the estimate is negative, and significantly so again for 26% (7 out of 27). Findings with the other two classifications are somewhat better. For the Bubula and Ötker-Robe classification, the estimate for β_1 is positive for 52% of the sample (13 out of 25), and significantly so for 24% (6 out of 25), while it is significantly negative for 24% (6 out of 25). For the Levy-Yeyati and Sturzenegger classification the estimate for β_1 is positive for 57% of regimes (12 out of 21), significantly positive for 38% (8 out of 21) and significantly negative for 29% (6 out of 21).

There can be two reasons for why do not see a positive relationship between the gap and the premium in the long run. It is either the case that a long run relationship just does not exist, or it exists but the data are not capturing it.

The first possibility was already discussed above. As was mentioned, it is possible that the weight attached to the gap from PPP has changed over time, perhaps because it depends on the size of the gap, in which case we should not expect to see a long run relationship between the gap and the premium. There is one way to explore this possibility - by referring to the CTA results. Recall that a CTA allows for the gap weight to change over time since it captures only the qualitative relationship between the gap and the premium. Although we are not able to comment on the significance of the CTA results, we could use these as suggestive evidence. One can see that, depending on the exchange rate regime classification, a time-varying gap weight could account for the negative estimate of the gap weight for 50-89% of the exchange rate regimes. For the Reinhart and Rogoff classification, for 10 out of the 14 (71%) negative estimates for the weight, the CTA indicates that the gap and the premium have moved together over the same sample period. When only significant negative estimates are considered, these numbers are 4 out of 7 (57%). For the Bubula and Ötker-Robe classifications for 9 out of 12 (75%) negative weight estimates the gap and the premium have moved together over the same sample period. When only significant negative estimates are considered, these numbers are 3 out of 6 (50%). For Levy-Yeyati and Sturzenegger, the numbers are 8 out of 9 (89%) and 5 out of 6 (83%), respectively.

Let us now consider the second possibility – that the data are not capturing the long run relationship between the gap and the premium. One problem might be the sensitivity of the results to the time frame, which is determined by the exchange rate regime classifications. Such a difference in the estimates of the gap weight is especially striking, for example, for the Brazilian real (BRL) and the Peruvian sol (PEN) with the Renhart and Rogoff and Bubula and Ötker-Robe classifications. The BRL (PEN) spans the period 02/99-09/00 (04/99-09/00) with the first, and 01/99-09/00 (05/98-09/00) with the second classification. For the BRL the inclusion of one observation (January 1998) leads to a change in the estimate of the gap weight from negative to positive (from –2.6883 to 0.43, both insignificant). For the PEN, the inclusion of eleven observations (05/98-03/99) leads to a change in the estimate of the gap weight from negative to positive (from -1.6343 to 0.3934, both significant). This suggests that if the cut-off dates that are determined by the classifications are not correct, then it could be that part of the sample period in fact does not belong to that regime, or that a relevant part of the sample is missing, leading to a parameter shift in the data. Also, this sensitivity in the parameter estimate could be due to a small sample bias.

Another reason might lie with the problems related to survey data, more specifically, the lag between the forward rate and the forecast of the future exchange rate, as discussed in the previous chapter. Although I have tried to alleviate the problems associated with this lag by taking the average of the forward exchange rate for the most likely days on which the forecasts were being formulated, I have been only able to improve the data. It is very likely that the data I use for the analysis are still different from the aggregate of the actual spot and forward rates that survey participants have used when forming their forecasts, affecting results.

The results also indicate that the error correction term enters the equation positively for all but one regime (the Australian dollar) and significantly so for almost all regimes. For the three classifications - Reinhart and Rogoff, Bubula and Ötker-Robe and Levy-Yeyati and Sturzenegger, respectively – for 89% (24 out of 27), 80% (20 out of 25) and 91% (19 out of 21) of the regimes, the estimate of α_2 is significantly positive. However, for the majority of the regimes with all three classifications the contemporaneous effect of the gap on the premium is larger than the influence of the long run relationship as captured by the error correction term (78%, 72% and 81% of the total number of regimes for the Reinhart and Rogoff, Bubula and Ötker-Robe and Levy-Yeyati and Sturzenegger classifications, respectively).

For easy comparison to the findings of Frydman and Goldberg (2007) for the Japanese yen, the German mark and the British pound vis-à-vis the U.S. dollar, I have constructed Table 5.5. For the Japanese yen, estimates using all three classifications are similar to those reported by Frydman and Goldberg. The results for the German mark are somewhat different, especially for the long run estimate of the effect of the gap weight on the premium. Estimates for the British pound are distinctively different from Frydman and Goldberg's findings. Results are not only different from the findings by Frydman and Goldberg, but also among the three classifications, whenever a different time frame was used. Since the sample size for these currencies is not small, this is not likely to be due to a small sample bias. Rather, the difference in the estimates for the gap weight could be due to the different cut-off dates and instability in the parameter.

Summarizing the findings discussed in the previous paragraphs, it appears that the short run component of the ADL model in error correction form provides strong support to the prediction of the premium model of a positive link between the gap from PPP and the market premium. As such, it appears that the gap and the premium move in the same direction in the short run. However, findings do not provide support for the long run positive relationship between these two variables.

Nevertheless, results also indicate that, for the majority of the currencies, the contemporaneous effect of the change in the gap on the change in the premium, as captured by the short run component in the ADL model, is larger than the effect of the ECT on the change in the premium. Furthermore, the results from the CTA suggest that for the majority of the exchange rate regimes in the sample for which the long run relationship was found to be negative, there might have been a shift in the gap weight. Therefore, one can conclude that the findings on the contemporaneous effect are more relevant for the prediction of the premium model, and these suggest that the gap and the premium are positively related to each other.

4 Conclusion

In this chapter I extended the empirical analysis of Frydman and Goldberg (2007) to up to 28 exchange rate regimes involving 24 different currencies. My sample includes the three currencies (Japanese yen, German mark and British pound) that Frydman and Goldberg (2007) have analyzed but with a different data and for a different time span. Although my results are different and weaker for some currencies compared to the findings of Frydman and Goldberg, in general both the contingency table analysis and the autoregressive distributive lag model provide support for the positive effect of the gap on the market premium. These findings generalize the positive link between the gap and the premium that was reported for three currencies by Frydman and Goldberg (2007) to 24 currencies.

Table 5.1: CTA for Australia

period: 10/86-09/00		$\Delta\widehat{pr}$ +	$\Delta\widehat{pr}$ -
$\Delta\widehat{gap}$	+	53	28
	-	31	55

Chi-sq:	14.41
SD/OD:	1.8
SD/N:	64.7%

Table 5.2a: Contingency Table Analysis
(Reinhart and Rogoff Classification)

currency	period	N	Chi-sq	SD	OD	SD/OD	SD/N (%)
Australian dollar	10/86-09/00	168	**14.41**	108	59	**1.8**	**64.7**
Brazilian real	02/99-09/00	20	**1.35**	12	7	**1.7**	**63.2**
British pound	08/86-08/92	73	**0.93**	40	32	**1.3**	**55.6**
British pound	09/92-09/00	97	0.00	48	48	1.0	50.0
Canadian dollar	08/86-09/00	170	**6.72**	101	68	**1.5**	**59.8**
Colombian peso	01/98-09/99	21	0.00	10	10	1.0	50.0
Czech koruna	04/98-09/00	30	0.02	14	15	0.9	48.3
Euro	01/99-09/00	21	**1.11**	11	9	**1.2**	**55.0**
German mark	08/86-09/00	170	**0.16**	88	81	**1.1**	**52.1**
Hungarian forint	04/98-09/00	30	0.84	12	17	0.7	41.4
Indonesian rupee	04/98-09/00	30	**4.44**	20	9	**2.2**	**69.0**
Japanese yen	08/86-09/00	170	**7.27**	102	67	**1.5**	**60.4**
Korean won	12/93-11/97	48	**3.58**	30	17	**1.8**	**63.8**
Korean won	12/97-09/00	34	**3.42**	22	11	**2.0**	**66.7**
Malaysian ringgit	03/93-07/97	53	**0.33**	28	24	**1.2**	**53.8**
Mexican peso	12/94-03/96	16	**0.08**	8	7	**1.1**	**53.3**
Mexican peso	04/96-09/00	54	**7.55**	37	16	**2.3**	**69.8**
New Zealand dollar	02/93-09/00	92	**1.16**	51	40	**1.3**	**56.0**
Norwegian krone	10/86-09/00	168	**6.75**	100	67	**1.5**	**59.9**
Peruvian sol	04/99-09/00	18	0.88	6	11	0.5	35.3
Phillipine peso	12/97-04/99	17	0.15	7	9	0.8	43.8
Polish zloty	04/98-09/00	30	**0.77**	17	12	**1.4**	**58.6**
Singapore dollar	01/88-11/98	131	0.18	63	67	0.9	48.5
Singapore dollar	12/98-08/00	21	0.27	9	11	0.8	45.0
Swiss frank	08/86-09/00	170	**4.44**	98	71	**1.4**	**58.0**
Thai baht	05/98-09/00	29	0.00	14	14	1.0	50.0
Turkish lira	05/98-09/00	29	0.54	12	16	0.8	42.9
Venezuelan bolivar	03/99-08/00	18	0.08	8	9	0.9	47.1

N: number of observations

SD: number of observations for which the gap and premium move in the same direction

OD: number of observations for which the gap and premium move in opposite directions

Table 5.2b: Contingency Table Analysis
(Bubula and Ötker-Robe Classification)

currency	period	N	Chi-sq	SD	OD	SD/OD	SD/N (%)
Australian dollar	01/90-09/00	129	**9.26**	81	47	**1.7**	**63.3**
Brazilian real	01/99-09/00	21	**0.80**	12	8	**1.5**	**60.0**
British pound	10/90-08/92	23	**4.18**	16	6	**2.7**	**72.7**
British pound	09/92-09/00	97	0.00	48	48	1.0	50.0
Canadian dollar	01/90-08/98	104	**9.40**	67	36	**1.9**	**65.0**
Canadian dollar	09/98-08/99	25	0.12	11	13	0.8	45.8
Colombian peso	01/98-09/00	20	**0.04**	10	9	**1.1**	**52.6**
Czech koruna	04/98-09/00	30	0.02	14	15	0.9	48.3
Euro	01/99-09/00	21	**1.11**	11	9	**1.2**	**55.0**
German mark	01/90-09/00	129	0.26	61	67	0.9	47.7
Hungarian forint	04/98-09/00	30	0.84	12	17	0.7	41.4
Indonesian rupee	04/98-09/00	30	**4.44**	20	9	**2.2**	**69.0**
Japanese yen	01/90-09/00	129	**1.54**	71	57	**1.2**	**55.5**
Korean won	12/93-11/97	48	**7.67**	33	14	**2.4**	**70.2**
Korean won	12/97-12/99	25	**2.74**	16	8	**2.0**	**66.7**
Malaysian ringgit	03/93-06/97	52	**0.16**	27	24	**1.1**	**52.9**
Mexican peso	12/94-09/00	70	**5.83**	45	24	**1.9**	**65.2**
New Zealand dollar	02/93-09/00	92	**1.16**	51	40	**1.3**	**56.0**
Norwegian krone	01/90-09/00	129	**4.15**	75	53	**1.4**	**58.6**
Peruvian sol	05/98-09/00	29	0.21	11	17	0.6	39.3
Polish zloty	04/98-09/00	30	**0.77**	17	12	**1.4**	**58.6**
Singapore dollar	01/90-08/00	128	**0.34**	67	60	**1.1**	**52.8**
Swiss frank	01/90-09/00	129	**1.97**	72	56	**1.3**	**56.3**
Thai baht	05/98-09/00	29	0.00	14	14	1.0	50.0
Turkish lira	05/98-09/00	29	0.54	12	16	0.8	42.9
Venezuelan bolivar	03/99-08/00	18	0.08	8	9	0.9	47.1

N: number of observations

SD: number of observations for which the gap and premium move in the same direction

OD: number of observations for which the gap and premium move in opposite directions

Table 5.2c: Contingency Table Analysis
(Levy-Yeyati and Sturzenegger Classification)

currency	period	N	Chi-sq	SD	OD	SD/OD	SD/N (%)
Australian dollar	10/86-09/00	168	**14.41**	108	59	**1.8**	**64.7**
British pound	08/86-09/00	170	**5.22**	99	70	**1.4**	**58.6**
Canadian dollar	01/87-12/88	24	**1.43**	13	10	**1.3**	**56.5**
Canadian dollar	01/92-09/00	105	**5.39**	64	40	**1.6**	**61.5**
Colombian peso	01/98-08/00	32	0.41	14	17	0.8	45.2
Czech koruna	04/98-09/00	30	0.02	14	15	0.9	48.3
Euro	01/99-09/00	21	**1.11**	11	9	**1.2**	**55.0**
German mark	08/86-09/00	170	**0.16**	88	81	**1.1**	**52.1**
Indonesian rupee	04/98-09/00	30	**4.44**	20	9	**2.2**	**69.0**
Japanese yen	08/86-09/00	170	**7.27**	102	67	**1.5**	**60.4**
Korean won	03/97-12/98	22	**0.40**	12	9	**1.3**	**57.1**
Mexican peso	01/95-12/96	24	**0.43**	13	10	**1.3**	**56.5**
Mexican peso	01/97-09/00	45	**8.06**	32	12	**2.7**	**72.7**
New Zealand dollar	02/93-09/00	92	**1.16**	51	40	**1.3**	**56.0**
Norwegian krone	10/86-09/00	168	**3.18**	95	71	**1.3**	**57.2**
Peruvian sol	05/98-12/99	20	0.02	8	11	0.7	42.1
Phillipine peso	01/97-04/99	28	**0.03**	14	13	**1.1**	**51.9**
Polish zloty	04/98-09/00	30	**0.77**	17	12	**1.4**	**58.6**
Swiss frank	08/86-09/00	170	**4.44**	98	71	**1.4**	**58.0**
Thai baht	01/99-09/00	21	0.22	9	11	0.8	45.0
Turkish lira	01/99-09/00	21	**0.20**	11	9	**1.2**	**55.0**
Venezuelan bolivar	03/99-08/00	18	0.08	8	9	0.9	47.1

N: number of observations

SD: number of observations for which the gap and premium move in the same direction

OD: number of observations for which the gap and premium move in opposite directions

Table 5.3: Summary of CTA Results by Classification

Classification	number of regimes	SD/OD > 1:1 for
Reinhart and Rogoff	28	17 regimes (61%)
Bubula and Ötker-Robe	26	17 regimes (65%)
Levy-Yeyati and Sturzenegger	22	17 regimes (77%)

SD: number of observations for which the gap and premium move in the same direction
OD: number of observations for which the gap and premium move in opposite directions

Table 5.4a: ADL Model Estimation Results
(Reinhart and Rogoff Classification)

currency	period	N	α_1	α_2	β_1
free floats					
Australian dollar	10/86-09/00	168	**0.2201** *	**-0.1845** ***	**0.2372** *
British pound	08/86-08/92	73	**2.0256** ***	**0.7479** ***	0.0686
Euro	01/99-09/00	21	0.3785	**1.4902** ***	**-1.0033** ***
German mark	08/86-09/00	170	**0.9436** ***	**0.3486** ***	**-0.3574** **
Hungarian forint	04/98-09/00	30	0.7204	**0.9758** ***	**-1.3529** ***
Indonesian rupee	04/98-09/00	30	**3.0717** ***	**0.8048** ***	-0.3254
Japanese yen[1]	08/86-09/00	170	**0.8286** ***	**0.3051** ***	0.0534
Korean won[1]	12/97-09/00	34	-0.0904	**0.5555** ***	-0.0253
Swiss frank	08/86-09/00	170	**2.1720** ***	**0.8146** ***	-0.1257
Turkish lira[2]	05/98-09/00	29	7.6735	0.3074	5.7700
managed regimes					
Brazilian real	02/99-09/00	20	**1.4801** **	**0.6849** ***	-2.6883
British pound	09/92-09/00	97	**1.2114** ***	**0.4043** ***	**0.4067** *
Canadian dollar	08/86-09/00	170	**2.3367** ***	**0.8161** ***	-0.0571
Colombian peso[1]	01/98-09/99	21	-1.1518	**0.6744** **	0.1344
Czech koruna	04/98-09/00	30	-0.8237	**0.9666** ***	**-0.5334** *
Korean won[1]	12/93-11/97	48	3.8063	**0.6464** ***	1.4771
Malaysian ringgit[1]	03/93-07/97	53	0.1042	**0.4331** ***	**-0.6935** *
Mexican peso[1]	04/96-09/00	54	**2.1380** ***	**0.9614** ***	-0.2770
New Zealand dollar	02/93-09/00	92	**2.3212** **	**0.8529** ***	0.1804
Norwegian krone	10/86-09/00	168	**2.3155** ***	**0.7723** ***	**0.2265** *
Peruvian sol	04/99-09/00	18	-2.0985	**1.3358** ***	**-1.6343** ***
Phillipine peso	12/97-04/99	17	1.1158	**0.3952** ***	1.6504
Polish zloty	04/98-09/00	30	**1.6956** *	**0.9460** ***	**-1.2252** *
Singapore dollar[2]	01/88-11/98	131	0.3632	0.9296	-0.0328
Singapore dollar	12/98-08/00	21	-1.3498	**0.7756** ***	1.1714
Thai baht	05/98-09/00	29	**2.1542** **	**0.9998** ***	**1.4355** **
Venezuelan bolivar	03/99-08/00	18	**4.0854** *	**0.4587** **	**6.5005** *

N: number of observations

[1] All significance tests valid asymptotically.

[2] Significance tests not valid.

Stars indicate significance levels at 1% (***), 5% (**) and 10% (*).

Table 5.4b: ADL Model Estimation Results
(Bubula and Ötker-Robe Classification)

currency	period	N	α_1	α_2	β_1
free floats					
Australian dollar[2]	01/90-09/00	129	2.6169	0.8489	0.1409
Brazilian real	01/99-09/00	21	**0.7670** *	**0.4977** ***	0.4300
British pound	09/92-09/00	97	**1.2114** ***	**0.4043** ***	**0.4067** *
Canadian dollar	09/98-09/00	25	**4.2012** ***	**0.9997** ***	**1.8565** **
Czech koruna	04/98-09/00	30	-0.8237	**0.9666** ***	**-0.5334** *
Euro	01/99-09/00	21	0.3785	**1.4902** ***	**-1.0033** ***
German mark[1]	01/90-09/00	129	**0.7905** ***	**0.3663** ***	**-0.2788** **
Hungarian forint	04/98-09/00	30	0.7204	**0.9758** ***	**-1.3529** ***
Indonesian rupee	04/98-09/00	30	**3.0717** ***	**0.8048** ***	-0.3254
Japanese yen[2]	01/90-09/00	129	0.6253	0.2574	0.1498
Korean won	12/97-12/99	25	**2.6298** *	**0.4620** ***	-0.5159
Mexican peso	12/94-09/00	70	0.2775	**0.7885** ***	-0.1525
Norwegian krone	01/90-09/00	129	**2.1719** ***	**0.7674** ***	0.1094
New Zealand dollar[2]	02/93-09/00	92	2.3212	0.8529	0.1804
Swiss frank	01/90-09/00	129	**1.8363** ***	**0.8573** ***	-0.0920
managed regimes					
Canadian dollar	01/90-08/98	104	**2.4803** ***	**0.8273** ***	-0.0723
Colombian peso	01/98-08/99	20	1.1642	2.0344	1.4176
Korean won[1]	12/93-11/97	48	3.5631	**0.6511** ***	5.6193
Malaysian ringgit	03/93-06/97	52	-0.1825	**0.3148** ***	**-0.7974** **
Peruvian sol	05/98-09/00	29	**2.7429** **	**1.0970** ***	**0.3934** *
Polish zloty	04/98-09/00	30	**1.6956** *	**0.9460** ***	**-1.2252** *
Singapore dollar[2]	01/90-08/00	128	0.0527	0.8975	-0.0578
Thai baht	05/98-09/00	29	**2.1542** **	**0.9998** ***	**1.4355** **
Turkish lira	05/98-09/00	29	**7.6735** ***	**0.3074** ***	**5.7700** ***
Venezuelan bolivar	03/99-08/00	18	**4.0854** *	**0.4587** **	**6.5005** *

N: number of observations

[1] All significance tests valid asymptotically.

[2] Significance tests not valid.

Stars indicate significance levels at 1% (***), 5% (**) and 10% (*).

Table 5.4c: ADL Model Estimation Results
(Levy-Yeyati and Sturzenegger Classification)

currency	period	N	α_1	α_2	β_1
free floats					
Australian dollar	10/86-09/00	168	**0.2201** *	**-0.1845** ***	**0.2372** *
British pound[1]	08/86-09/00	170	**1.9386** ***	**0.7625** ***	**0.2944** *
Canadian dollar	01/87-12/88	24	**2.4494** ***	**0.5594** ***	**0.8435** ***
Canadian dollar	01/92-09/00	105	-0.0233	**1.0368** ***	**-0.1220** **
Colombian peso	01/98-08/00	32	-0.6410	**0.6668** ***	0.0752
Czech koruna	04/98-09/00	30	-0.8237	**0.9666** ***	**-0.5334** *
Euro	01/99-09/00	21	0.3785	**1.4902** ***	**-1.0033** ***
German mark	08/86-09/00	170	**0.9436** ***	**0.3486** ***	**-0.3574** **
Japanese yen[1]	08/86-09/00	170	**0.8290** ***	**0.3053** ***	0.0534
Mexican peso	01/97-09/00	45	**2.3393** ***	**0.9980** ***	0.0225
Norwegian krone	10/86-09/00	167	**2.3242** ***	**0.7729** ***	**0.2280** *
Peruvian sol	05/98-12/99	20	2.2628	**1.2315** ***	**0.6958** **
Phillipine peso	01/97-04/99	28	**1.9294** *	**0.2308** **	-0.0212
Polish zloty	04/98-09/00	30	**1.6956** *	**0.9460** ***	**-1.2252** *
Swiss frank	08/86-09/00	170	**2.1720** ***	**0.8146** ***	-0.1257
Thai baht	01/99-09/00	21	**3.4122** ***	**1.3182** ***	**2.2451** ***
Turkish lira	01/99-09/00	21	**7.5333** ***	**0.5112** ***	**3.1442** *
managed regimes					
Indonesian rupee	04/98-09/00	30	**3.0717** ***	**0.8048** ***	-0.3254
Korean won	03/97-12/98	22	-1.8421	**0.8680** ***	**-2.3807** ***
New Zealand dollar[2]	02/93-09/00	92	2.3155	0.7723	0.2265
Venezuelan bolivar	03/99-08/00	18	**4.0854** *	**0.4587** **	**6.5005** *

N: number of observations

[1] All significance tests valid asymptotically.

[2] Significance tests not valid.

Stars indicate significance levels at 1% (***), 5% (**) and 10% (*).

Table 5.5: ADL Model Estimation Results
Compared to Results by Frydman and Goldberg (2007)

	Estimate	British pound	German mark	Japanese yen
Results according to classification by Reinhart and Rogoff[1]	α_1	2.03 *** 1.21 ***	0.94 ***	0.83 ***
	α_2	0.75 *** 0.40 ***	0.35 ***	0.31 ***
	β_1	0.07 0.41	-0.36 **	0.05
Results according to classification by Levy-Yeyati and Sturzenegger (August 1986-September 2000)[2]	α_1	1.94 ***	0.94 ***	0.83 ***
	α_2	0.76 ***	0.35 ***	0.31 ***
	β_1	0.29	-0.36 **	0.05
Results according to classification by Bubula and Ötker-Robe[3]	α_1	1.21 ***	0.79 ***	0.63
	α_2	0.40 ***	0.37 ***	0.26
	β_1	0.41	-0.28	0.15
Results by Frydman and Goldberg (2007) (December 1982-February 1997)	α_1	0.84 ***	1.10 ***	0.84 ***
	α_2	0.33 **	0.28 ***	0.29 ***
	β_1	0.56 ***	0.29 *	0.19

[1] Periods are August 1986-September 2000 for JPY and DEM; August 1986-August 1992; then September 1992-September 2000 for GBP. Significance tests for the JPY are valid asymptotically.

[2] Significance tests for the JPY and GBP are valid asymptotically.

[3] Periods are January 1990-September 2000 for JPY and DEM; September 1992-September 2000 for GBP. Significance tests for the DEM are valid asymptoically. Significance tests for JPY are not valid.

Stars indicate significance levels at 1% (***), 5% (**) and 10% (*).

CHAPTER 6

LIMITING EXCHANGE RATE SWINGS IN A WORLD OF IMPERFECT KNOWLEDGE

1 Introduction

The empirical results presented in Chapter 5 provide evidence of the positive effect of the gap from PPP on the market premium in the short run. These findings suggest that if central bank policy can lead to a higher weight attached to the gap from PPP, then there is a new channel – the uncertainty premium channel – through which official intervention aimed at pushing the exchange rate back to some announced or unannounced parity level can limit long swings in exchange rates.

In this chapter, I investigate if the data supports the existence of the uncertainty premium channel. I use two different approaches. In Section 2, I use different estimates for the weight attached to the gap from PPP and investigate if, on the average, the weight attached to PPP in speculating is higher in countries with some managed exchange rate regime compared to the weight in countries with a freely floating exchange rate regime. Findings from this analysis provide some evidence that official intervention and parity announcement have led to smaller swings in exchange rates. Results depend on the exchange rate regime classification –the average weight for managed regimes is significantly higher compared to the average weight for freely floating regimes only for the Bubula and Ötker-Robe classification.

Then in Section 3, to circumvent some major issues regarding exchange rate regime classifications that were raised in Chapter 4, I investigate if markets in which there is more intervention, as proxied by changes in reserves, are associated with a larger weight attached to the gap from PPP. Supporting evidence would suggest that in markets that are characterized with a larger volume of foreign exchange intervention, swings in exchange rates will be more limited. Note, however, that results obtained by using the change in reserves still depend on the exchange rate regime classifications because the classifications determine the cut-off periods for the currencies used to estimate the weight attached to the gap from PPP. As was discussed in Chapter 5, with small samples, different sample periods could lead to different estimates for the gap weight. For all three regime classifications, results from this analysis provide evidence that in markets characterized by central bank intervention to support some parity, the weight attached to the gap from PPP is significantly higher compared to the weight under freely floating regimes.

The main conclusion of this chapter is that the implication of the premium model on a higher gap weight under exchange rate regimes involving central bank intervention supporting some parity level, compared to freely floating regimes receives general empirical support. When the classifications by Reinhart and Rogoff, Bubula and Ötker-Robe and Levy-Yeyati and Sturzenegger are used to test if the average gap weight for managed regimes is higher compared to the average gap weight for free floaters, results are mixed. However, when countries are classified according to the degree of official intervention, as proxied by the change in reserves, the prediction of the premium model is strongly supported.

2 Is the Gap from PPP More Important under Managed Regimes?

To investigate if the market tends to attach more weight to the gap from PPP under managed regimes compared to free floats, I follow the following approach. In Section 2.1, I use the results from the autoregressive distributive lag model that I reported in Chapter 5 and investigate if the average effect of the gap on the premium is larger for currency markets in which there is central bank intervention and parity announcement (the managed regimes), versus the average weight for free floats. A larger weight attached to the gap under managed regimes would indicate that exchange rate swings are smaller in such regimes compared to free floats. Then in Section 2.2, I follow the same methodology by using regression results from a static OLS regression. In Section 2.3, I discuss findings and some future research avenues.

2.1 ADL Results: Short-run and Long-run Effects of the Gap on the Premium

The average weights attached to the gap from PPP for managed regimes and free floats that are obtained using the ADL results from Chapter 5 are provided in Tables 6.1a-6.1b for all three classifications. Table 6.1a provides the average weight for free floats and managed regimes using the short run estimates for the weight from the ADL model, whereas Table 6.1b reports results using the long run estimate for the gap weight.

The Bubula and Ötker-Robe classification provides support for the implication of the premium model that the average weight attached to the gap should be larger under managed regimes with both short run and long run ADL estimates - the average of the estimates of the gap weight for managed regimes is significantly higher than the one for freely floating regimes (at the 10% and 5% level for the short run and long run effects, respectively). For the Levy-Yeyati and Sturzenegger classification, the average of the estimates of the gap weight is larger for managed regimes both in the short run and the long run, but the difference is not significant. The same holds with the Reinhart and Rogoff classification for the long run. In the short run, however, for the Reinhart and Rogoff classification the average of estimates of the gap weight for managed regimes is insignificantly *smaller* than the average for free floats. Thus, the Levy-Yeyati and Sturzenegger, and Reinhart and Rogoff classifications do not provide support to the hypothesis that the weight attached to the gap from PPP depends on the exchange rate regime that a central bank is pursuing. In contrast, the Bubula and Ötker-Robe classification suggest that the gap weight will be higher in countries in which there is central bank intervention supporting some parity level.

Recall that the managed floating category of the Reinhart and Rogoff and Bubula and Ötker-Robe classifications required caution because they did not necessarily indicate larger central bank intervention. Thus, I have performed the analysis by excluding the currencies identified as 'managed floating' or by switching them to the group of free floaters. Results of both classifications change quantitatively, but the general conclusion does not.

In sum, results obtained by using the short run and long run estimates for the weight attached to the gap from PPP from the ADL model depend on the classification. The only significant result was obtained for the Bubula and Ötker-Robe classification, and that result provides evidence that the average weight in markets that are characterized by central bank intervention and parity announcement is larger compared to markets that do not involve such policy interventions. A discussion on why that might be the case follows in Section 2.3 below.

2.2 Static OLS Results: Effect of the Gap on the Premium

To test whether the average weight attached to the gap from PPP, $\hat{\sigma}$, is higher in countries with some managed exchange rate regime compared to countries with a free float using static OLS results, I employ the following approach. First I get an estimate of $\hat{\sigma}$ for every country and every regime that a country has adopted over the period under consideration. To do so, I estimate the following equation using a static OLS regression:[1]

$$\widehat{pr}_{t|t+1} = \alpha + \hat{\sigma}\left(\hat{s}_{t|t+1} - \hat{s}_t^{PPP}\right) + \varepsilon_t \qquad (1)$$

where $\hat{s}_t^{PPP}$ is the PPP exchange rate, ε_t is the white noise error term and all other variables are as defined before.

Similarly to the analysis with the ADL estimates, I the group the OLS estimates of $\hat{\sigma}$ in two groups: managed regimes and free floats, and I test whether the average weight attached to the gap from PPP, $\hat{\sigma}$, is larger for the first group.

The OLS results from regressing the gap on the equilibrium premium are given in Tables 6.2a-6.2c for the Reinhart and Rogoff, Bubula and Ötker-Robe and Levy-Yeyati and Sturzenegger classifications, respectively. Results using all three classifications indicate that the average of $\hat{\sigma}$ for the managed group is larger than for the free floats,

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[1] As was noted in Chapter 5, OLS estimation using time series data does not allow for a comment on the significance of the parameters, since the conventionally calculated critical values are incorrect (see Hendry and Juselius, 2000). However, as long as no other classic linear model assumptions are violated, which appears to be the case with the data at hand, except for the small sample size for some currencies and possibly an omitted variable problem, it produces unbiased coefficient estimates, which is what we need here. The possibility of an omitted variable bias is explored in Section 2.3.

however the difference is significant (at the 10% level) only for the Bubula and Ötker-Robe classification.[2] Again, results are somewhat affected if the currencies under a managed floating regime are excluded from the analysis or added to the freely floating group, but the main conclusion does not change for any of the three classifications.

To sum up, in this section I compared the ADL short run and long run estimates, as well as static OLS estimates of the gap weight for two groups of regimes – freely floating and managed regimes. A higher average gap weight for the managed group would support the prediction of the premium model that such currencies experience more limited swings in exchange rates. The analysis produced mixed results that depend on the exchange rate regime classification that was used to group the countries. Significant results supporting the prediction of a higher weight for the managed group of regimes are obtained using the Bubula and Ötker-Robe classificaion, but not using the Levy-Yeyati and Sturzenegger or Reinhart and Rogoff classifications.

2.3 Discussion

Results in this section suggest that the exchange rate regime classification is crucial for the results. Results change with the classification due to two reasons. One is the different time frame due to different cut-off dates, and another is the type of regime – freely floating versus managed – that is attributed to a specific currency by the different classifications. Several of the currencies that are classified as freely floating under the

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[2] For some currencies, the Reset test reveals that the OLS estimates might be biased. Therefore, these have been excluded from the sample. In general, however, results do not depend on whether these currencies are included in the analysis or not. These are the Japanese yen (08/86-09/00), Brazilian real (02/99-09/00), Korean won (12/93-11/97) and Norwegian krone (11/86-09/00) for the Reinhart and Rogoff, and the Canadian dollar (09/98-09/00), Japanese yen (01/90-09/00), Korean won (12/93-11/97), Norwegian krone (01/90-09/00) and Peruvian sol (05/98-09/00) for the Bubula and Ötker-Robe classifications, respectively.

Reinhart and Rogoff classification are identified as managed regimes under the Bubula and Ötker-Robe classification, such as the Czech koruna and the Polish zloty.

According to the Reinhart and Rogoff and Levy-Yeyati and Sturzenegger classifications, the average weight attached to the gap from PPP is not significantly higher under exchange rate regimes that involve central bank intervention supporting some parity level compared to freely floating regimes.

According to the Bubula and Ötker-Robe classification, on the other hand, the weight attached to the gap from PPP is significantly higher under managed regimes than it is under free floats. This result holds for the short run ADL, long run ADL and static OLS estimates of the gap weight. This finding suggests that central bank intervention supporting a parity level would lead to smaller swings in exchange rates.

Which of these results should be given more weight? There is no way of telling which classification is a better representation of reality. One thing we can do is to compare the classifications and arrive at some conclusion as to which one might be more reliable. Refer back to the discussions in Chapter 4 that provided detailed analysis on the classifications. Recall from these discussions that one of the big advantages of the Bubula and Ötker-Robe classification is its primary reliance on information obtained through bilateral consultation discussions, and regular contacts with IMF country desk economists to identify exchange rate regimes. While this classification uses exchange rate behavior only as supplementary evidence, the classifications by Reinhart and Rogoff and Levy-Yeyati and Sturzenegger rely primarily on exchange rate behavior to identify regimes. It was discussed in Chapter 4 that the use of exchange rate behavior, in particular, its volatility, might pose problems for empirical analysis. Although one would expect this problem to bias results in favor of finding a higher gap weight for managed regimes, it is not clear that this is the case because these two classifications do not provide strong support for that prediction.

Several other things can be noted from the results in this section. First, the sample size for many currencies is 30 or less, and so the coefficient estimates obtained from such small sample sizes may not be very reliable due to the small sample bias. Comparing the OLS estimates for the same currencies with the three classifications, one can notice a pattern. It is the case that for several currencies, the sample size among the three classifications differs by several observations. And it also happens to be the case that the weight estimate is in general larger with a larger sample size. Comparing just the Reinhart and Rogoff and Bubula and Ötker-Robe classifications alone, this is the case, for example, with the Malaysian ringgit (-0.1847 vs. –0.2433) or the Mexican peso (0.0399 vs. -0.2167).[3] One possible strategy for increasing the sample size for some currencies would be to use a three-month ahead monthly forecast data instead of the one-month ahead forecast data that I have used in my dissertation. As was mentioned before, the one-month forecast data was discontinued in October 2000, but the three-month ahead forecast data is still being collected.

As was discussed in Chapter 5, another possibility is that perhaps the weight that market participants attach to the gap from PPP actually depends on how far the exchange rate is from benchmark levels. It could well be the case that individuals would attach more importance to the gap in forming their forecasts the farther the exchange rate is from PPP. One way to capture such a relationship would be to formulate some threshold

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[3] The first estimate is obtained with the larger sample size.

levels for the gap size and use dummy variables to estimate different gap weights with the different levels for the size of the gap. Another way would be to use a different specification for the gap that would still be consistent with the spirit of the premium model, perhaps some nonlinear version.

Another point to be made is that macroeconomic fundamentals are assumed to affect the premium through their effect on the market's assessment of the gap from historical benchmark. However, it is quite possible that they also have a direct effect on the premium. If that is the case, then the current estimates of the gap weight will be biased because of an omitted variable problem. Such an issue could provide an explanation for the negative estimates for the weight attached to the gap.[4] A negative weight attached to the gap from PPP implies that as the market increases their forecast of the future exchange rate, they would ask for a *lower* uncertainty premium. This is in contrary to the prediction of the premium model that as the gap rises, so would the uncertainty premium. This prediction of the model, however, assumes that all other factors that would *directly* affect the uncertainty premium are held constant.[5] Thus, another future avenue of research would be to add some macroeconomic variables that are available for the currencies in my sample, such as relative output levels and relative inflation rates, to the regression equation.

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[4] For about half of the estimates using the Reinhart and Rogoff classificantion, and about a third of the estimates using Bubula and Ötker-Robe and Levy-Yeyati and Sturzenegger. Note that none of the negative estimates are significantly different from zero.

[5] In addition, a negative weight attached to the gap could also be due to any of the reasons discussed in the previous two paragraphs, namely small sample size, or the weight depending on the size of the gap – perhaps the gap was so small during the sample period that individuals did not really care about it.

3 Does More Intervention Lead to Smaller Swings in Exchange Rates?

In this section I investigate whether the market attaches a larger weight to the gap in assessing potential losses during regimes with greater intervention, as proxied by changes in international reserves. If that is the case, we would expect to observe smaller exchange rate swings in these markets.

As was discussed in Chapter 4, such an approach allows one to circumvent the issues related to classifying exchange rate regimes. To test this implication, I separately regress the short-run ADL, long-run ADL and the OLS estimates of the weight attached to the gap from PPP on the change in official reserves, i.e. I run the following regression:

$$\hat{\sigma}_i = \delta_0 + \delta_1 OI_i + \varepsilon_i \qquad (2)$$

for $i = 1,...n$ exchange rate regimes, where $\hat{\sigma}_i$ denotes the weight estimate attached to the gap from PPP during exchange rate regime i, OI_i stands for official intervention during exchange rate regime i, as proxied by the change in reserves, and ε_i is the white noise error term.

The empirical results obtained from this analysis are provided in Tables 6.3a-6.3c. For the Bubula and Ötker-Robe and Levy-Yeyati and Sturzenegger classifications, results using short-run and long-run ADL estimates of the weight attached to the gap, given in Tables 6.3a and 6.3b, respectively, provide evidence of a positive but insignificant effect of the change in reserves on the weight attached to the gap from PPP. For the Reinhart and Rogoff classification, on the other hand, the estimate of δ_1 is significantly positive for the short run estimate of the gap weight, whereas it is insignificantly negative for the long run estimates of the weight.

Results using the OLS estimate of the weight attached to the gap, provided in Table 6.3c, show that with all three classifications, official intervention has a significant (at the 10% for Reinhart and Rogoff and the 1% level for the other two classifications, respectively) positive influence on the weight attached to the gap from PPP.

In sum, the findings from the regression of the gap weight ($\hat{\sigma}$) on the change in reserves provide mixed results. When the short run and long run estimates from the ADL model are used, the size of intervention appears to have a positive but insignificant effect on the weight attached to the gap from PPP, except for the Reinhart and Rogoff classification that finds a significant positive relationship in the short run and insignificant negative relationship in the long run. When the OLS estimates for the gap weight are regressed on the change in reserves, all three classifications indicate a significant influence of the size of intervention on the weight attached to the gap, implying that in markets characterized with greater official intervention we will observe swings of smaller magnitude. These findings provide support to the implication of the premium model, suggesting that central bank policy composed of intervention supporting some parity can lead more limited swings in exchange rates.

4 Conclusion

In this chapter I investigated the implication of the premium model that central bank intervention at unpredictable moments in time aimed at pushing the exchange rate back to some announced or unannounced parity level may lead to more limited swings in exchange rates by increasing the weight that the market attaches to the gap from PPP in assessing potential losses.

In general, findings provide support to this implication. Results tend to depend on how one classifies exchange rate regimes - results obtained by using the Bubula and Ötker-Robe classification provide strong support independently of the method used for testing the prediction. Also, findings strongly support the prediction of the model when currencies are classified according to the degree of official intervention as proxied by the change in reserves, independently of the classification that is used to obtain the gap weight. One can conclude from these findings that central bank intervention aimed at pushing the exchange rate back to some announced or unannounced parity level has led to more limited swings in exchange rates.

Some future research avenues were also discussed, which include increasing the sample size by using three-month ahead monthly forecast data, allowing for the gap weight to change with the size of the gap and controlling for other factors that might have a direct influence on the market premium, besides the gap from PPP.

Table 6.1a: Aggregate Weight for Free Floats Versus Managed Regimes: Short-Run Effects

Classification	Aggregate weight		DIMS[1]
	free floats	managed regimes	
Reinhart and Rogoff	1.7944	1.1590	-0.7549
Bubula and Ötker-Robe	1.5197	2.5429	1.3417 *
Levy-Yeyati and Sturzenegger	1.7024	1.9076	0.1485

Table 6.1b: Aggregate Weight for Free Floats Versus Managed Regimes: Long-Run Effects

Classification	Aggregate weight		DIMS[1]
	free floats	managed regimes	
Reinhart and Rogoff	0.2939	0.3554	0.0781
Bubula and Ötker-Robe	-0.0654	1.8983	2.1715 **
Levy-Yeyati and Sturzenegger	0.2618	1.0052	0.3846

[1] Difference-in-means statistic

Stars indicate significance levels at 5% (**) and 10% (*).

Table 6.2a: OLS Estimates of Gap Weight (Reinhart and Rogoff Classification)

currency	period	N[1]	Estimates of $\hat{\sigma}$
free floats			
Australian dollar	10/86-09/00	168	0.3482
British pound	08/86-08/92	170	0.0834
Euro	01/99-09/00	21	-0.8979
German mark	08/86-09/00	170	-0.1127
Hungarian forint	04/98-09/00	30	-0.9483
Indonesian rupee	04/98-09/00	30	0.3618
Korean won	12/97-09/00	34	-1.5553
Mexican peso	12/94-03/96	16	0.1515
Swiss frank	08/86-09/00	170	0.0113
Turkish lira	05/98-09/00	29	6.0212
average			**0.3463**
managed regimes			
British pound[2]	09/92-09/00	97	0.6341
Canadian dollar	08/86-09/00	170	0.0248
Colombian peso	01/98-09/99	21	-0.4390
Czech koruna[2]	04/98-09/00	30	-0.7044
Malaysian ringgit	03/93-07/97	53	-0.1847
Mexican peso[2]	04/96-09/00	54	-0.2167
New Zealand dollar[2]	02/93-09/00	92	0.3161
Peruvian sol	04/99-09/00	18	-1.8185
Phillipine peso[2]	12/97-04/99	17	-0.6836
Polish zloty[2]	04/98-09/00	30	-0.5776
Singapore dollar	01/88-11/98	131	-0.0392
Singapore dollar[2]	12/98-08/00	21	0.7479
Thai baht[2]	05/98-09/00	29	1.5726
Venezuelan bolivar	03/99-08/00	18	6.4279
average			**0.3614**
difference in means statistic			**0.0180**

[1] N: number of observations

[2] Managed floating regime

Table 6.2b: OLS Estimates of Gap Weight (Bubula and Ötker-Robe Classification)

currency	period	N[1]	Estimates of $\hat{\sigma}$
free floats			
Australian dollar	01/90-09/00	129	0.2423
Brazilian real	01/99-09/00	21	4.2395
British pound	09/92-09/00	97	0.6341
Czech koruna	04/98-09/00	30	-0.7044
Euro	01/99-09/00	21	-0.8979
Hungarian forint	04/98-09/00	30	-0.9483
Indonesian rupee	04/98-09/00	30	0.3618
Korean won	12/97-12/99	25	-1.4914
Mexican peso	12/94-09/00	70	0.0399
New Zealand dollar	02/93-09/00	92	0.3161
Swiss frank	01/90-09/00	129	0.0513
average			**0.1675**
managed regimes			
British pound	10/90-08/92	23	1.3088
Canadian dollar[2]	01/90-08/98	104	0.0599
Colombian peso	01/98-08/99	20	-0.0997
Malaysian ringgit[2]	03/93-06/97	52	-0.2433
Polish zloty	04/98-09/00	30	-0.5776
Singapore dollar[2]	01/90-08/00	128	-0.0592
Thai baht[2]	05/98-09/00	29	1.5726
Turkish lira	05/98-09/00	29	6.0212
Venezuelan bolivar	03/99-08/00	18	6.4279
average			**1.6012**
difference in means statistic			**1.4141** *

[1] N: number of observations

[2] Managed or tightly managed floating regime

* Significant at 10%.

Table 6.2c: OLS Estimates of Gap Weight (Levy-Yeyati and Sturzenegger Classification)

currency	period	N [1]	Estimates of $\hat{\sigma}$
free floats			
Australian dollar	10/86-09/00	168	0.3482
British pound	08/86-09/00	170	0.3093
Canadian dollar	01/87-12/88	24	1.0054
Canadian dollar	01/92-09/00	105	-0.1071
Colombian peso	01/98-08/00	32	-0.1200
Czech koruna	04/98-09/00	30	-0.7044
Euro	01/99-09/00	21	-0.8979
German mark	08/86-09/00	170	-0.1127
Japanese yen	08/86-09/00	170	0.1152
Mexican peso	01/97-09/00	45	0.2277
Peruvian sol	05/98-12/99	20	0.4932
Phillipine peso	01/97-04/99	28	-0.3078
Polish zloty	04/98-09/00	30	-0.5776
Swiss frank	08/86-09/00	170	0.0113
Thai baht	01/99-09/00	21	2.1630
Turkish lira	01/99-09/00	21	5.6372
average			**0.4677**
managed regimes			
Indonesian rupee	01/99-09/00	21	1.1389
Korean won	03/97-12/98	22	-2.6339
Mexican peso	01/95-12/96	24	0.8382
New Zealand dollar[2]	02/93-09/00	92	0.4418
Venezuelan bolivar	03/99-08/00	18	6.4279
average			**1.2426**
difference in means statistic (DIMS)			**0.5123**

[1] N: number of observations

[2] Fixed regime

Table 6.3a: Results from Regressing the Short-Run ADL Estimates of the Gap Weight on the Change in Reserves

Classification	Sample size	Estimate of δ_1
Reinhart and Rogoff	27	0.0116 *
Bubula and Ötker-Robe	25	0.0064
Levy-Yeyati and Sturzenegger	21	0.0125

Table 6.3b: Results from Regressing the Long-Run ADL Estimates of the Gap Weight on the Change in Reserves

Classification	Sample size	Estimate of δ_1
Reinhart and Rogoff	27	-0.0035
Bubula and Ötker-Robe	25	0.0020
Levy-Yeyati and Sturzenegger	21	0.0119

Table 6.3c: Results from Regressing the OLS Estimates of the Gap Weight on the Change in Reserves

Classification	Sample size	Estimate of δ_1
Reinhart and Rogoff	24	0.0148 *
Bubula and Ötker-Robe	20	0.0164 **
Levy-Yeyati and Sturzenegger	22	0.0250 **

Stars indicate significance levels at 1%(***), 5%(**) and 10%(*).

APPENDICES

APPENDIX A

PROSPECT THEORY, ENDOGENOUS PROSPECT THEORY AND UAUIP

In Section 1 I discuss the experimental findings by Kahneman and Tversky (1979) and Tversky and Kahneman (1992) that led them to develop prospect theory as an alternative way to expected utility theory that incorporates how individuals make choices under uncertainty. Here I also touch upon the main differences between prospect theory and expected utility theory. In Section 2, I summarize the main difficulties that a researcher is faced with when trying to apply prospect theory to real world issues and the approaches that extant behavioral-finance economists have proposed. This is followed by the solution to these problems proposed by Frydman and Goldberg, which leads to endogenous prospect theory, discussed in Section 3. In Section 4 I derive UAUIP.

1 Experimental Findings and Prospect Theory

1.1 Experimental Findings

Decision making under risk or uncertainty involves making choices between prospects or gambles. A prospect $(x_1, p_1; ...x_n, p_n)$ is defined as a contract that yields outcome x_i with probability p_i, where $\sum_{i=1}^{N} p_i = 1$. The expected utility theory due to Von Neumann and Morgenstern (1944) postulates that the overall utility of a prospect is the expected utility of its outcomes:

$$EU = \sum_{i=1}^{N} p_i U(x_i) \qquad (1)$$

This expected utility function incorporates the following properties: it is a linear sum of probability-weighted outcomes and it depends on the level of final stakes. With risk aversion, where risk-averse preferences imply that an individual is better off when he replaces an uncertain final wealth by its expected value, the utility function is concave in the level of wealth.

In series of experiments, Kahneman and Tversky (1979) and Tversky and Kahneman (1992) discovered, however, that these characteristics of the expected utility function are constantly refuted. They found that individuals care about the gains and losses, i.e. changes in wealth, rather than the level of their final wealth; that individuals are more sensitive to losses than gains of the same size; and that in choosing among alternatives individuals use decision weights that are not equal to probability weights, rather they are nonlinear functions of probabilities.[1] In light of these findings, they develop prospect theory as an alternative way to model preferences that is consistent with experimental findings on how individuals make choices under uncertainty.[2]

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[1] More on decision weights will follow below.

[2] Expected utility theory is based on ordinal preferences, whereas prospect theory is consistent with rank – dependent preferences. Rank dependence is a generalization of ordinal preferences that explains the observation that individuals can be both risk-loving (lottery tickets) and risk-averse (insurance policies); and the behavior in the Allais paradox. The Allais paradox is related to the observation that individuals overweight outcomes that are considered to be certain relative to probable outcomes, which Kahneman and Tversky (1979) label as the 'certainty effect'.

1.2 Prospect Theory

Prospect theory postulates a value function with three characteristics that summarize the experimental findings by Kahneman and Tversky on how individuals actually choose among gambles with uncertain outcomes. These characteristics of reference dependence, diminishing sensitivity and loss aversion are embodied in the following utility function, which is depicted in Figure A1:[3]

$$V(\Delta W) = \begin{cases} (\Delta W)^{\alpha} & \text{if } \Delta W > 0 \\ -\lambda(-\Delta W)^{\beta} & \text{if } \Delta W < 0 \end{cases} \qquad (2)$$

where ΔW denotes the change in wealth, and α, β and λ are parameters, explained below.

a) Reference dependence

The utility function depends on the *change* in an individual's wealth (gain or loss), relative to some reference point. This is as opposed to the expected utility hypothesis, in which, as mentioned before, the utility function depends on an individual's level of wealth.

b) Diminishing sensitivity

The utility function depends nonlinearly on the magnitudes of gains and losses. More precisely, the marginal value of gains and losses decreases with their size, which implies that the utility function is concave in the domain of gains and convex in the domain of losses, i.e. $\alpha < 1$ and $\beta < 1$. In contrast, expected utility is linear in gains and losses.

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[3] See Tversky and Kahneman (1992).

c) Loss aversion

Individuals are more sensitive to negative changes in their wealth (losses) than to positive changes (gains) of the same size. In Kahneman and Tversky's words, "losses loom larger than corresponding gains." Under the assumption that $\alpha = \beta$, which is used by Tversky and Kahneman (1992) as well as other researchers, loss aversion implies that $\lambda > 1$.

The utility function given in (2) attaches a value to single outcomes. However, to represent an individual's preferences over prospects (or gambles) with different outcomes one needs to arrive at a weighted sum of the utilities of single outcomes comprising a gamble.

In experimental settings Kahneman and Tversky (1979) and Tversky and Kahneman (1992) have asked individuals to choose among M gambles by disclosing the true values of the payoffs and the true probabilities associated with each. Using the utility function given by (2), the *prospective utility* from choosing gamble j is thus given by

$$PU_j = \sum_{k}^{K_j^+} \pi_{j,k} (\Delta W)^\alpha - \lambda \sum_{k}^{K_j^-} \pi_{j,k} (-\Delta W)^\beta \tag{3}$$

where $\pi_{j,k}$ denotes the weights that an individual attaches to the utility of each outcome k, called *decision weights*, K_j^+ is the set of outcomes comprised of potential gains, K_j^- is the set of outcomes comprised of potential losses, and $K_j = K_j^+ + K_j^-$ is the set of potential returns from choosing gamble j.

As opposed to expected utility theory, where the utility of a gamble is expressed as the probability-weighted sum of the utilities of the single outcomes of a gamble, Kahneman and Tversky (1979) present experimental evidence that these decision-weights are nonlinear functions of the true probabilities - individuals tend to overweight small probabilities and underweight moderate and high probabilities (see Figure A2).[4]

2 Issues Concerning the Application of Prospect Theory

As compelling as Kahneman and Tversky's experimental evidence is concerning the properties of their utility function, the application of prospect theory to model both individual behavior and aggregate outcomes in real markets is challenging on two grounds. First, the utility function is nonlinear in gains and losses. With heterogeneous forecasts, this nonlinearity of the utility function leads to aggregation problems. Moreover, as was noted above, Kahneman and Tversky present evidence that decision weights are nonlinear functions of true probabilities. Although Kahneman and Tversky have estimated decision weights from their experiments, they have pointed out that these weights may not be applicable in non-experimental settings, because "[in] the typical situation of choice, where the probabilities of outcomes are not explicitly given[,]...the decision weights may be affected by other considerations, such as ambiguity or vagueness" Kahneman and Tversky (1979: 288-289). Therefore, to formulate a prospective utility of a gamble, an economist also needs to represent decision weights.

As different from experimental settings, however, in the context of the foreign exchange market neither the payoffs associated with each gamble nor the probabilities associated with each payoff are known to market participants. Therefore, in order to

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[4] In laboratory experiments, individuals are asked to choose between gambles with payoffs whose true probabilities are known to them. Therefore, one can infer the difference between decision weights and true probabilities from individuals' choices among the gambles. Tversky and Kahneman (1992) use their experimental data to estimate a nonlinear function relating decision weights to true probabilities.

represent decisions in the foreign exchange market, an economist needs to represent market participants' forecasting strategies and the revisions of these strategies over time. Doing so implies a probability distribution of the potential return on a unit position at time t that is conditional on the structure of this representation and the realizations of any causal variables at time t.

As was discussed in the text, to circumvent the aggregation difficulties posed by the nonlinearity of the utility function in single outcomes, behavioral-finance economists have constrained the marginal value of gains and losses to be constant by setting $\alpha = \beta = 1$.[5] This linear specification of the utility function, however, implies that individuals would want to hold positions of unlimited size whenever they perceive profit opportunities. Thus, to derive a well-defined equilibrium, Barberis and Huang (2001), Barberis, Huang, and Santos (2001), as well as other behavioral-finance economists have relied on risk-averse preferences, despite the rejection of this assumption in the behavioral literature in favor of loss aversion.

Besides constraining Tversky and Kahneman's (1992) utility function to be linear over gains and losses, behavioral-finance economists have also set decision weights equal to probabilities. This has enabled them to formulate prospective utilities as linear functions of the expected prospects implied by their representations of forecasting behavior. However, as Kahneman and Tversky (1979) point out, when the probabilities of outcomes are not explicitly given, the decision weights may be affected by factors that cannot be represented adequately with specific parametric functions of probabilities, such

[5] Schmidt and Zank (2001) use a piece-wise linear utility specification where the utility function is linear in both gains and loses, but steeper in the region of losses. Although this solves the aggregation problem, it does not allow for diminishing sensitivity.

as ambiguity or vagueness.[6] Thus, the practice of replacing decision weights with probabilities does not allow for the possibility that decisions, and thus decision weights and prospects, in real world markets depend on factors such as "ambiguity" and "vagueness" as well as other factors that arise from the imperfection of knowledge.

In sum, these "simplifying" assumptions by behavioral-finance economists disregard key experimental findings concerning individual behavior in uncertain situations.[7]

3 Endogenous Prospect Theory

Kahneman and Tversky (1979) provide experimental evidence indicating that not only is the utility function nonlinear in single outcomes, but that its curvature in the domain of losses may be greater than in the domain of gains.[8] Frydman and Goldberg (2007) note that this implies a positive relationship between the degree of loss aversion and the position size, and they build on this observation to modify Tversky and Kahneman's (1992) utility function in a way that enables them to model limits to speculation on the basis of prospect theory. This alternative formulation of the utility function implies a representation of prospective utilities that is linear in prospects, allowing for aggregation, but nonlinear in the position size, providing limits to speculation. Furthermore, in contrast to other behavioral-finance models, it does not

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[6] See Ellsberg (1961) and Fellner (1965).

[7] See Chapter 9 in Frydman and Goldberg (2007) for a detailed discussion on the problems with the extant behavioral-finance literature.

[8] See Figure A2.

violate any of Kahneman and Tversky's experimental findings on the properties of the utility function for single outcomes.

3.1 The Modified Utility Function

Frydman and Goldberg (2007) propose the following utility function in the context of the foreign exchange market:

$$V(\Delta W)=\begin{cases} (W_t|a_t|)^{\alpha}|\hat{r}^g| & \text{if } \Delta W>0 \\ -\lambda_1(W_t|a_t|)^{\alpha}|\hat{r}^l|-\frac{\lambda_2}{-\hat{\Pi}(\hat{r}^l)}(W_t|a_t|)^{\beta}|\hat{r}^l| & \text{if } \Delta W<0 \end{cases} \tag{4}$$

where $\beta=\alpha+1$, $\lambda_1>1$, $\lambda_2>0$ are constant parameters, and $\hat{\Pi}(\hat{r}^l)$ is the sum of potential losses from a unit position in foreign exchange weighted by the decision weights. Recall that a negative realization of the nominal return on a pure long position in foreign exchange is a loss for a bull while it is a gain for a bear. Thus, the sum of potential losses is given by $\hat{\Pi}(\hat{r}^l)=\sum_k^{K^-}\hat{\pi}^-_{t|t+1,k}\hat{r}^-_{t|t+1,k}$ for a bull and by $\hat{\Pi}(\hat{r}^l)=-\sum_k^{K^-}\hat{\pi}^+_{t|t+1,k}\hat{r}^+_{t|t+1,k}$ for a bear. With this utility function, the degree of loss aversion, which is the ratio of disutility from losses to the utility from gains *of the same magnitude*, becomes

$$\Lambda=\lambda_1+\frac{\lambda_2}{-\hat{\Pi}(\hat{r}^l)}W_t|a_t| \tag{5}$$

where $-\hat{\Pi}(\hat{r}^l)$ serves as a scaling parameter.

As can be seen from equation (5), in this alternative formulation of the utility function, the degree of loss aversion is endogenous as it depends on the position size. The utility function in (4) has the following characteristics:

a) Reference dependence

As with the original formulation of prospect theory, the utility function still depends on the change in an individual's wealth (gain or loss) relative to some reference point.

b) Loss aversion

It is still the case that the disutility from losses exceeds the utility from gains of the same magnitude, that is $\Lambda > 1$, because $\lambda_1 > 1$, $\lambda_2 > 0$ and $-\hat{\Pi}\left(\hat{r}^l\right) > 0$.

Additionally, this modified utility function also displays

c) Endogenous loss aversion

With $\beta > \alpha$, the degree of loss aversion increases with the position size for both gains and losses for bets that involve equal value of gains and losses on a unit position. This is seen by $\frac{d\Lambda}{d|a_t|} > 0$, which states that the degree of loss aversion increases with the unit position size. This characteristic is consistent with the experimental evidence of Kahneman and Tversky indicating that the curvature of the utility function in the domain of losses is greater than in the domain of gains, i.e. $\beta > \alpha$.[9]

[9] See Figure A1.

d) Endogenous sensitivity

The marginal value of both gains and losses decreases with the position size, except for large values of losses, at which point the marginal value of losses increases with the position size. To see this, first note that payoffs of gambles in the foreign exchange model differ only by the unit position size, so that $d\hat{L} = W\hat{r}^l d|a_t|$, where $\hat{L}$ stands for the amount of forecasted losses from a unit position size a_t, and $\frac{dV}{d\hat{L}} = \frac{\partial V}{\partial \hat{L}} \frac{1}{W_t r^l}$. Consequently, it follows that:[10]

$$\frac{d^2V(\Delta W)}{d\hat{L}d(-\hat{L})} = (a)^{\alpha-2}(A + aB) \qquad (6)$$

where $A = -\frac{\alpha(\alpha-1)\lambda_1 W_t^{\alpha-2}}{\hat{r}^l} < 0$ and $B = -\frac{\alpha(\alpha+1)\lambda_2 W_t^{\alpha-1}}{\left(-\hat{\Pi}(\hat{r}^l)\right)^2 \hat{r}^l} > 0$.

The utility function in (4) embodies diminishing sensitivity, i.e. $\frac{d^2V(\Delta W)}{d\hat{L}d(-\hat{L})} < 0$, for small unit position sizes $\left(a_t < \frac{-A}{B}\right)$, and increasing sensitivity, i.e. $\frac{d^2V(\Delta W)}{d\hat{L}d(-\hat{L})} > 0$, for large unit position sizes $\left(a_t > \frac{-A}{B}\right)$. This characteristic is also consistent with experimental evidence: Kahneman and Tversky (1979: 278) state that although smaller gambles are characterized by diminishing sensitivity, for larger gambles individual preferences may be consistent with increasing sensitivity.

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[10] Recall that $\hat{r}^l$ is the forecasted losses for a unit position on foreign exchange.

The prospective utilities implied by the utility function in (4) are given by the following equations for bulls and bears, respectively:

$$PU_t^L = (a_t W_t)^\alpha \left[\hat{\Pi}(\hat{r}) - (1-\lambda_1)\hat{\Pi}(\hat{r}^-)\right] + \lambda_2^2 (a_t W_t)^\beta \hat{\Pi}(\hat{r}^-) \tag{7}$$

$$PU_t^S = (-a_t W_t)^\alpha \left[\hat{\Pi}(\hat{r}) - (1-\lambda_1)\hat{\Pi}(\hat{r}^-)\right] + \lambda_2^2 (a_t W_t)^\beta \hat{\Pi}(-\hat{r}^+) \tag{8}$$

3.2 Utility-Maximizing Position Size

The position size that maximizes the utility function given in (4) is found by differentiating (7) and (8) with respect to a_t and setting the resulting equations equal to 0:

$$a_t^L W_t = \frac{\alpha}{\lambda_2(\alpha+1)}\left[\hat{\Pi}(\hat{r}) - (1-\lambda_1)\hat{\Pi}(\hat{r}^-)\right] \tag{9}$$

$$-a_t^S W_t = \frac{\alpha}{\lambda_2(\alpha+1)}\left[\hat{\Pi}(\hat{r}) - (1-\lambda_1)\hat{\Pi}(-\hat{r}^+)\right] \tag{10}$$

where $a_t^L \geq 0$ is the unit position size for a bull and $a_t^S \leq 0$ is the unit position size for a bear.[11]

In order to examine the implications of these representations for the way market participants revise the size of their speculative positions, and the implications of such revisions for the movements in the exchange rate and the equilibrium premium, the decision weighted sums of prospect realizations have to be related to some causal variables. However, as was discussed earlier, decision weights depend on factors that

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[11] $\hat{\Pi}(\hat{r}) = \sum_k^K \hat{\pi}_{t|t+1,k}\hat{r}_{t|t+1,k}$; $\hat{\Pi}(\hat{r}^-) = \sum_k^{K^-} \hat{\pi}_{t|t+1,k}\hat{r}^-_{t|t+1,k}$; $\hat{\Pi}(-\hat{r}^+) = -\sum_k^{K^-} \hat{\pi}_{t|t+1,k}\hat{r}^+_{t|t+1,k}$.

cannot be represented adequately with specific parametric functions of probabilities. Frydman and Goldberg (2007, Ch.9, Pg.24) argue that "in representing behavior, economist should not presume that he could fully prespecify the way individuals make and revise their decisions." Consequently, to model preferences over gambles with uncertain outcomes, Frydman and Goldberg replace the decision-weighted sums of prospective utilities with the IKE representations of an individual's forecasts.[12]

Replacing the decision-weighted sums $\hat{\Pi}(\hat{r})$ and $\hat{\Pi}(\hat{r}^{l})$ with the IKE representations of an individual's forecasts of return and loss, $\hat{r}_{t|t+1}^{IKE}$ and $\hat{l}_{t|t+1}^{IKE}$, respectively, and substituting $\lambda_3 = \dfrac{\lambda_2(1+\alpha)}{\alpha}$, the utility-maximizing position size can be written as:[13]

$$a_t^L W_t = \frac{1}{\lambda_3}\left[\hat{r}_{t|t+1}^{L,IKE} - (1-\lambda_1)\hat{l}_{t|t+1}^{L,IKE}\right] \tag{11}$$

$$-a_t^S W_t = \frac{1}{\lambda_3}\left[\hat{r}_{t|t+1}^{S,IKE} - (1-\lambda_1)\hat{l}_{t|t+1}^{S,IKE}\right] \tag{12}$$

4 Uncertainty Adjusted Uncovered Interest Parity (UAUIP)

Using endogenous prospect theory to model preferences and IKE representations of forecasts lead to a new equilibrium condition in the foreign change market – UAUIP.

Momentary equilibrium in the foreign exchange market is defined as the balance between the supply of and demand for foreign exchange. In deriving the condition for momentary equilibrium, Frydman and Goldberg (2007) assume that:

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[12] A more detailed discussion on the IKE representations of a forecast is beyond the scope of this thesis. The interested reader should refer to Frydman and Goldberg (2007).

[13] Note that, in the discussions in Chapter 3, the IKE subscript has been omitted.

1) Equilibrium in both the domestic and foreign money markets is determined independently of the spot-rate determination process and the level of wealth. This assumption allows one to model equilibrium in the foreign exchange market in terms of domestic (foreign) individuals' decisions on how to divide their non-monetary wealth between the safe, A (B), bonds and the risky, B (A), bonds.
2) Domestic (foreign) money is held only by domestic (foreign) wealth holders. This assumption ensures that whenever a domestic (foreign) individual changes his holdings of B (A) bonds, which are sold only in B (A) currency, he will buy or sell foreign (domestic) currency.

With these assumptions, momentary equilibrium in the foreign exchange market can be expressed as

$$\sum_i \left(B_t^{d^i} - B_t^i \right) = B_t^d - B_t = 0 \tag{13}$$

where $B_t^{d^i}$ denotes an individual's demand for B bonds at time t, B_t^i denotes his holdings of B bonds at time t, and B_t^d and B_t stand for the aggregate demand for and supply of B bonds at time t, respectively. In each period t, an individual decides how much of his monetary wealth he wants to hold in B bonds. If this demand is greater (less) that the B bonds he currently holds, he will purchase (sell) foreign exchange in the amount of $\left(B_t^{d^i} - B_t^i \right)$. In equilibrium, the sum of individual demands and supplies of foreign exchange equals zero.

The optimal position size for the bulls and bears in country A was derived in Section 3.2, given by equations (11) and (12). Similarly, for country-B wealth holders:[14]

$$\left(a_t^L - 1\right)W_t = \frac{1}{\lambda_3}\left[\hat{r}_{t|t+1}^{L,IKE} - \left(1-\lambda_1\right)\hat{i}_{t|t+1}^{L,IKE}\right] \tag{14}$$

$$-\left(a_t^S - 1\right)W_t = \frac{1}{\lambda_3}\left[\hat{r}_{t|t+1}^{S,IKE} - \left(1-\lambda_1\right)\hat{i}_{t|t+1}^{S,IKE}\right] \tag{15}$$

where $\left(a_t^L - 1\right) \geq 0$ and $\left(a_t^S - 1\right) \leq 0$.[15]

Substituting the optimal position sizes for country-A and country-B wealth holders into the momentary equilibrium condition in (13) by taking into account the decision rule outlined in Chapter 3, Section 3.2.3, which implies that an individual will take a long (short) position if she expects a positive excess return from holding foreign (domestic) assets, and stay out of the market otherwise, and assigning equal wealth shares (1/2) to bulls and bears, we get:

$$\begin{aligned} \frac{1}{2}\left(\hat{r}_{t|t+1}^{L} - \hat{r}_{t|t+1}^{S}\right) = \frac{1}{2}\left(1-\lambda_1\right)\left(\hat{i}_{t|t+1}^{L} - \hat{i}_{t|t+1}^{S}\right) + \sum_i^{N_t^L}\left[I_t^i\left(\frac{\lambda_2 W_t^i}{W_t^M}\right) - \frac{\lambda_2 B_t^i}{W_t^M}\right] \\ + \sum_i^{N_t^S}\left[I_t^i\left(\frac{\lambda_2 W_t^i}{W_t^M}\right) - \frac{\lambda_2 B_t^i}{W_t^M}\right] + \sum_i^{N_t^0}\left[I_t^i\left(\frac{\lambda_2 W_t^i}{W_t^M}\right) - \frac{\lambda_2 B_t^i}{W_t^M}\right] \end{aligned} \tag{16}$$

where N_t^L, N_t^S and N_t^0 denote the number of individuals taking long, short and no positions in foreign exchange, respectively;[16] I_t^i is an indicator variable that equals 1 (0)

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[14] An individual from country B holds a long position in foreign exchange when she holds B bonds in excess of her total wealth, $\left(a_t^i - 1\right) > 0$, and a short position when she holds A bonds, $\left(a_t^i - 1\right) < 0$.

[15] The degree of loss aversion for bulls and bears is assumed to be the same. In Chapter 11, Frydman and Goldberg (2007) consider the house-money effect of Thaler and Johnson (1990) where individuals become less (more) loss averse when they incur gains (losses).

if individual i is from country A (B), $W_t^M = \sum_i^{N_t^L+N_t^S} W_t^i$ denotes the real wealth of all individuals that take open positions at time t, and, for convenience, domestic and foreign price levels at time t are set to equal one.

Equation (16) can be rewritten as an equality between the aggregate forecast of the return on foreign exchange and the market premium where the market premium depends on the aggregate uncertainty premium, which is the UAUIP:

$$\hat{r}_{t|t+1} = \widehat{pr}_{t|t+1} \tag{17}$$

where

$$\hat{r}_{t|t+1} = \frac{1}{2}\left(\hat{r}^L_{t|t+1} - \hat{r}^S_{t|t+1}\right) \tag{18}$$

$$\widehat{pr}_{t|t+1} = \widehat{up}_{t|t+1} + \lambda_3 IFP_t \tag{19}$$

$$\widehat{up}_{t|t+1} = \frac{1}{2}\left(\widehat{up}^L_{t|t+1} - \widehat{up}^S_{t|t+1}\right) = \frac{1}{2}(1-\lambda_1)\left(\hat{i}^L_{t|t+1} - \hat{i}^S_{t|t+1}\right) \tag{20}$$

$$IFP_t = \frac{B_t^A - A_t^B / s_t}{W_t} \tag{21}$$

---

[16] Note that the N_t^0 individuals that decide to stay out of the market will set $a = 0$ if they are from country A, and $a = 1$ if they are from country B. These individuals are included in the equation because they might be holding A or B bonds when they enter period t.

Figure A1: The Value Function in Prospect Theory

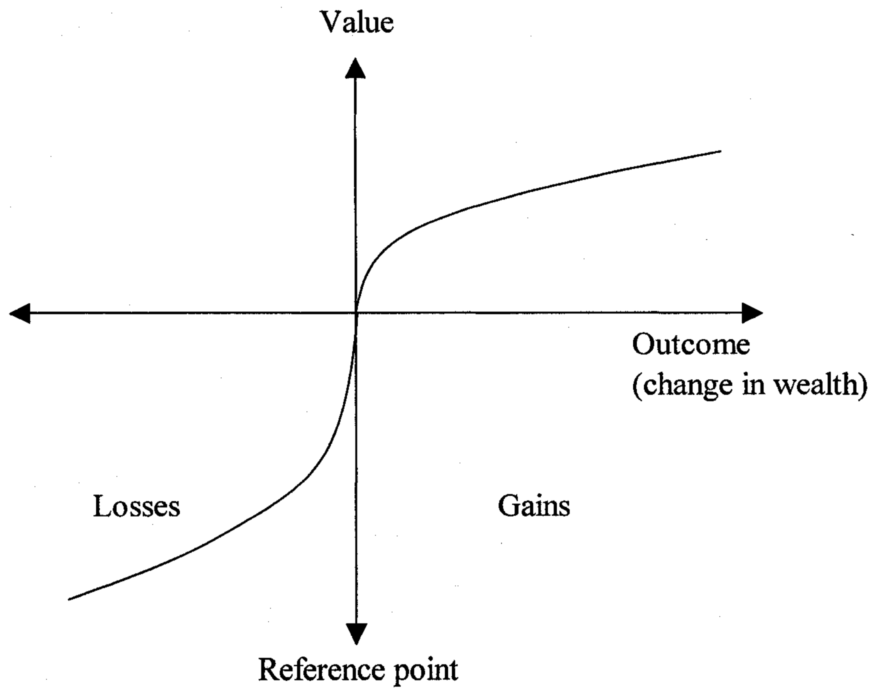
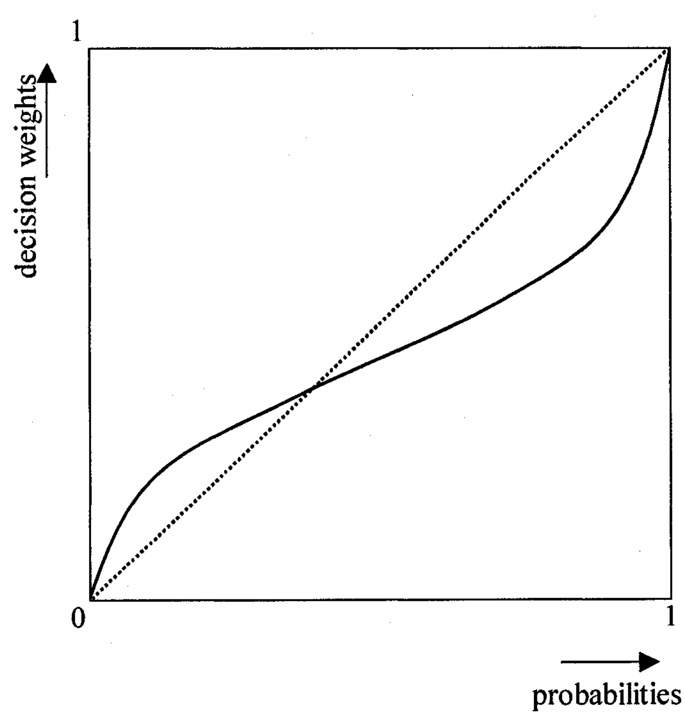


Figure A2: Nonlinear Relationship Between Probabilities and Decision Weights



APPENDIX B

CURRENT SURVEY PARTICIPANTS IN THE CONSENSUS FORECASTS DATABASE

ABN AMRO
Allied Irish Bank
ANZ Bank
Banca Intesa
Bank of America
Bank of New York
Bank of Tokyo - Mitsubishi
Bank One
BBVA
BMO Nesbitt Burns
BNP Paribas
Citigroup
Commerzbank
Credit Agricola Indosuez
Credit Suisse – First Boston
Daiwa Securities
Danske Bank
Deutsche Bank
Dresdner Bank
Dresdner Kleinwert Wasserstein
Fortis
Goldman Sachs
Grupo Santander
HSBC
HVB Group, Munich
ING Bank
JP Morgan Chase
Macquarie Bank
Mellon
Merrill Lynch
Mizuho Bank
National Australia Bank
Nordea
Rabobank
Royal Bank of Canada

Royal Bank of Scotland
Scotia Bank
Societe Generale
Standard Chartered
Suntrust
Toronto Dominion
UBS Warburg
Wachovia
West LB Dusseldorf
Westpac

APPENDIX C

THE ADL MODEL WITH TWO AND THREE LAGS

1 ADL of Order Two

The ADL model of order two is given by:

$$\widehat{pr}_t = b_0 + b_{11}\widehat{pr}_{t-1} + b_{12}\widehat{pr}_{t-2} + b_{20}\widehat{gap}_t + b_{21}\widehat{gap}_{t-1} + b_{22}\widehat{gap}_{t-2} + \varepsilon_t \qquad (1)$$

Equation (1) can also be written in an error-correction form, which is achieved by subtracting $\widehat{pr}_{t-1}$ from both sides, and adding the following term to the right side and rearranging:

$$\left[(b_{11}-1)\widehat{pr}_{t-2} - (b_{11}-1)\widehat{pr}_{t-2}\right] + \left[b_{20}\widehat{gap}_{t-1} - b_{20}\widehat{gap}_{t-1}\right] + \left[(b_{21}+b_{20})\widehat{gap}_{t-2} - (b_{21}+b_{20})\widehat{gap}_{t-2}\right]:$$

$$\Delta\widehat{pr}_t = \alpha_0 + \alpha_1\Delta\widehat{pr}_{t-1} + \alpha_{20}\Delta\widehat{gap}_t + \alpha_{21}\Delta\widehat{gap}_{t-1} + \alpha_3 ECT_{t-2} + \varepsilon_t \qquad (2)$$

where the error correction term (ECT) is given by:

$$ECT_{t-2} = \beta_1\widehat{gap}_{t-2} + \beta_0 - \widehat{pr}_{t-2} \qquad (3)$$

and $\alpha_0 = b_0 - (1 - b_{11} - b_{12})\beta_0$, $\alpha_1 = (b_{11} - 1)$, $\alpha_{20} = b_{20}$, $\alpha_{21} = (b_{20} + b_{21})$, $\alpha_3 = (1 - b_{11} - b_{12})$, $\beta_1 = \dfrac{b_{20} + b_{21} + b_{22}}{1 - b_{11} - b_{12}}$.

Here, in addition to the two steps outlined in the text, we need to solve for the static solution to capture the total effect of the gap on the premium:[1]

$$\Delta\widehat{pr}_t = \gamma_0 + \gamma_1 \Delta\widehat{gap}_t + \gamma_2 ECT_{t-2} + \varepsilon_t \qquad (4)^2$$

where $\gamma_0 = \frac{\alpha_0}{1-\alpha_1}$, $\gamma_1 = \frac{\alpha_{20}+\alpha_{21}}{1-\alpha_1}$ and $\gamma_2 = \frac{\alpha_3}{1-\alpha_1}$.

In the context of an ADL of order two, the premium model predicts that $\gamma_1 > 0$ and $\beta_1 > 0$.

2 ADL of Order Three

The ADL model of order three is derived similarly to an ADL (2). The ADL (3) is given by:

$$\widehat{pr}_t = b_0 + b_{11}\widehat{pr}_{t-1} + b_{12}\widehat{pr}_{t-2} + b_{13}\widehat{pr}_{t-3} + b_{20}\widehat{gap}_t + b_{21}\widehat{gap}_{t-1} + b_{22}\widehat{gap}_{t-2} + b_{23}\widehat{gap}_{t-3} + \varepsilon_t$$

(5)

Similarly, equation (5) can be written in an error-correction form as follows:

$$\Delta\widehat{pr}_t = \alpha_0 + \alpha_{11}\Delta\widehat{pr}_{t-1} + \alpha_{12}\Delta\widehat{pr}_{t-2} + \alpha_{20}\Delta\widehat{gap}_t + \alpha_{21}\Delta\widehat{gap}_{t-1} + \alpha_{22}\Delta\widehat{gap}_{t-2} + \alpha_3 ECT_{t-3} + \varepsilon_t$$

(6)

where the error correction term (ECT) is given by:

$$ECT_{t-3} = \beta_1 \widehat{gap}_{t-3} + \beta_0 - \widehat{pr}_{t-3} \qquad (7)$$

---

[1] Obtained by setting $\Delta\widehat{pr}_t = \Delta\widehat{pr}_{t-1}$ and $\Delta\widehat{gap}_t = \Delta\widehat{gap}_{t-1}$.

[2] Note that in this case the γ_1 and γ_2 here correspond to the α_1 and α_2 in the text.

and $\alpha_0 = b_0 - (1 - b_{11} - b_{12} - b_{13})\beta_0$, $\alpha_{11} = (b_{11} - 1)$, $\alpha_{12} = (b_{12} + b_{11} - 1)$, $\alpha_{20} = b_{20}$, $\alpha_{21} = (b_{20} + b_{21})$, $\alpha_{22} = (b_{20} + b_{21} + b_{22})$, $\alpha_3 = (1 - b_{11} - b_{12} - b_{13})$, $\beta_1 = \dfrac{b_{20} + b_{21} + b_{22} + b_{23}}{1 - b_{11} - b_{12} - b_{13}}$.

Solving for the static solution we get:

$$\Delta \widehat{pr}_t = \gamma_0 + \gamma_1 \Delta \widehat{gap}_t + \gamma_2 ECT_{t-3} + \varepsilon_t \qquad (8)$$

where $\gamma_0 = \dfrac{\alpha_0}{1 - \alpha_{11} - \alpha_{12}}$, $\gamma_1 = \dfrac{\alpha_{20} + \alpha_{21} + \alpha_{22}}{1 - \alpha_{11} - \alpha_{12}}$ and $\gamma_2 = \dfrac{\alpha_3}{1 - \alpha_{11} - \alpha_{12}}$.

Similarly, in the context of an ADL of order three, the premium model predicts that $\gamma_1 > 0$ and $\beta_1 > 0$.

LIST OF REFERENCES

Adam, M. C. and Ariane Szafarz (1992), "Speculative Bubbles and Financial Markets," *Oxford Economic Papers*, 44, 626-640.

Allen, Helen and Mark P. Taylor (1990), "Charts, Noise and Fundamentals in the London Foreign Exchange Market", *Economic Journal*, 100, 49-59.

Amato, Jeffery D., Morris, Stephen and Hyun Song Shin (2003), "Communication and Monetary Policy", Cowles Foundation Discussion Paper No. 1405, Yale University.

Andersen, Torben G., Tim Bollerslev, Francis X. Diebold and Clara Vega (2003), "Micro Effects of Macro Announcements: Real-Time Price Discovery in Foreign Exchange," *American Economic Review*, 71, 579-625.

Backus, David (1984), "Empirical Models of the Exchange Rate: Separating the Wheat From the Chaff," *Canadian Journal of Economics*, 17, 824-846.

Barberis, Nicolas C. and Ming Huang (2001), "Mental Accounting, Loss Aversion, and Individual Stock Returns," *Journal of Finance*, 56 (4), 1247-1292.

Barberis, Nicolas C., Huang, Ming and Tano Santos (2001), "Prospect Theory and Asset Prices," *Quarterly Journal of Economics*, 116 (1), 1-53.

Barberis, Nicholas C. and Richard H. Thaler (2003), "A Survey of Behavioral Finance," in Constantinides, George, Harris, Milton and Rene Stulz (eds.), *Handbook of the Economics of Finance*, Amsterdam: North-Holland.

Beine, Michel, Benassy-Quere, Agnes and Christelle Lecourt (2002), "Central Bank Intervention and Foreign Exchange Rates: New Evidence from FIGARCH Estimations", *Journal of International Money and Finance*, 21, 115-144.

Bergsten, C. Fred and John Williamson (1983), "Exchange Rates and Trade Policy", in Cline, William R. (eds), *Trade Policy in the 1980s*, Institute for International Economics: Washington, DC, 99-120.

Bernanke, Ben S. (2004), *Fedspeak*, Address to the American Economic Association Meetings, San Diego, 3 January 2004.

Bilson, John. F.O. (1978), "The Monetary Approach to the Exchange Rate: Some Empirical Evidence," International Monetary Fund Sta. Papers, 25 (March), 48-75.

Bisignano, Joseph and Kevin Hoover (1982), "Some Suggested Improvements to a Simple Portfolio Balance Model of Exchange Rate Determination with Special Reference to the U.S. Dollar/Canadian Dollar Rate", *Weltwirtschaftliches Archiv*, 118 (1), 19-38.

Blanchard, Olivier J. and Mark W. Watson (1982), "Bubbles, Rational Expectations and Speculative Markets", in P. Wachtel (ed.), *Crisis in Economic and Financial Structure: Bubbles, Bursts, and Shocks*, Lexington Books: Lexington.

Blinder, Alan S. (1998), *Central Banking in Theory and Practice*, MIT Press: Cambridge, Massachusetts.

Bofinger, Peter and Timo Wollmershäuser (2001), " Managed Floating: Understanding the New International Monetary Order", Würzburg Economic Papers, No.30

Branson, William H. (1977), "Asset Prices and Relative Prices in Exchange Rate Determination" *Sozialwissenschaftliche Annalen, 1*, 69-89.

Brock, William and Cars H. Hommes (1998), "Heterogeneous Beliefs and Routes to Chaos in a Simple Asset Pricing Model," *Journal of Economic Dynamics and Control*, 22 (8-9), 1235-1274.

Brock, William and Cars H. Hommes (1999), "Rational Animal Spirits", in P. Herings, V. Laan and A. Talman (eds.), *The Theory of Markets*, North-Holland: Amsterdam.

Bubula, Andrea and Inci Ötker-Robe (2002), "The Evolution of Exchange Rate Regimes Since 1990: Evidence from De Facto Policies", IMF Working Paper No.155.

Calvo, Guillermo and Carmen Reinhart (2002), "Fear of Floating", *Quarterly Journal of Economics*, 117 (2), 379-408.

Cheung, Yin-Wong and Menzie D. Chinn (2001), "Currency Traders and Exchange Rate Dynamics: A Survey of the U.S. Market" *Journal of International Money and Finance*, 20 (4), 439-471.

Cheung, Yin-Wong, Menzie D. Chinn and Ian W. Marsch (2004), "How Do UK-Based Foreign Exchange Dealers Think Their Market Operates?" *International Journal of Finance and Economics*, 9 (4), 289-306.

Cheung, Yin-Wong and Kon S. Lai (1993), "A Fractional Cointegration Analysis of Purchasing Power Parity", *Journal of Business and Economic Studies*, 11, 103-112.

Corbae, Dean and Sam Oiliaris (1988), "Cointegration and Tests of Purchasing Power Parity", *Review of Economics and Statistics*, 70, 508-511.

Danker, Deborah J., Richard A. Haas, Dale W. Henderson, Steven A. Symansky, and Ralph W. Tryon (1987), "Small Empirical Models of Exchange Market Interventions: Applications to Germany, Japan and Canada", *Journal of Policy Modeling*, 9, 143-173.

Davidson, Paul (1982), *International Money and the Real World*, John Wiley and Sons: New York.

De Grauwe, Paul and Marianna Grimaldi (2005a), "Heterogeneity of Agents, Transactions Costs and the Exchange Rate," *Journal of Economic Dynamics and Control*, 29 (4), 691-719.

De Grauwe, Paul and Marianna Grimaldi (2005b), "The Exchange Rate and its Fundamentals in a Complex World," *Review of International Economics*, 13 (3), 549-575.

De Grauwe, Paul and Marianna Grimaldi (2006), "Exchange Rate Puzzles: A Tale of Switching Attractors," *European Economic Review*, 50 (1), 1-33.

DeLong, Bradford J., Shleifer, Andrei, Summers, Lawrence H. and Robert J. Waldman (1990a), "Noise Trader Risk in Financial Markets," *Journal of Political Economy*, 98, 703-738.

DeLong, Bradford J., Shleifer, Andrei, Summers, Lawrence H. and Robert J.Waldman (1990b), "Positive Feedback Investment Strategies and Destabilizing Rational Speculation," *Journal of Finance*, 45, 375-395.

Domac, Ilker and Alfonso Mendoza (2004), "Is There Room for Forex Intervention under Inflation Targeting Framework? Evidence from Mexico and Turkey", The World Bank, Policy Research Working Paper Series No. 3288.

Dominguez, Kathryn M. (2003), "Foreign Exchange Intervention: Did It Work in the 1990s?", in J. Williamson and C.F. Bergsten (eds.), *Dollar Overvaluation and the World Economy*, Institute for International Economics: Washington DC.

Dominguez, Kathryn M. and J.A. Frankel (1993a), "Does Foreign Exchange Intervention Matter? The Portfolio Effect", *American Economic Review*, 83(5), 1356-1369.

Dominguez, Kathryn M. and Jeffrey A. Frankel (1993b), *Does Foreign Exchange Intervention Work?*, Institute for International Economics: Washington DC.

Dominguez, Kathryn M. and J.A. Frankel (1993c), "Foreign Exchange Intervention: An Empirical Assessment", in Frankel, Jeffrey A. (ed.), *On Exchange Rates*, MIT Press: Cambridge, Massachusetts.

Dornbusch, Rudiger (1976), "Expectations and Exchange Rate Dynamics", *Journal of Political Economy*, 84, 1161-1174.

Dornbusch, Rudiger (1980), "Exchange Rate Economics: Where do we Stand?," *Brookings Papers on Economic Activity*, 1, 143-94; reprinted in Eijffinger, Sylvester C.W. (ed.), *Foreign exchange intervention: Objectives and Effectiveness*, 1998, 70-112, Elgar Reference Collection. International Library of Critical Writings in Economics, vol. 98. Cheltenham, U.K. and Northampton, Mass.: Elgar; distributed by American International Distribution Corporation, Williston, Vt.,

Dornbusch, Rudiger (1983), "Exchange Rate Risk and the Macroeconomics of Exchange Rate Determination," in R. Hawkins, R. Levich and C. G. Wihlborg (eds.), The Internationalization of Financial Markets and National Economic Policy, Vol. 3, Greenwich, CT: JAI Press, 3-27.

Dornbusch, Rudiger (1989), "Real Exchange Rates and Macroeconomics: A Selective Survey," *Scandinavian Journal of Economics*, 91 (2), 401-32.

Dornbusch, Rudiger and Jeffrey A. Frankel (1988), "The Flexible Exchange Rate System: Experience and Alternatives," in S. Borner, ed., *International Finance and Trade*, London: Macmillan, reprinted in Jeffrey A. Frankel ed., *On Exchange Rates*, Cambridge MA: The MIT Press, chapter 1,1995.

Edison, Hali J. (1993), "The Effectiveness of Central Bank Intervention: A Survey of the Literature After 1982", Princeton University International Finance Section, Special Papers in International Economics No.18.

Edison, Hali J. (1997), "The Reaction of Exchange Rates and Interest Rates to News Releases", *International Journal of Finance and Economics*, 2, 87-100.

Edison, Hali J. and Jan Tore Klovland (1987), "A Quantitative Reassessment of the Purchasing Power Parity Hypothesis: Evidence from Norway and the United Kingdom", *Journal of Applied Econometrics*, 2, 309-333.

Ellsberg, Daniel (1961), "Risk, Ambiguity and the Savage Axioms", *Quarterly Journal of Economics*, 75, 643-669; reprinted in *Classics in Risk Management*, Vol.2, 2004, 523-49, Elgar Reference Collection. Cheltenham, U.K. and Northampton, Mass.: Elgar

Evans, George (1986), "A Test for Speculative Bubbles in the Sterling-Dollar Exchange Rate: 1981-84," *American Economic Review*, 76 (4), 621-36.

Fatum, Rasmus and Michael M. Hutchison (1999), "Is Intervention a Signal of Future Monetary Policy? Evidence from the Federal Funds Futures Market", *Journal of Money, Credit and Banking*, 31 (1), 54-69.

Fatum, Rasmus and Michael M. Hutchison (2003), "Is Sterilised Foreign Exchange Intervention Effective After All? An Event Study Approach", *The Economic Journal*, 113, 390-411.

Fatum, Rasmus and Michael M. Hutchison (2006), "Effectiveness of Official Daily Foreign Exchange Market Intervention Operations in Japan", *Journal of International Money and Finnace*, 25, 199-219.

Fellner, William (1965), *Probability and Profit-A study of Economic Behavior Along Bayesian Lines*, Homewood, Il.: Richard D. Irwin.

Frankel, Jeffrey A. (1979), "On the Mark: A Theory of Floating Exchange Rate Based on Real Interest Differentials", *American Economic Review*, 69, 610-622.

Frankel, Jeffrey A. (1982a), "A Test of Perfect Substitutability in the Foreign Exchange Market", *Southern Economic Journal*, 49 (October), 406-416.

Frankel, Jeffrey A. (1982b), "In Search of the Exchange Risk Premium: A Six Currency Test Assuming Mean-Variance Optimization", *Journal of International Money and Finance*, 1 (December), 255-274.

Frankel, Jeffrey A. (1984), "Tests of Monetary and Portfolio Balance Models of Exchange Rate Determination," in J. Bilson and R. Marston, eds., *Exchange Rate Theory and Practice*, Chicago: University of Chicago Press.

Frankel, Jeffrey A. (1985), "The Dazzling Dollar," *Brookings Papers on Economic Activity*, 1, 190-217.

Frankel, Jeffrey A. and Charles M. Engel (1984), "Do Asset Demand Functions Optimize Over the Mean and Variance of Real Returns? A Six-Currency Test", *Journal of International Economics*, 17 (November), 309-323.

Frankel Jeffrey A. and Kenneth A. Froot (1986), "Understanding the U.S. Dollar in the Eighties: The Expectations of Chartists and Fundamentalists", *Economic Record*, Dec., 24-38, reprinted in J.A. Frankel (ed.), *On Exchange Rates*, The MIT Press: Cambridge, Massachusetts, 1995, 295-316.

Frankel, Jeffrey and Andrew K. Rose (1995), "Empirical Research on Nominal Exchange Rates," in G. Grossman and K. Rogoff (eds.), *Handbook of International Economics*, Vol. III, Amsterdam: North-Holland, 1689-1729.

Fratzscher, Marcel (2004), "Communication and Exchange Rate Policy", European Central Bank Working Paper Series No.363.

Fratzscher, Marcel (2005), "How Successful are Exchange Rate Communication and Interventions? Evidence from Time Series and Event Study Approaches", European Central Bank Working Paper Series No.528.

Frenkel, Jacob A. (1976), "A Monetary Approach to the Exchange Rate: Doctrinal Aspects and Empirical Evidence," *Scandinavian Journal of Economics*, 78, 200-224.

Frenkel, Jacob A. (1981), "Flexible Exchange Rates, Prices and the Role of 'News'", *Journal of Political Economy*, 89 (4), 665-705.

Frydman, Roman and Michael D. Goldberg (2004),"Limiting Exchange Rate Swings in a World of Imperfect Knowledge", in Peter Sorensen (ed.), *European Monetary Integration: Historical Perspectives and Prospects for the Future. Essays in Honour of Niels Thygesen.* Copenhagen: DJOEF Publishing.

Frydman, Roman and Michael D. Goldberg (2007), *Imperfect Knowledge Economics: Exchange Rates and Risk*, Princeton University Press, forthcoming.

Galati, Gabriele and William Melick (1999), "Perceived Central Bank Intervention and Market Expectations: An Empirical Study of the Yen/Dollar, 1993-96", BIS Working Paper No.77.

Galati, Gabriele, William Melick and Marian Micu (2005), "Foreign Exchange Market Intervention and Expectations: The Yen/Dollar Exchange Rate", *Journal of International Money and Finance*, 24 (6), 982-1011.

Ghosh, Asim R. (1992), "Is It Signalling? Exchange Rate Intervention and the Dollar-Deutschemark Rate", *Journal of International Economics*, 32, 201-220.

Goodhart, Charles (1988), "The Foreign Exchange Market: A Random Walk with a Dragging Anchor," *Economica*, 55, 437-460.

Guimarães, Roberto F. and Cem Karacadag (2004), "The Empirics of Foreign Exchange Intervention in Emerging Market Countries: The Cases of Mexico and Turkey", IMF Working Paper No. 123.

Harvey, John T. (1991), "A Post Keynesian View of Exchange Rate Determination", *Journal of Post Keynesian Economics*, 14 (1), 61-71.

Harvey, John T. (1993), "Daily Exchange Rate Variance", *Journal of Post Keynesian Economics*, 15 (4), 515-540.

Harvey, John T. (1999), "Exchange Rates", *The Encyclopedia of Political Economy,* Philip O'Hara, eds., Routledge: London, 302-304.

Helpman, Elhanan (1981), "An Exploration of the Theory of Exchange Rate Regimes," *Journal of Political Economy*, 89 (5), 865-90.

Hendry, David F. and Katarina Juselius (2000), "Explaining Cointegration Analysis: Part I", *Energy Journal*, 21 (1), 1-42.

Humpage, Owen F. (1988), "On the Effectiveness of Exchange-Market Intervention", Federal Reserve Bank of Cleveland.

Humpage, Owen F. (1999), "US Intervention: Assessing the Probability of Success", *Journal of Money, Credit and Banking*, 31 (4), 732-747.

International Monetary Fund (2003), "Exchange Arrangements and Foreign Exchange Markets: Developments and Issues", World Economic and Financial Surveys, IMF: Washington, DC.

Ito, Takashi (2003), "Is Foreign Exchange Intervention Effective? The Japanese Experiences in the 1990s", Essays in honour of Charles Goodhart. Volume 2. *Monetary History, Exchange Rates and Financial Markets*, 2003, pp. 126-53, Elgar, Cheltenham, U.K. and Northampton, Mass.

Kahneman, Daniel and Amos Tversky (1979), "Prospect Theory: An Analysis of Decision Under Risk", *Econometrica*, 47, 263-291.

Kaminsky, Graciela L. and Karen K. Lewis (1996), "Does Foreign Exchange Intervention Signal Future Monetary Policy?", *Journal of Monetary Economics*, 37 (2), 285-312.

Kearney, Colm and Ronald MacDonald (1986), "Intervention and Sterilization under Floating Exchange Rates: The UK 1973-1983", *European Economic Review*, 30, 345-364.

Keynes, John M. (1936), *The General Theory of Employment, Interest and Money*, Harcourt, Brace and World: New York.

Kim, Yoonbai (1990), "Purchasing Power Parity in the Long Run: A Cointegration Approach", *Journal of Money, Credit and Banking*, 22, 491-503.

Kouri, Penty J.K. (1976), "The Exchange Rate and the Balance of Payments in the Short Run and the Long Run", *Scandinavian Journal of Economics*, 78, 280-304.

Krause, Laurence A. (1991), *Speculation and the Dollar: The Political Economy of Exchange Rates*, Westview Press: Boulder, Colorado.

Krugman, Paul R. (1986), "Is the Strong Dollar Sustainable?," *National Bureau of Economic Research*, Working Paper No. 1644.

Krugman, Paul (1991), "Target Zones and Exchange Rate Dynamics", *Quarterly Journal of Economics*, 106 (3), 669-682.

Krugman, Paul and Marcus Miller (1992), *Exchange Rate Targets and Currency Bands*, Cambridge University Press: Cambridge.

Krugman, Paul and Marcus Miller (1993), "Why Have a Target Zone?", *Carnegie-Rochester Conference Series on Public Policy*, 38, 279-314.

Kubelec, Christopher (2004a), “FOREX Trading Strategies and the Efficiency of Sterilized Intervention”, mimeo.

Kubelec, Christopher (2004b), “Intervention When Exchange Rate Misalignments Are Large”, in C.F. Bergsten and J. Williamson (eds.), *Dollar Adjustment: How Far? Against What?*, Special Report 17, Institute for International Economics: Washington DC.

Levy-Yeyati, Eduardo and Frederico Sturzenegger (2002), “Classifying Exchange Rate Regimes: Deeds vs. Words”, *European Economic Review*, 49 (6), 1603-1635.

Lewis, Karen K. (1988), “Testing the Portfolio Balance Model: A Multilateral Approach”, *Journal of International Economics*, 24 (1/2), February, 109-127.

Lewis, Karen K. (1995), “Are Foreign Exchange Intervention and Monetary Policy Related and Does It Really Matter?”, *Journal of Business*, 68 (2), 185-214.

Loopesko, Bonnie E. (1984), “Relationships Among Exchange Rates, Intervention, and Interest Rates: An Empirical Investigation”, *Journal of International Money and Finance*, 3, December, 257-277.

Lothian, James R. and Mark P. Taylor (1996), “Real Exchange Rate Behavior: The Recent Float from the Perspective of the Past Two Centuries”, *Journal of Political Economy*, 104, 488-510.

Lucas, Robert E. Jr. (1982), "Interest Rates and Currency Prices in a Two-Country World," *Journal of Monetary Economics*, 10 (November), 335-59.

Maier, Rolf (2005), “Exchange Rate Regimes and Pro-Poor Growth”, EconWPA.

Meese, Richard A. (1986), “Testing for Bubbles in Exchange Markets: A Case of Sparkling Rates?”, *Journal of Political Economy*, 94 (2), 345-373.

Meese, Richard A. and Kenneth Rogoff (1983), “Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample?,” *Journal of International Economics*, 14 (February), 3-24.

Meese, Richard A. and Kenneth Rogoff (1988), “Was it Real? The Exchange Rate-Interest Differential Relation Over the Modern Floating-Rate Period,“ *Journal of Finance*, 43 (September), 993-948.

Meese, Richard A. and Andrew K. Rose (1991), “An Empirical Assessment of Non-Linearities in Models of Exchange Rate Determination,” *Review of Economic Studies*, 58, 603-19.

Morris, Stephan and Hyun Song Shin (2002), “Social Value of Public Information”, *American Economic Review*, 92 (5), 1521-1534.

Mussa, Michael (1981), *The Role of Official Intervention*, Occasional Papers No. 6, The Group of Thirty, New York, NY.

Neely, Christopher J. (2000a), "Are Changes in Foreign Exchange Reserves Well Correlated with Official Intervention?", *Federal Reserve Bank of St. Louis Review*, 82 (5), 17-31.

Neely, Christopher J. (2000b), "The Practice of Central Bank Intervention: Looking Under the Hood", *Central Banking*, 11 (2), 24-37.

Obstfeld, Maurice (1983), "Exchange Rates, Inflation and the Sterilization Problem. Germany 1975-81", *European Economic Review*, 21, 161-189.

Ramaswami, Ramana and Hossein Samiei (2000), "The Yen-Dollar Rate: Have Interventions Mattered?", IMF Working Paper No. 95.

Reeves, Silke F. (1997), "Exchange Rate Management when Sterilized Interventions Represent Signals of Monetary Policy", *International Review of Economics and Finance*, 6 (4), 339-360.

Reinhart, Carmen M. and Kenneth S. Rogoff (2004), "The Modern History of Exchange Rate Arrangements: A Reinterpretation", *The Quarterly Journal of Economics*, 1, 1-48.

Rogoff, Kenneth S. (1984), "On the Effects of Sterilized Intervention: An Analysis of Weekly Data", *Journal of Monetary Economics*, 14, 133-150.

Rogoff, Kenneth S. (1996), "The Purchasing Power Puzzle," *Journal of Economic Literature*, 34 (June), 647-68.

Sarno, Lucio and Mark P. Taylor (2001), "Official Intervention in the Foreign Exchange Market: Is it Effective, and, If So, How Does it Work?, *Journal of Economic Literature*, 39, 839-868.

Sarno, Lucio and Mark P. Taylor (2002), *The Economics of Exchange Rates*, Cambridge University Press: Cambridge.

Schmidt, Ulrich and Horst Zank (2001), "An Axiomatization of Linear Cumulative Prospect Theory with Applications to Portfolio Selection and Insurance Demand", Royal Economic Society Annual Conference.

Schulmeister, Stephan (1988), "Currency Speculation and Dollar Fluctuations", *Banca Nazionale Del Lavoro Quarterly Review*, December, 343-365

Stockman, Alan C. (1980), "A Theory of Exchange Rate Determination," *Journal of Political Economy*, 88 (4), 673-98.

Stockman, Alan C. (1987), "The Equilibrium Approach to Exchange Rates," *Economic Review*, March/April, 12-30.

Svensson Lars E.O. (1985), "Currency Prices, Terms of Trade, and Interest Rates: A General Equilibrium Asset Pricing Cash-in-Advance Approach," *Journal of International Economics*, 18 (February), 17-41.

Svensson, Lars E.O. (1992), "An Interpretation of Recent Research on Exchange Rate Target Zones", *The Journal of Economic Perspectives*, 6 (4), 119-144.

Tapia, Matias and Andrea Tokman (2004), "Effects of Foreign Exchange Intervention Under Public Information: The Chilean Case", Central Bank of Chile Working Papers 255.

Taylor, Mark P. (1995), "The Economics of Exchange Rates", *Journal of Economic Literature*, 33, 13-47.

Taylor, Mark P. (2004), "Is Official Exchange Rate Intervention Effective?", *Economica*, 71, 1-11.

Taylor, Mark P. and Hellen Allen (1992), "The Use of Technical Analysis in the Foreign Exchange Market", *Journal of International Money and Finance*, 11, 304-314.

Taylor, Mark P. and David A. Peel (2000), "Nonlinear Adjustment, Long-Run Equilibrium and Exchange Rate Fundamentals," *Journal of International Money and Finance*, 19, 33-53.

Taylor, Mark P. and David A. Peel and Lucio Sarno (2001), "Nonlinear Mean-Reversion in Real Exchange Rates: Towards a Solution to the Purchasing Power Parity Puzzles," *International Economic Review*, 42, 1015-42.

Taylor, Mark P. and Lucio Sarno (1998), "The Behavior of Real Exchange Rates During the Post-Bretton Woods Period", *Journal of International Economics*, 46, 281-312.

Taylor, Alan and Mark P. Taylor (2004), "The Purchasing Power Parity Debate," *Journal of Economic Perspectives*, 18(4), 135-158.

Thaler, Richard. H. and Eric Johnson (1990), "Gambling with the House Money and Trying to Break Even: The Effects of Prior Outcomes in Risky Choice," *Management Science*, 36 (6), 643-660.

Tversky, Amos and Daniel Kahneman (1992), "Advances in Prospect Theory: Cumulative Representation of Uncertainty", *Journal of Risk and Uncertainty*, 5, 297-323.

Von Neumann, John and Oscar Morgenstern (1944), *Theory of Games and Economic Behavior*, Princeton, NJ: Princeton University Press.

Watanabe, Tsutomu (1994), "The Signaling Effect of Foreign Exchange Intervention: The Case of Japan", in Reuven Glick and Michael M. Hutchison, eds., *Exchange rate policy and interdependence: Perspectives from the Pacific Basin*, Cambridge University Press: Cambridge, New York and Melbourne, 258-286.

Williamson, John (1985), *The Exchange Rate System*, Institute for International Economics: Washington, DC.

Williamson, John (2002), "The Evolution of Thought on Intermediate Exchange Rate Regimes", *The Annals of the American Academy of Political and Social Science*, 579 (0), 73-86.