

Kaltenbrunner, Annina; Nissanke, Machiko

## Working Paper

# The case for an intermediate exchange rate regime with endogenizing market structures and capital mobility: The empirical study of Brazil

WIDER Research Paper, No. 2009/29

## Provided in Cooperation with:

United Nations University (UNU), World Institute for Development Economics Research (WIDER)

*Suggested Citation:* Kaltenbrunner, Annina; Nissanke, Machiko (2009) : The case for an intermediate exchange rate regime with endogenizing market structures and capital mobility: The empirical study of Brazil, WIDER Research Paper, No. 2009/29, ISBN 978-92-9230-200-9, The United Nations University World Institute for Development Economics Research (UNU-WIDER), Helsinki

This Version is available at:

<https://hdl.handle.net/10419/45167>

### Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

### Terms of use:

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*



UNITED NATIONS  
UNIVERSITY

**UNU-WIDER**

World Institute for Development  
Economics Research

Research Paper No. 2009/29

# **The Case for an Intermediate Exchange Rate Regime with Endogenizing Market Structures and Capital Mobility**

The Empirical Study of Brazil

Annina Kaltenbrunner  
and Machiko Nissanke\*

May 2009

## **Abstract**

Set in the context of the recent theoretical and policy debates on appropriate exchange rate regimes for emerging market economies in a world of free capital mobility, the paper attempts to present the case for an intermediate exchange rate regime, drawing on recent theoretical and empirical literatures on behavioural finance and currency market structures; and to examine empirically the experiences and evolution of Brazil's foreign exchange market under different exchange rate regimes.

After a brief review of the policy debates, we discuss theoretical discourses on appropriate exchange rate regimes for emerging market economies, drawing on both .../.

Keywords: exchange rate management, emerging markets, Brazil

JEL classification: E44, F31, F41, O24

Copyright © UNU-WIDER 2009

\* School of Oriental and African Studies, University of London, London; emails: ak82@soas.ac.uk (A. Kaltenbrunner) and mn2@soas.ac.uk (M. Nissanke)

This study has been prepared within the UNU-WIDER project on Southern Engines of Global Growth, co-directed by Amelia U. Santos-Paulino and Guanghua Wan.

UNU-WIDER gratefully acknowledges the financial contributions to the research programme by the governments of Denmark (Royal Ministry of Foreign Affairs), Finland (Ministry for Foreign Affairs), Norway (Royal Ministry of Foreign Affairs), Sweden (Swedish International Development Cooperation Agency—Sida) and the United Kingdom (Department for International Development).

ISSN 1810-2611

ISBN 978-92-9230-200-9

macroeconomic propositions and microeconomic market perspectives. Next, we discuss empirical studies of currency market conditions with focus on the most recent applications of behavioural finance models to currency markets. We emphasize the importance of endogenizing structures of market conditions in our consideration of appropriate exchange rate regimes for emerging market economies, presenting hypotheses for empirical tests, methodology adopted and empirical results, and briefly conclude with final remarks.

## **Acknowledgements**

This research has benefited from the ESRC Scholarship to the first author (PTA-031-2006-00140) for her PhD study as well as the financial support provided by the Swiss National Foundation under the NCCR Trade Regulation Programme to the second author. We are grateful for the financial contributions to this research. We are also grateful to Graham Smith and Sebastian Castresana for their valuable advice on the econometric part of this study and to participants at the UNU-WIDER Workshop on Southern Engines of Global Growth in Rio de Janeiro, July 2008.

## **Acronyms**

CTT currency transaction tax  
FEER the fundamental equilibrium exchange rate  
MVR multiple variance ratio test  
PPP purchasing power parity

*The World Institute for Development Economics Research (WIDER) was established by the United Nations University (UNU) as its first research and training centre and started work in Helsinki, Finland in 1985. The Institute undertakes applied research and policy analysis on structural changes affecting the developing and transitional economies, provides a forum for the advocacy of policies leading to robust, equitable and environmentally sustainable growth, and promotes capacity strengthening and training in the field of economic and social policy making. Work is carried out by staff researchers and visiting scholars in Helsinki and through networks of collaborating scholars and institutions around the world.*

*[www.wider.unu.edu](http://www.wider.unu.edu)*

*[publications@wider.unu.edu](mailto:publications@wider.unu.edu)*

UNU World Institute for Development Economics Research (UNU-WIDER)  
Katajanokanlaituri 6 B, 00160 Helsinki, Finland

Typescript prepared by Liisa Roponen at UNU-WIDER

The views expressed in this publication are those of the author(s). Publication does not imply endorsement by the Institute or the United Nations University, nor by the programme/project sponsors, of any of the views expressed.

## 1 Introduction

For any small open economy, exchange rates are universally regarded as the key relative price to determining its macroeconomic configuration. However, a question as to what constitutes the appropriate or optimal exchange rate regime for developing countries and emerging market economies has long been in the domain of intense debates among academics and policymakers alike. The choice of the exchange rate regime is complicated because the exchange rate policy affects both external balance and internal balance in terms of macroeconomic adjustment as a stabilization instrument as well as an expenditure-switching policy instrument. In turn, as expenditure-switching policy, the exchange rate policy influences not only net external trade balances through the competitiveness of tradable goods but also the internal resource allocation between tradables and nontradables through changes in the real exchange rates.

In the earlier debate, this dual role of exchange rate policy had given rise to two distinct approaches to an appropriate exchange regime among development macroeconomists (Agénor and Montiel 1996):

- the *real target approach* with a focus on the need to keep international competitiveness of tradable goods so as to ensure a viable and sustainable position in the current account;
- the *nominal anchor approach* with a focus on the need to ensure domestic monetary stability.

Setting targets in real terms, the first approach is geared for the attainment of external balance. In order for exchange rates to satisfy the real targets over time in the face of various real shocks to the external balance, the approach opts for a regime that provides a greater *flexibility* to the exchange rate. In contrast, the second approach opts for a regime that brings a greater *stability* to nominal variables in order to ensure financial discipline.

Seen in this perspective, there is an inherent tension between two approaches. Therefore, the practical policy issue is then over the trade-off between the two objectives, and hence, the relative weight that should be assigned to each of these objectives in formulating exchange rate policy. Ultimately, it can be said that optimal management of exchange rates for a given economy depends on the policymakers' objectives, the source of macroeconomic shocks, and its structural characteristics and special circumstances of an economy. For example, for a developing country whose external position imposes a binding constraint for economic growth, it may be of utmost importance to give particular attention to the current account target in relation to its developmental objectives such as the need to develop non-traditional exports in its efforts to diversify its trade structure away from the commodity-dependence and the vulnerability associated with it. Such a developmental perspective would inevitably raise a critical question as to whether it is possible to define the *fundamental equilibrium real exchange rate* at a point of time.<sup>1</sup> If this is feasible, one can proceed to

---

<sup>1</sup> For example, Williamson (1994) set a quest for understanding the fundamental equilibrium exchange rate (FEER), by defining it in the Keynesian tradition but in an abstract form, as 'the real effective exchange rate compatible with simultaneous achievement of internal and external balance in the *medium term*'.

examine how different exchange rate regimes affect the level and path of the real exchange rate relative to such a benchmark value and trajectory,

Given a variety of these policy considerations discussed above, there are several grounds to argue that intermediate regimes such as a target zone or crawling band system may be one of best options for many developing, emerging market economies, as they combine elements of both ‘flexibility’ and ‘stability’. In theory, they could provide some scope for an independent monetary policy in a world of free capital mobility, as adjustment within the band permits the exchange rate to bear a part of the burden of absorbing unanticipated real and monetary shocks. They could also potentially provide an anchor for monetary stability because certain monetary discipline is required to keep the exchange rate within the band. In practice, a central issue to resolve for sustaining any intermediate regime, however is how to establish the *credibility* of policymakers’ commitment to such exchange rate regimes.

Indeed, it is on this credibility issue that the prospect for an ‘intermediate regime option’ was severely tested and challenged when a series of currency and financial crises plagued many emerging market economies in the 1990s. By the early 2000s, there emerged a new consensus—the *two corner solution view*—as a dominant position in the debate on the appropriate exchange rate regimes for emerging market economies prone to financial crises. Resorting to the ‘impossible trinity thesis, this view argues that intermediate regimes are not viable under financial globalization, because of their vulnerability to speculative attacks (self-fulfilling or otherwise). It is argued that under a floating regime, the monetary stability can be ensured, without having exchange rate-based stabilization in place, by adopting an inflation-targeting framework and some variations of the Taylor rule as a policy guide (Taylor 2001).

However, as Frankel (1999) suggests, the inconsistent trinity thesis does not, in principle, imply that countries cannot have a half-independent monetary policy and a half-fixed exchange rate by adopting intermediate regimes such as a target zone; nor does it imply that countries cannot have both an independent monetary policy and a fixed exchange rate by imposing effective capital controls. In reality, the ‘fear of floating’ has been prevalent among emerging market economies (Calvo and Reinhart 2002). Even among the emerging economies of East Asia, many of which managed to stage a quick recovery from the devastating Asian crisis of 1997-98, we find a continuing adherence to the East Asian dollar pegged regimes (McKinnon and Schnabl 2004). Given their bitter experiences with currency attacks and collapses, in order to surmount the fear over the loss of the credibility towards their pegged regimes, many emerging economies have, instead, opted to hold large amounts of international reserves for self-insurance purposes, far in excess of any foreseen shortfalls stemming from the needs for current account transactions (Jeanne 2007; Miller and Zhang 2007).

At the same time, as we argue elsewhere in relation to the effect of the currency transaction tax (CTT) on market liquidity and efficiency (Nissanke 2005), the discourse on the appropriate exchange rate regime, in particular, on the desirability or the feasibility of policy-based interventions in currency markets is closely related and shaped by varied perceptions economists hold about how well and efficiently currency markets function without intervention. A critical question debated in this regard is whether speculators or noise traders make exchange rates excessively more volatile than warranted by fundamentals.

Set in the context of these theoretical and policy debates on appropriate exchange rate regimes for emerging market economies in a world of free capital mobility, the primary objectives of this paper are: (i) to present the case for an intermediate exchange rate regime, drawing on recent theoretical and empirical literatures on behavioural finance and currency market structures; and (ii) to examine empirically the experiences and evolution of Brazil's foreign exchange market under alternative exchange rate regimes. Brazil switched from a managed band to market-based floating regime after experiencing a speculative currency attack at the end of 1998. Since then the central bank has followed an inflation-targeting regime, under which exchange rate movements should only enter the bank's objective function if at odds with its inflation target. In this sense, we hope that our comparative empirical analysis of Brazil's foreign exchange market under different exchange rate regimes will yield some valuable insights into how foreign exchange markets are structured and performed in an era of financial globalization, as the outcome of interactive forces among heterogeneous market traders/participants as well as between market traders on the one hand and the central bank on the other.

The paper is structured as follows: in section 2, for building a solid case for intermediate exchange rate regimes, we discuss theoretical discourses on appropriate exchange rate regimes for emerging market economies, drawing on both macroeconomic propositions and microeconomic market perspectives. In section 3, we discuss empirical studies of currency market conditions with a focus on the most recent applications of behavioural finance models to currency markets. We emphasize the importance of endogenizing structures of market conditions in our consideration of appropriate exchange rate regimes for emerging market economies. Section 4 presents the hypotheses for empirical tests, the methodology adopted and the empirical results. Finally, our brief concluding remarks are offered in section 5.

## **2 Theoretical discourse**

### **2.1 The possible trinity: the case for an intermediate exchange rate regime from a macroeconomic perspective**

As financial globalization has accelerated, discussions on appropriate exchange rate regimes for emerging markets economies in macroeconomic literature have increasingly been framed in relation to the infamous theoretical proposition of 'impossible trinity thesis'. The thesis stipulates that policymakers in open economies face a macroeconomic *trilemma*: that is, whilst policymakers typically have three desirable objectives (exchange rate stability, free international capital mobility, and monetary policy independence to engage domestic economic goals), they are in practice forced to give up one objective, since only two out of the three can be mutually consistent. Resorting to this thesis, it is argued that the only exchange rate regimes that remain viable in an era of free cross-border capital mobility are the two corners positions within the trinity, i.e. either pure floating or hard pegs. Hence, this position is referred to in the literature as the *two-corner view* on the exchange rate regime, but also known as the *hollowing out hypothesis* or the *bi-polar view*. For example, Eichengreen (1999: 134) concludes that, 'a middle ground of pegged but adjustable exchange rates and exchange rate target zones will hollow out and policymakers will be confronted with a choice between floating and monetary union'.

However, it should be noted that this debate on appropriate exchange rate regimes is driven by the imperative of financial globalization. The arguments rest on the assumption that financial openness alone should not be challenged in the *trinity*, either because of the considerable benefits which openness is promised to produce in emerging economies, or because free capital mobility is inevitable due to changes in global technology, market structure or politics. While the impossible trinity thesis applies to any open economy, developed mature economies or emerging market economies alike, the policy constraint posed is seen as particularly severe for the latter group, reflecting their disadvantaged position in global finance. As Eichengreen and Hausmann (1999) note, emerging market economies are handicapped by the *original sin* due to incomplete domestic financial markets as an additional source of financial fragility that makes them more susceptible to global financial and currency crises.<sup>2</sup>

Indeed, the financial fragility and instability of emerging market economies is closely related to their asymmetric position vis-à-vis advanced countries in international finance as well to their structural characteristics. As Bordo and Flandreau (2001) note, the degree of *financial maturity*—the ability to issue international securities denominated in own domestic currency—is a key factor in distinguishing *core* countries from *periphery* ones for exchange rate regime choices over the past century. The prevalence of their ‘fear of floating’ (Calvo and Reinhart 2000) or ‘the case of hard pegs’ (Calvo 2000) is also closely related to:

- i) *liability dollarization*, i.e., the condition in which financial contracts are expressed in foreign currency;
- ii) fear of inflation due to the high pass-through coefficients (measurements of the speed of transmission of devaluation to inflation); and
- iii) their nascent capital markets.

Despite the strong case made by many influential macroeconomists for the two-polar view (e.g., Fisher 2001), Husain, Mody and Rogoff (2005) show that intermediate regimes have actually proved the most resilient over recent years

## **2.2 Agents’ behaviour and market conditions: the case for an intermediate exchange rate regime from a microeconomic perspective**

In mainstream economic thought, the exchange rate is considered a relative price, which restores equilibrium in real or financial markets. As such, exchange rate movements can only result from changes in underlying ‘fundamentals’, which require an adjustment in relative prices (Harvey 2001). While in the long run, the need for a balanced current account determines the exchange rate, asset market considerations, such as differential money supplies or interest rates, are acknowledged to predominate in the short run.

---

<sup>2</sup> The original sin hypothesis advanced by Eichengreen and Hausmann (1999: 3) refers to ‘a situation in which the domestic currency cannot be used to borrow abroad or to borrow long term even domestically. In the presence of this incompleteness, financial fragility is unavoidable because of all domestic investments will have either a currency mismatch ... or maturity mismatch ...’. Critically, as they note, these mismatches exist not because banks and firms lack either the prudence to hedge their currency exposures or the foresight to maturity mismatch, but because they are unable to do so due to their ‘emerging markets’ status.

However, along with the acknowledgement of asset market consideration (and the search for micro foundations in neoclassical economics) came the incorporation of agents' expectations and behaviour in exchange rate theory, which has shaped the policy debate on appropriate exchange rate regimes from this microeconomic perspective.

Those who argue that any intervention in currency markets would reduce market efficiency tend to treat traders and speculators as rational agents, i.e., informed investors guided by their expectations about future underlying fundamentals. That is, as traditional fundamentalists or 'informed' traders, market participants are seen to keep the exchange rate in line with macroeconomic fundamentals and help stabilize markets around a new equilibrium. Traders whose judgments of an asset's value are sufficiently mistaken lose money to arbitrageurs and so eventually disappear from the market. Hence, they argue that destabilizing trading cannot be profitable (Friedman 1953; Fama 1965).

In this view, foreign exchange markets work efficiently in the sense that the price of the exchange rate will reflect all relevant information about the fundamental variables that determine its value. The implications for exchange rate policy are clear: as markets work efficiently, freely floating exchange rates will generate the pareto-optimal solution and any form of government intervention can only be distortionary.

In contrast, those who see the case for intervention in currency markets argue that markets function inefficiently. For example, Frankel (1996) notes that speculative bubbles—a deviation from the value justified by fundamentals—are generated, as *noise traders* (as opposed to *traditional fundamentalists* or *informed traders*) follow the herd in the face of uncertainty.<sup>3</sup> In their analyses, a critical distinction is usually made between informed traders and noise traders: while informed traders act on homogeneous rational expectation, noise traders make their decisions on the basis of 'fads' which are unrelated to fundamentals.

In this context, Jeanne and Rose (1999) suggest that whilst the volatility in exchange rates is generated both by fundamentals and noise, the source of excessive exchange rate volatility (i.e., speculative bubbles) is attributed to the presence of noise traders. In particular, their model shows that noise traders are attracted to the market in search for a risk premium, and that as the number of noise traders increases, so does the volatility of exchange rates.

Overall, these model support the view that speculators, acting on fads or guided by extrapolative expectations at short-term horizon, can exert destabilizing effects on markets and 'overshooting of the overshooting equilibrium' takes place. Furthermore, not only do deviations from the rational stabilizing speculator exist, but they can—contrary to Friedman's reasoning—also be profitable and have a lasting impact on financial sector prices.

---

<sup>3</sup> Keynes (1936/1997) uses a 'beauty contest' analogy to describe fund managers' herd behaviour, in that they must guess in an instant how other market players will interpret a new event and follow them accordingly.



### 3 The importance of endogenizing market structure

#### 3.1 Behavioural finance

The role of agents' expectations and behaviour in the price formation process is more explicitly modelled in the relatively recent behavioural finance approach.<sup>4</sup> In this literature, exchange rate dynamics are the result of the interaction of heterogeneous agents in the foreign exchange market, where for one group of agents the assumption of rationality is abandoned.

Recurring to experimental results and evidence from psychology, sociology and organizational behaviour, the behavioural finance approach acknowledges that agents are not rational, not only constrained by the availability of information, but differ in their ability to absorb, understand and process information. This induces agents to use simple rules ('heuristics') to guide their behaviour. One such trading rule is positive feedback trading or trend chasing, where past prices are extrapolated in the future.<sup>5</sup> Agents do this not because they are stupid or irrational, but because the complexity of the world is overwhelming, making it pointless to understand it completely (De Grauwe and Grimaldi 2006). The widespread use of chartism/technical trading<sup>6</sup>, momentum trading or the evidence of herding in financial markets, could be characterized by such a trading rule (e.g., Galati and Melvin 2005).

Formally,

$$E_{c,t}(\Delta s_{t+1}) = \beta \Delta s_t \quad (1)$$

where,  $E$  is an expectations operator,  $s$  is the exchange rate and  $\beta$  is the extrapolation parameter (De Grauwe and Grimaldi 2006: 15).<sup>7</sup> Such extrapolative expectations or positive feedback trading, however, act destabilizing, driving the price of an asset away from its fundamental value.

In many of these models, a second group of traders, rational traders or fundamentalists, acting like Friedman's stabilizing speculator, counteract these destabilizing forces and

---

<sup>4</sup> This exposition is primarily based on the seminal paper by Frankel and Froot (1990) and the recent application and extension of this framework to the foreign exchange market by de Grauwe and Grimaldi (2006). Other contributions include Brock and Hommes (1997, 1998), Lux and Marchesi (2000) and Farmer and Joshi (2002). Westerhoff (2003) and Xu (2005) explicitly focus on the foreign exchange market.

<sup>5</sup> Other strategies that depend on extrapolative expectations are 'stop loss' orders, which prescribe selling after a certain level of losses, regardless of future prospects, and portfolio insurance, which involves buying more stocks (to raise exposure to risk) when prices rise and selling stocks (to cut exposure to risk) when prices fall (Shleifer and Summers 1990: 28).

<sup>6</sup> In practice, trading strategies followed by technical traders might be more complex than a mere feedback rule (see e.g., Schulmeister 2006). However, the important principle that past price behaviour, rather than underlying fundamentals, determine the trading pattern remains valid.

<sup>7</sup> This exposition assumes that agents can realize their expectations and trade according to them.

align financial asset prices to their underlying value <sup>8</sup>. Again formally,

$$E_{f,t}(\Delta s_{t+1}) = -\psi(s_t - s_t^*) \quad (2)$$

where  $s_t^*$  stands for the fundamental exchange rate (De Grauwe and Grimaldi 2006: 15). The price dynamics is ultimately determined by the interaction between the two agents and the weight assigned to the respective trading rule. Formally,

$$\Delta s_{t+1} = -\omega_{f,t}\psi(s_t - s_t^*) + \omega_{c,t}\beta\Delta s_t + \varepsilon_{t+1} \quad (3)$$

where  $\omega_{i,t}$  ( $i = f, c$ ) is the respective share of fundamentalists and chartists (De Grauwe and Grimaldi 2006: 19). It is important to note that rather than two types of traders, the juxtaposition of ‘chartists’ and ‘fundamentalists’ is interpreted in terms of trading rules, which can be combined in one agent and prevail depending on market conditions and, more controversially, time horizon (Frankel and Froot 1990). In addition, it is probably also the case that different market participants follow different trading rules more often, which could have important implications for the regulation of financial markets.

As De Grauwe and Grimaldi (2006) show in computer simulations, in such a scenario exchange rate dynamics can be characterized by two different kinds of equilibria: a fundamental equilibrium, in which fundamentalists and chartists co-exist and the former keep the exchange rate close to its fundamental value, and a bubble equilibrium characterized by the predominance of destabilizing chartists. In addition, the exchange rate is not only very often disconnected from its fundamental value, but also experiences more short-term volatility than the fundamental exchange rate and is occasionally subject to very large changes.

### 3.2 Agents’ interactions

Thus, an interesting question, especially for policy implications, is how the weight between the two trading rules is determined and what induces shifts between the fundamental and the bubble equilibrium. Several of the models which focus on heterogeneous traders point to the important interface between them and the risk the presence of noise traders creates for stabilizing arbitrageurs. Because, as we argued earlier (Nissanke 2005), the interaction between arbitrageurs and noise traders in currency markets is very complex, as the former often have to respond to the unpredictable behaviour of the latter rather than to expected changes in fundamentals.

To determine the weight between chartists and fundamentalists, De Grauwe and Grimaldi 2006 (2006) assume that agents regularly compare the utility of the alternative trading rules and switch between them according to their relative risk adjusted

---

<sup>8</sup> There are also models that only focus on one investor and not the interaction between heterogeneous traders (e.g., Barberis, Shleifer and Vishny 1998; Daniel, Hirshleifer and Subrahmanyam 1998). For this paper and especially its policy implications the interaction between heterogeneous traders, however, is important. In addition, as Frankel and Froot (1990: 94) point out, the large volume of foreign exchange trading in itself suggests that market participants are not identical agents, who share the same rational expectations.

profitability. If an initial shock in the exchange rate increases the profitability of extrapolative forecasting, an increasing share of traders will switch to this rule.

$$\omega_{i,t} = \frac{\exp(\gamma\pi'_{i,t})}{\exp(\gamma\pi'_{i,t}) + \exp(\gamma\pi'_{j,t})} \quad (4)$$

where  $\pi'_{i/j}(i, j = f, c)$  are the risk adjusted profits and  $\gamma$  measures the intensity with which the traders revise their forecast rule (De Grauwe and Grimaldi 2006: 17).

Similarly, Frankel and Froot (1990: 101) argue that the traders' weight changes over time according to their respective wealth generated through the trading success. However, they do not explicitly consider the risk, which chartists' behaviour could generate for stabilizing fundamentalists. Yet, de Grauwe and Grimaldi (2006: 34) point out:

Agents who use fundamentalists' forecasting rules recognize that a profit opportunity arises when the exchange rate deviates from its fundamental value. However, because of the losses they incur and the large forecast errors they make during a bubble phase, these risk-averse fundamentalists switch to safer and more profitable forecasting rules. Arbitrage opportunities exist, but everybody is afraid to take these opportunities.

The attempt to introduce rationality in the system through the ex post application of a fitness rule, however, seems to miss the essence of financial markets, which are inherently forward looking and driven by ex ante expectations.

The role of risk is most explicit in de Long et al. (1990b: 705): 'Arbitrage does not eliminate the effects of noise because noise itself creates risk'. That is, the unpredictability of noise traders' beliefs and expectations, which can be erroneous and stochastic in light of fundamentals, could create a *noise trader risk*—a risk in the price of assets that deters rational arbitrageurs from aggressively betting against them. This is because arbitrageurs are likely to be risk averse, acting with a short time horizon. Hence, they tend to have limited willingness to take positions against risks created by noise traders. As a result, 'prices can diverge significantly from fundamental values even in the absence of fundamental risk' (de Long et al. 1990b: 705). Moreover, bearing a disproportionate amount of risk thus generated enables noise traders to earn a higher expected return than rational investors engaged in arbitrage against noise.

### 3.3 Market conditions

As outlined above, exchange rate dynamics are the result of the complex interaction between noise traders and fundamentalists. This interaction, however, does not take place in a vacuum and the question arises whether and how 'external' market conditions can affect the interface between these two types of heterogeneous traders. As we argue earlier (Nissanke 2005), the market composition between the two types of traders shifts, as market conditions change. Equally, depending on market conditions, traders could switch their position from arbitrageurs to 'destabilizing' speculators. Hence, as de Long et al. (1990a, 1990b) note, the interface between arbitrageurs and noise traders is non-linear.

Thus, we argue that emphasis has to be placed on both, what we call *objective* and *subjective* market conditions. While objective market conditions refer to the role of *fundamentals* in shaping the interaction between heterogeneous traders, subjective market conditions point to the institutional framework which influences the (subjectively felt) risk parameter of traders and hence the predominance of one trading rule over the other.

### 3.4 Objective market conditions

For Jeanne and Rose (1999), the entry decision of noise traders is positively related to fundamental variance and a risk premium (exchange rate volatility). Their paper predicts that when the volatility of fundamentals is low, there is a single equilibrium where noise traders are not active, resulting in a low volatility in exchange rates. Conversely, when the volatility of fundamentals is high, a large number of noise traders enter the market, producing a high volatility in exchange rates. When the volatility of fundamentals is in the intermediate range, however, multiple stable equilibria are possible, depending on the number of noise traders seeking for a risk premium.

According to De Grauwe and Grimaldi (2006: 28) once in a bubble equilibrium, the higher profitability of chartists continues to drive the exchange rate away from its fundamental value. This leaves the question open whether there are underlying market conditions, which favour the development of a bubble in the first place. They argue that the development of multiple equilibria is crucially dependent on initial conditions—defined as an initial shock in the exchange rate. The larger the initial shock in the exchange rate, the more profitable the chartist trading rule and the farther the attractors are removed from the fundamental exchange rate. Hence, some sort of ‘underlying volatility’ is necessary to enter the economy in bubble equilibrium. However it remains indeterminate, what will determine the outcome in an ‘intermediate’ situation, as not any shock in the exchange rate has to result in a bubble equilibrium.

Hence, both publications agree that some form of fundamental variance is necessary to make it profitable for noise traders to enter the market. However, both remain indeterminate as to the specification and identification of such fundamentals.

The role of fundamentals is complex, theoretically as well as empirically, and is hardly dealt with in the behavioural finance literature. In other words while much emphasis is put on specifying the noise trader behaviour the theoretical assumptions about fundamentals remain unquestioned. They remain either firmly embedded in the monetary approach to exchange rate determination, or altogether unclear.<sup>9</sup> However, if the expectations and behaviour of heterogeneous market players comes to the fore of the analysis and expectations cease to be formed rationally—in the sense that they are formed endogenously according to the model under consideration—there is little reason to expect a unique set of fundamentals to remain the permanent driver of exchange rate movements.

---

<sup>9</sup> For example, De Grauwe and Grimaldi (2006) never really define what they think fundamentalists base their assessment on. They mention either purchasing power parity (PPP) or some fundamental equilibrium rate (FEER) a la Williamson, but do not spend more consideration on this topic. However, this paper questions the assumption that foreign exchange traders have an equilibrium rate a la FEER in their mind.

The fact that agents are heterogeneous and might use different models, across agent and time, to form expectations about future exchange rate values, has been acknowledged in mainstream exchange rate literature. One example is Bacchetta and van Wincoop's (2004) interesting scapegoat model, where investors, due to confusion about the true source of exchange rate fluctuation, use fundamentals which show large imbalances as a 'scapegoat' for exchange rate movements. In a similar vein, empirical literature has shown that the importance of fundamentals varies over time (e.g., Heimonen 2006). However, although the importance of financial market players in the determination of exchange rate dynamics is acknowledged, the same set of exchange rate fundamentals as specified in traditional exchange rate theory—mainly monetary variables—is maintained.

Post-Keynesian literature (see e.g., Davidson 2002a, 2002b; Alvés, Ferrari-Filho and de Paula 2000) has long criticized the assumption of an ergodic world, where underlying fundamentals can be calculated from past data, projected in the future and hence firmly pinned down by (if only a few) fundamentalists. In Keynes' world of fundamental uncertainty, expectations and *convention*—the assumption that 'the existing state of affairs will continue indefinitely',—and the psychological confidence with which we hold this convention govern investment behaviour (Keynes 1997: 152). However, if convention determines current market prices, foreseeing future convention and hence market psychology becomes crucial to maintain the value of one's portfolio (Keynes 1997: 155). It is not merely the short-horizon and risk created for rational arbitrageurs or the presence of 'dumb' feedback traders, but the underlying uncertainty, and lack of a 'true' anchor to the price system, which causes Keynes' 'beauty contest'.

Although we agree with the assumption of fundamental uncertainty, the importance of expectations and the state of confidence in the determination of exchange rate movements, we suggest that it is theoretically unsatisfactory to reject the notion of fundamentals *per se*. Indeed, if the expectations and behaviour of asset market players are acknowledged to be the driving factors of exchange rate movements, an attempt has to be made to understand the formation of these expectations and the motivations of asset holders. This has to go beyond the current set of mainstream fundamentals and specify alternative fundamentals, which are found to drive investors' behaviour.<sup>10</sup>

### **3.5 Subjective market conditions: a case for exchange rate policy**

In addition to fundamental risk, we argue that the interaction between stabilizing and destabilizing traders will be influenced by *subjective market conditions*—or the institutional setting—which influence the risk perception of market players. Probably the most important institutional setting in this sense is the exchange rate regime in place.

Now, in Jeanne and Rose's (1999) noise trader model, the entry decision of noise traders is positively related to a risk premium (exchange rate volatility), which itself is generated through the entry of noise traders in the market. Hence, similar to self-fulfilling crisis models the expectation of a higher risk premium is validated through the resulting entrance of noise traders as it changes the structure of risks and returns in a way that makes it more attractive for other noise traders to join. Similarly, in De

---

<sup>10</sup> Although not discussed in this paper, we deal this issue within our current research programme.

Grauwe and Grimaldi's (2006) model, exchange rate behaviour is crucially determined by the risk aversion parameter of fundamentalists.<sup>11</sup> A fall in this parameter (subjectively perceived or objectively determined) induces fundamentalists to bet more aggressively against destabilizing noise traders and maintains the exchange rate in a fundamental equilibrium.

However, the view that exchange rate behaviour is determined by the interaction of heterogeneous traders, rather than directly by macroeconomic fundamentals, and that this interaction is fundamentally shaped by a subjectively felt risk perception, has important implications for exchange rate policy. Market structure has to be endogenized rather than taken as given and can be changed through government policy, which influences trading behaviour and/or the composition of traders operating in the market. In this view, a stabilized exchange rate does not transmit into higher fundamental volatility, but delivers stability 'at not cost' as market conditions and hence market structure change.

For Jeanne and Rose, the monetary authority's announcement to prevent exchange rate volatility is enough to deter destabilizing noise traders seeking for a risk premium and pins down the economy on the low volatility equilibrium. Although the stable exchange rate commitment constrains the monetary policy response function *out of equilibrium, in equilibrium* there is no observable sacrifice of monetary autonomy.<sup>12</sup> The implication that the exchange rate regime in place effectively changes market structure is also analysed in Flood and Rose (1999). In their model, the process governing the exchange rate changes according to expectations about future exchange rate volatility. They show that in periods where expected volatility is non-zero—such as in a floating regime or non-credibly fixed pegged exchange rate regime—forces other than those from money and goods markets come to determine the exchange rate.

Although Jeanne and Rose argue that their definition of stable exchange rates is flexible enough to encompass a wide spectrum of exchange rate regimes, it is probably most interesting in the context of the stabilizing properties of intermediate exchange rate regimes, such as target zones or Williamson's (2000) *basket band crawl* (BBC) proposition.

Williamson (2000) recommends the intermediate 'target zone' regime, governed by the BBC rule, as a more appropriate exchange rate regime for most emerging market economies in preference over one of the two-corner solutions of pure floating or hard pegs. He lists the fundamental reasons found in literature for preferring a band system over floating: (i) the band performs the function of crystallizing market expectations of where the equilibrium exchange rate may lay, and thus making expectations stabilizing at the time-horizons relevant for influencing market behaviour (Svensson 1992); (ii) a band has a pronounced effect in limiting exchange rate variability by preventing noise

---

<sup>11</sup> De Grauwe and Grimaldi dedicate nearly an entire chapter to this parameter and perform simulations how it affects exchange rate dynamics. They show that a reduced risk aversion by fundamentalists avoids bubble equilibria and pins down the economy at a 'good' equilibrium. However, disappointingly, the authors do not use this parameter to derive implications for exchange rate policy.

<sup>12</sup> The authors argue that their 'announcement effect' is stronger than Krugman's (1991) 'honeymoon' effect, where the exchange rate is stabilized by the promise of interventions that have to be fulfilled in equilibrium (Jeanne and Rose 1999).

traders, particularly, stop-loss traders from making money by introducing noise into the exchange market (Rose 1996). Hence, in contrast to the traditional target zone literature (Krugman 1991), target zones in this view are not stabilizing, because agents are rational ('honeymoon effect'), but because it makes market expectations more rational as it is more difficult for irrational traders to survive in an environment with little volatility (Jeanne and Rose 1999).<sup>13</sup>

De Grauwe and Grimaldi (2006) arrive at a similar conclusion, although in their model rather than building *ex ante* credibility, the existence of a target zone increases the profitability of fundamentalist trading *ex post* as it strengthens the mean-reverting behaviour of the exchange rate. Although the authors stress the sustainability of foreign exchange reserves, we suggest that their reactive theory understates the cost of defending the currency in the case of a speculative attack and/or the opportunity costs of holding a large stock of foreign exchange reserves. In addition, in this regard, we should bear in mind, under conditions of self-fulfilling crises such as those examined in the second-generation model of currency crises (Obstfeld 1996), the issue at stake is not merely whether speculators increase exchange rate volatility, but also whether they generate and exacerbate exchange rate misalignments in terms of fundamentals. These deviations, however, (even if only temporary) can have devastating macroeconomic effects.

Hence, we argue that the interesting aspect of a target zone would be its ability to build *ex ante* credibility, which drives destabilizing noise traders from the market and makes costly intervention on the margins unnecessary. As stressed by 'self-fulfilling' crisis models, the crisis mechanism works through speculators' expectations of the choices the government would make in a tight crisis situation (e.g., Obstfeld 1996). If exchange rate volatility is not credibly contained, noise traders will not be impeded to enter the market.

In this sense, one could argue that the government's firm commitment to defend the exchange rate band lowers the (subjectively felt) risk aversion of fundamentalists, encouraging them to bet more aggressively against destabilizing chartists.<sup>14</sup>

## **4 Empirical analysis: the study of Brazil**

### **4.1 Empirical prelude**

There is extensive empirical evidence that the exchange rate seems to be unrelated to its fundamentals implied by macroeconomic theory. Probably the most prominent paper in

---

<sup>13</sup> This argument is very similar to Krugman and Miller (1993), where a target zone forestalls currency crashes by keeping the exchange rate below the threshold that triggers stop-loss trading. The stabilizing properties of an exchange rate band system, through driving destabilizing noise traders from the system, have also been expressed by Williamson (1983).

<sup>14</sup> That having been said, given emerging markets' position in a hierarchic international monetary system the need to build credibility might require a partial withdrawal from the impossible trinity through the temporary restriction on capital movements (for a concrete proposal in this direction see Nissanke 2005). This might also have implications for the design of the band system—an issue we are aiming to address in our current research programme.

this direction is Meese and Rogoff (1983), who show that a simple random walk has more predictive power of future exchange rate behaviour than any structural model.<sup>15</sup> In a similar vein, Flood and Rose (1999) document that exchange rate volatility is ‘excessive’ in relation to the volatility of underlying fundamentals (money growth and interest rates).

Not only have fundamentals little predictive power for exchange rate behaviour, it has also been shown that exchange rates react unpredictably to news about those fundamentals (e.g., Goodhart 1988; Goodhart and Figliuoli 1991). Interesting for this paper is the result by Andersen et al. (2003), who find that announcement effects are asymmetric (bad news have stronger effects than good news) and seem to be a function of the state of uncertainty in the economy.

Empirical evidence that exchange rate stabilization could come at ‘no cost’ has been convincingly presented by Flood and Rose (1995) and Baxter and Stockman (1989). The authors show that despite increased real exchange rate volatility under flexible exchange rates, they find no systematic differences in the behaviour of macroeconomic aggregates under alternative exchange rate arrangements.

Due to the difficulty to identify and quantify exchange rate fundamentals an extensive share of empirical literature has concentrated on the timeseries properties of exchange rates and discovered anomalies, which stand in stark contrast to the efficient market rational expectations view of foreign exchange markets.<sup>16</sup> First, there is widely documented evidence that exchange rate returns are not normally distributed and are subject to heteroscedasticity. While the first is evidence of large ‘excessive’ spikes in the exchange rate, ARCH effects support the hypothesis of multiple equilibria, where periods of exchange rate tranquillity alternate with periods of turbulence (e.g., de Grauwe and Grimaldi 2006: 5). Of special interest for this paper is the finding by Bauer and Herz (2005), who show that exchange rate trends—representing chartist behaviour—result in higher exchange rate volatility, giving some support to the results presented in Jeanne and Rose (2002).

The predictability of returns in the presence of price trends has led many to test the interesting implication that chartism/technical trading is profitable and survives for long periods. And indeed, results tend to favour the hypothesis that chartism is *on average* profitable and evolutionary stable (e.g., Neely 1997; Schulmeister 2006).

Finally, there is substantial survey evidence on the formation of expectations and alternative trading rules in foreign exchange markets. Frankel (1996), for example, reports that traders, using the ‘chartist technical analysis’ or the ‘momentum’ models, act on extrapolative expectations at short horizons under three months, while they act on adaptive, regressive or distributed lag expectations at longer horizons of three months to

---

<sup>15</sup> Recent empirical work based on cointegration techniques argues that while insignificant in the short run, macroeconomic fundamentals seem to determine the exchange rate in the long run (e.g., Mark 1995). In addition, adjustment (to the fundamentals) might be nonlinear (e.g., Kilian and Taylor 2001).

<sup>16</sup> Another large strand of literature, which points to the fact that exchange rate markets are not populated by rationally optimizing agents, focuses on uncovered interest parity and ‘its failure’ to hold empirically. For an overview, see Lewis (1995) and for a model, which tries to account for this ‘puzzle’ through the presence of noise traders, see Mark and Wu (1998).



one year. Hence, he suggests that the former generates destabilizing speculations, while the latter produces stabilizing effects. In a similar vein, Cheung and Wong (2000) report survey evidence on Asian foreign exchange markets, that short-term variability is largely attributed to non-economic forces including bandwagon effects, overreaction to news, speculation and technical trading, while fundamental trading dominates over longer horizon. In general, survey evidence (see also Allen and Taylor 1992; Menkhoff 1997) reports that technical trading is an important complement to fundamental analysis, used to forecast market psychology and often acting in a self-fulfilling manner, detracting from fundamental analysis. Interestingly, Spahn (2002) notes that chartists may be found more among institutional investors such as investment fund managers, rather than dealers-arbitrageurs. These empirical observations point to the importance of distinguishing those who act as arbitrageurs from those whose behaviour tends to be speculative, pushing markets away from equilibrium.

## 4.2 Hypotheses

The theoretical considerations above have two major implications for exchange rate behaviour. First, it is argued that floating exchange rates are subject to multiple equilibria, where fundamental equilibria alternate with bubble equilibria, in which destabilizing noise traders drive the exchange rate away from its 'equilibrium' level. Second, it has been argued that the credible commitment to a target zone stabilizes the exchange rate 'at not cost' by driving destabilizing noise traders from the market and lowering the risk (perception) of stabilizing traders. Although preliminary results of the existence of multiple equilibria are presented, the primary focus of this paper's empirical work is on the stabilizing effect of a credible target zone.

In general, empirical evidence has not been too kind to Krugman's (1991) original target zone model, where the expectation of intervention at the margin should make speculators act in a stabilizing way and induce mean-reverting behaviour in the exchange rate (Svensson 1992: 125f). However, recent empirical evidence shows that exchange rate policy can have an important effect on the formation of expectations. Jeanne and Rose (2002) show that managed exchange rate regimes have lower forecast dispersion and fewer deviations from uncovered interest parity than floating regimes. Williamson (2000: 23) points out that forward rates normally change by less than spot rates in target zones, indicating the presence of mean-reverting expectations.

## 4.3 Methodology

Due to the difficulty to correctly identify and quantify the underlying exchange rate fundamentals—not to speak of its equilibrium rate—this paper primarily bases itself on observed timeseries behaviour. More concretely, it analyses the simple serial correlation pattern in exchange rate returns implied by the theoretical models presented above. To do so, it applies Lo and MacKinlay's (1988) heteroscedasticity robust variance ratio test, extended by Chow and Denning's (1993) multiple variance ratio test (MVR).<sup>17</sup>

---

<sup>17</sup> The serial correlation tests in this paper are joint tests so that no serial correlation is present at any lagged return under consideration. In this context, however, it has been argued that it is inappropriate to focus on the significance of individual variance ratios without controlling for the joint test size, as this could give rise to the problem of multiple comparisons among test statistics, which causes an

Lo and MacKinlay's (1988: 43) variance ratio test exploits the fact that without serial correlation in returns, the variance of the increments should be linear in the sampling interval. In other words, if a series  $X_t$  is uncorrelated, the variance of its  $q$ -differences would be  $q$  times the variance of its first differences. Formally,

$$\text{Var}(X_t - X_{t-q}) = q\text{Var}(X_t - X_{t-1}) \quad (5)$$

in which  $q$  is any positive integer. The variance ratio is then given by

$$\text{VR}(q) = \frac{\frac{1}{q}\text{Var}(X_t - X_{t-q})}{\text{Var}(X_t - X_{t-1})} = \frac{\sigma_c^2(q)}{\sigma_a^2} \quad (6)$$

And the test statistic

$$\hat{M}_r(q) \equiv \hat{V}\hat{R}(q) - 1 \quad (7)$$

Under the null hypothesis of no serial correlation,  $V(q) = 1$ . The authors derive the asymptotic distribution of the estimated variance ratios and calculate two test-statistics,  $Z(q)$  and  $Z^*(q)$ . While the former tests for homoscedastic uncorrelated increments the latter controls for time varying variance, heteroscedasticity, in returns.<sup>18</sup> Under the null hypothesis the test statistic follows a standard null distribution. Lo and MacKinlay (1988) further show that  $\hat{M}_r(q)$  is asymptotically equal to a weighted sum of autocorrelation coefficients

$$\hat{M}_r(q) = \sum_{j=1}^{q-1} \frac{2(q-j)}{q} \hat{\rho}(j) \quad (8)$$

hence for  $q = 2$

$$\hat{M}_r(2) = \hat{V}\hat{R}(2) - 1 = \hat{\rho}(1) \quad (9)$$

Where  $\hat{\rho}(1)$  is approximately the first-order autocorrelation coefficient of the differences (p. 48).

Using a Monte Carlo experiment Lo and MacKinlay (1989) show that under the heteroscedasticity null (the asset price follows a martingale) the variance ratio test is more powerful than the Box Pierce Q-statistic.<sup>19</sup> In addition, Poterba and Summers

inappropriately large probability of Type I error. Chow and Denning's (1993) MVR test attempts to control for this problem by applying higher critical values to the maximum absolute value of a set of Lo and MacKinlay's test statistics. For a more detailed exposition of methodology and critical values, see Smith, Jefferis and Ryoo (2002) and the Appendix.

<sup>18</sup> For exact methodology and derivation of test-statistics, please see Appendix.

<sup>19</sup> The lack of power of the Q-statistic in the presence of heteroscedasticity might be especially severe in the case of foreign exchange rates, which have been shown to be subject to considerable ARCH effects (e.g., Engle, Ito and Lin 1990). Campbell, Lo and MacKinlay (1997) further point out that the

(1988) find that variance ratio tests have slightly higher power than regression-based tests for serial correlation.

As outlined in the theoretical section, one common way to formalize destabilizing noise trader behaviour is through the use of simple trading rules, such as positive feedback trading or trend chasing, where past prices are extrapolated into the future. This, in turn should result in short-run positive serial correlation in returns. Although this methodology uses a very simplified version of noise trading, it should allow identifying periods of sustained exchange rate trends, caused by chartism or even stronger herding and panic in financial crises, where investors only trade on the currency's past—weakening—value. While evidence of short-run momentum seems to be relatively robust in stock markets, evidence is mixed for the foreign exchange market (e.g., Fong, Koh and Ouliaris 1997; Lee, Liu and Pan 2001).

A second strand of literature has focused on long-run dependencies in asset returns. For example, Poterba and Summers (1988) show that the correlation in returns turns negative as the horizon increases and attribute this mean-reverting behaviour to departures from fundamental values through noise traders and the eventual correction of 'erroneous' market moves (ibid.: 28). Mean-reverting behaviour in the exchange rate has been primarily tested on the basis of unit root tests. This strand of empirical literature has largely concluded that shocks to the exchange rate are permanent and rejected the hypothesis that the exchange rate is a stationary mean-reverting process (e.g., Takagi 1988).

This paper attempts to combine the two approaches presented above. Destabilizing noise trading is operationalized as simple positive feedback trading, which results in short-run positive serial correlation and momentum in returns. In addition, it is conjectured that if an 'overshooting of the overshooting' in response to a shock to the exchange rate takes place, positive serial correlation in the short run should be followed by some form of mean reversion or negative serial correlation in the long run<sup>20</sup>.

In order to test for multiple equilibria the paper applies a methodology used by Yilmaz (2003) and Kim (2004), where moving subsamples of fixed window size are applied to the exchange rate series. This methodology allows distinguishing between the different dynamics of the exchange rate series and—with some precision—identifying the structural breaks and switch to a different equilibrium.

One important caveat to this methodology, however, is that there are several possible alternative explanations for autocorrelation in exchange rate returns. While non-synchronous trading is judged less prevalent in foreign exchange markets, official intervention and a time-varying risk premium have been advanced as possible explanations for the observed autocorrelation.<sup>21</sup> Finally and more fundamentally,

---

power of the Q-statistic will be critically affected by the order of autocorrelations included, which could impede detecting the presence of higher order serial correlation.

<sup>20</sup> The same conjecture is also tested in Cutler, Poterba and Summers (1990), who find significant evidence of short-run serial correlation in excess exchange rate returns, followed by mean reversion in the long run.

<sup>21</sup> Indeed, it has been argued that price deviations from the random walk (martingale) do not by themselves imply market inefficiency, but can result from shifting risk premia which are consistent

foreign exchange behaviour cannot be analysed detached from underlying fundamentals and the analysis of timeseries behaviour can only yield partial results.

The second and main hypothesis presented in this paper is that a credibly managed exchange rate regime—especially in the form of a target zone or crawling band—anchors convention, and drives destabilizing noise traders from the system. As a result, the exchange rate should fluctuate around the band's parity.

Following Myrvin and MacDonald (1998) rather than focusing on exchange rate expectations, this paper directly tests the presence of mean reversion. As regressive expectations dominate 'normal' overshooting à la Dornbusch (1976) and hence short-run negative serial correlation should dominate.

Again, one important caveat to this methodology is that the focus on serial correlation patterns does not allow controlling for other causes of the observed timeseries behaviour. More concretely, it does not allow distinguishing between stabilizing trading and 'leaning against the wind' official exchange rate intervention by the central bank. However, although intervention in a target zone should be limited to the margin—or unnecessary overall, due to the honeymoon effect—intramarginal intervention has been a widespread phenomenon (Svensson 1992).

#### 4.4 Results

The country analysed in this study is Brazil. This choice was motivated by several reasons: First, the focus is on the emerging countries with a certain degree of economic and financial development and integration in international financial markets. Brazil is among the emerging countries with the most developed financial market, where asset market considerations play an important role in the determination of exchange rate behaviour. Second, Brazil introduced a narrow band around the *real* on 6th March 1995 which was maintained until the financial crisis at the beginning of 1999. Since then the central bank of Brazil has followed an inflation-targeting regime, where the exchange rate should only enter the central bank's objective function if it has an effect on inflation. This allows analysing exchange rate behaviour under two very distinct exchange rate regimes. Finally, Brazil's current floating exchange rate regime is characterized by substantial volatility, which could give interesting clues for the analysis of agents' behaviour in emerging countries foreign exchange markets.<sup>22</sup>

The series used is the daily, nominal spot rate to the US\$ dollar, provided by Reuters through the financial statistical database Datastream. Exchange rate returns are calculated as the natural logarithm of the first difference of the nominal exchange rate series. Days with missing data have been deleted.

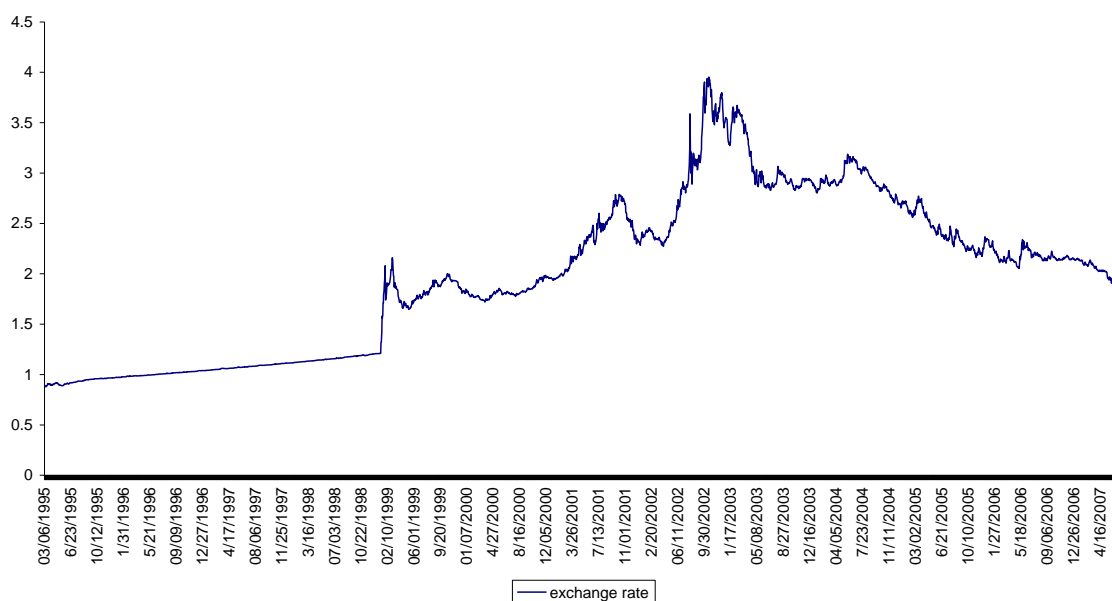
---

with efficient markets (e.g., Leroy 1973; Lucas 1978). In this context, however, Goodhart (1988) argues that 'without an explicit theory of why there is such a premium and why it varies, it has not function but tautologically to save the theory' (Mankiw and Summers 1984; Goodhart 1988). In addition, Shleifer and Summers (1990) argue that observed asset price changes seem too excessive to be accounted for by a changing risk premium.

<sup>22</sup> However, these characteristics are not exclusive for Brazil and indeed in our current research programme we also analyse other emerging markets such as Chile, Indonesia and Thailand. Results are available upon request.

Figure 1 shows nominal exchange rate behaviour over the two distinct exchange rate regimes. While relative nominal exchange rate stability during the crawling band regime found its end in a financial crisis at the end of 1998, the subsequent ‘floating’ period has been characterized by two distinct trends: a sustained period of depreciation until the beginning of 2003 and a recent appreciation trend. In addition, the years between 2001 and 2003 are characterized by high volatility or even crisis.<sup>23</sup>

Figure 1  
Brazil daily spot nominal US\$ exchange rate, 6 March 1995 to 23 July 2008



Source: Datastream.

Table 1  
Preliminary statistical indicators for band and floating period, Brazil

	Band	Float
	6 March 1995 until 12 January 1999	2 February 1999 to 23 July 2007
Mean	0.00034	-0.00003
SD	0.00179	0.01026
Skewness	3.332683*	-5.5459
Kurtosis	50.50642*	19.93752*
Jar-Be	96558.16*	26526.63*
Q(1)	0.32	18.884
Q(6)	10.03	72.687
Q(12)	79.68*	77.844*
No. of obs	1007	2210

Note: \*indicates rejection of 0.05 level.

<sup>23</sup> An obvious and important caveat to this section is the presence of ‘fear of floating’. Despite a de jure exchange rate regime of a free float, several authors (e.g., Calvo and Reinhart 2000; Levy-Yeyvati and Sturzenegger 2002) have shown that countries significantly manage their exchange rates. This evidence is partly confirmed by data on foreign exchange market intervention by the Brazilian central bank and highlights the importance of considering this important actor when analysing exchange rate behaviour.

Table 1 presents preliminary statistics about the difference in exchange rate behaviour between the band and floating exchange rate regime.

Several points seem noteworthy. First, while the Brazilian *real* depreciated during the managed regime, the floating period is characterized by an appreciating currency. Second, and expectedly, the volatility, as measured in terms of standard deviation, is substantially higher in the floating regime. Third, deviations from normality are even more pronounced in the managed exchange rate regime. Finally, and probably most interestingly for this study, the managed exchange rate regime seems to be characterized by less autocorrelation in returns than the floating period. Although the evidence on ARCH effects is slightly less marked in the managed regime, this does not seem to fully explain the reduction in autocorrelation.

We have argued in this paper that floating exchange rate regimes are characterized by multiple equilibria, where calm periods alternate with periods during which destabilizing noise traders deviate the exchange rate from its 'equilibrium value'. Destabilizing noise trading is operationalized as simple positive feedback trades, resulting in short-run positive serial correlation. Hence, in the presence of multiple equilibria, periods of no or insignificant serial correlation should alternate with periods of significant return dependency. We have further argued that in the presence of destabilizing noise traders which cause the exchange rate to overshoot, a period of positive serial correlation should be followed by long-run mean-reverting behaviour.

Finally, the stabilizing properties of exchange rate band systems should result in negatively correlated exchange rate returns as destabilizing noise traders are deterred from the market.

In order to test these hypotheses, and derive some indications about the differential exchange rate behaviour in alternative exchange rate regimes, Lo and MacKinlay's variance ratio test is applied to a fixed size moving sub-sample. The window size is chosen at 512 observations.<sup>24</sup> As the focus is on short-run serial correlation only lags of 2, 5 and 10 are considered.<sup>25</sup> In Figures 2 and 3, Chow and Denning's (1993) adjusted critical values are reported.

Figures 2 and 3 present our results. Several points are noteworthy. First, there seems to be preliminary support for our hypothesis of differing exchange rate dynamics, depending on the exchange rate regime in place. As can be seen from the variance ratio in Figure 3, a period of negative serial correlation during Brazil's band systems is followed by positive serial correlation during the floating period. This evidence is especially strong for the short-run serial correlation separated by one lag ( $V(2)$ ).

Second, it is evident that the inclusion of the crisis days in the moving sample results in a considerable jump in the test statistic and significant correlation in exchange rate

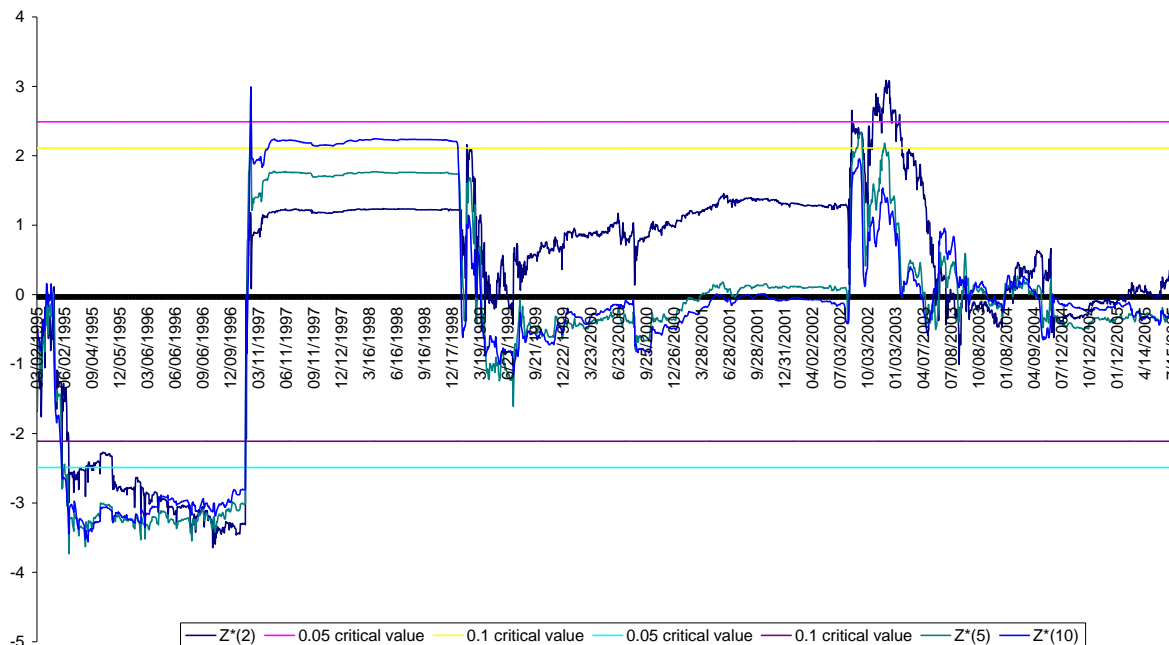
---

<sup>24</sup> Chow and Denning show that for a sample size of above and equal 512, the power of the multiple variance ratio test is comparable with the ADF and PP test for a unit root against an AR(1) process and much more powerful against an ARIMA (1,1,1) and ARIMA (1,1,0). Furthermore, choosing a larger sample size could mask important exchange rate dynamics and structural breaks.

<sup>25</sup> Sensitivity tests were applied and lags above 20 were hardly ever significant. In addition, the decision to restrict results to three variables was motivated to maintain the clarity of results.

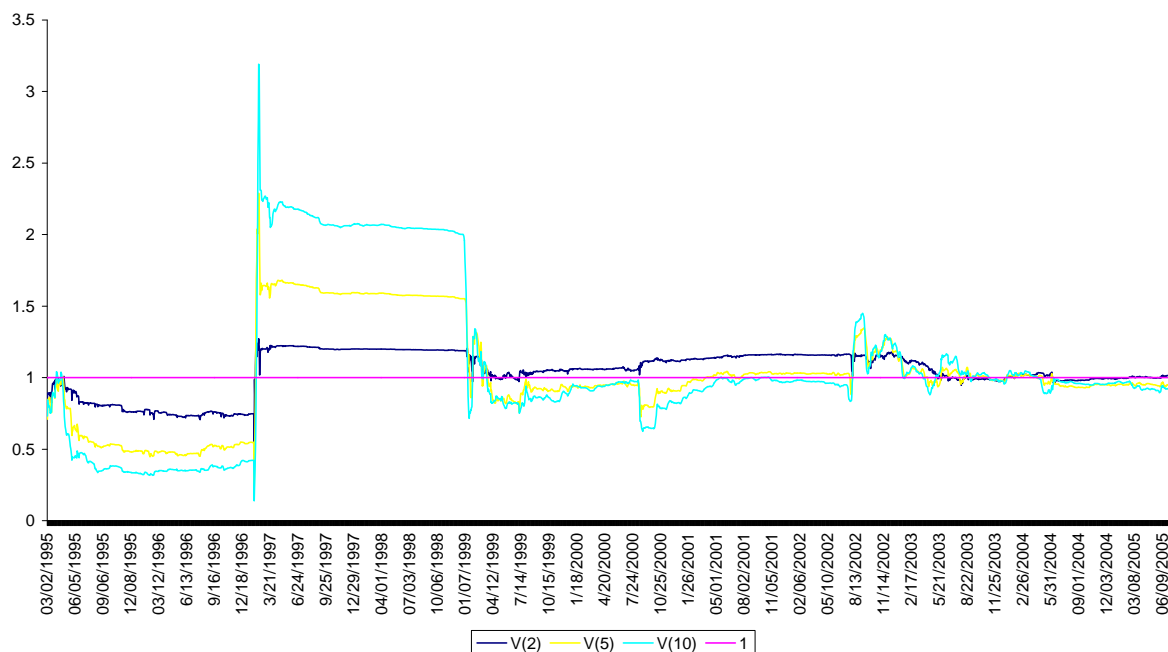
returns. This in turn could point to the fact that the devaluation of the currency and increased risk environment drove stabilizing fundamentalists from the market, while ‘irrational’ feedback traders moved the currency away from its fundamental value.

Figure 2  
Brazil, Heteroscedasticity robust test statistics  $Z^*(q)$



Source: Datastream for exchange rate; variance ratio best based on authors' own calculations.

Figure 3  
Brazil: Variance ratio  $V(q)$



Notes: X-axis denotes the starting period of the moving sample; Results have been tested for robustness to outliers in the data; Large spikes in the results have been removed from the graph for clarity. Only heteroscedasticity robust critical values are reported; Standard normal 0.05 critical value 1.96; Chow and Denning (1993) 0.1 critical value 2.23 and 0.05 critical value 2.49.

Source: Datastream for exchange rate; variance ratio best based on authors' own calculations.

Third, the current floating exchange rate regime is characterized by at least one period of significant positive autocorrelation. This provides strong preliminary support for the hypothesis of multiple equilibria.<sup>26</sup> However, there are two main caveats to this result. First, they are incomplete. As outlined above, the analysis of timeseries behaviour detached from ‘fundamentals’ or the risk environment has little explanatory power. Rather than knowing that there are changing equilibria, it would be crucial to analyse *why* and *under what market conditions* this change takes place. Second, there is a problem of identification. Although the methodology of a moving sub-sample can locate structural breaks and periods of different market behaviour, it is difficult to determine the exact switch between the equilibria.<sup>27</sup>

Fourth, one has to be clear about how to interpret these results. The methodology presented above might not be able to discover noise traders or technical trading, which are based on exploiting short-term trends in the data and contribute to higher volatility in exchange rates.<sup>28</sup> However, it shows that the interaction between heterogeneous traders in foreign exchange markets and/or the uncertainty about a ‘true’ underlying value can give rise to periods of speculative bubbles, characterized by feedback trading (possibly the result of herding), driving the exchange rates away from its underlying value.<sup>29</sup>

Table 2 confirms our results obtained from the moving sample application.

First, although not significant, it shows that while variance ratios for the floating period are all higher than one, indicating positive serial correlation, they are below one during the band system. This in turn could confirm our hypothesis of mean-reverting behaviour in target zones, as destabilizing noise traders are deterred from the system. However, as also previously mentioned, this methodology cannot distinguish between stabilizing trading and ‘leaning against the wind’ policies by the central bank. Hence, in order to obtain a full picture of exchange rate dynamics, the above results would have to be seen in conjunction with foreign exchange intervention.

Second, it is interesting to note that the inclusion of the crisis days in the variance ratio tests leads to significant positive serial correlation in returns and a rejection of the null hypothesis of a unit root. In other words, if taking the crisis years under consideration positive serial correlation is followed by mean-reverting behaviour. This in turn could serve as strong evidence that in the crisis destabilizing noise traders drove the exchange

---

<sup>26</sup> The period of significant serial correlation seems to coincide with the financial turmoil around the election of President Lula and (unwarranted) fears about a change in economic policy ‘to the left’. In addition, concerns about the large domestic debt and the future of IMF assistance contributed to the uncertainty.

<sup>27</sup> Attempts to locate such a ‘switching point’ have been made through the use of fixed endpoints. However, although this procedure helps to locate the switch more precisely, results are not robust, due to the varying sample size. Again, results are available on request.

<sup>28</sup> An identification of these phenomena would probably require higher frequency data and a more detail study of ‘events’.

<sup>29</sup> This caveat is also warranted given the reduction in positive serial correlation at the end of the sample, despite an obvious and continuous appreciation trend. The authors would conjecture this is due to the intermittent volatility in exchange rate behaviour, whose origin is subject to current research.



rate away from its underlying value, as the increasing risk environment deterred stabilizing arbitrageurs from the market.

Table 2  
Variance ratio tests for band and floating period

			q = 2	q = 5	q = 10	q = 20	ADF
Float	Excluding crisis	V(q)	1.0903	1.0132	0.9769	1.0314	-0.96741
		Z*(q)	1.511	0.0989	-0.1218	0.1303	0.7666
	Including crisis	V(q)	<b>1.1215</b>	1.0822	1.0213	0.974	<b>-2.993726</b>
		Z*(q)	2.0757*	0.6299	0.112	-0.1046	0.0356
Band		V(q)	0.858	0.751	0.771	0.465	<b>-7.250655</b>
		Z*(q)	-1.659	-1.370	-0.857	-1.328	0

Note: \*significant at 5% level according to standard normal (0.05 critical value is 1.96)

## 5 Concluding remarks

There have been intense debates among policymakers as well as academics what could be appropriate exchange rate regimes for emerging market economies in a world of free capital mobility. The paper aims at contributing to this discourse by presenting the case for an intermediate exchange rate regime. While macroeconomic literature has so far conducted theoretical and empirical discussions in relation to the infamous proposition of ‘impossible trinity thesis’, this paper attempted to examine the case for an intermediate regime from a microeconomic perspective, drawing on recent theoretical and empirical literatures on behavioural finance and currency market structures.

Thus, in this paper, exchange rate dynamics are analysed, not as a result of market equilibrating forces, but as one resulting from changing expectations and behaviour of heterogeneous traders in currency markets, in particular from complex, non-linear interactions of destabilizing noise trading and stabilizing fundamentalists. In our analysis, a distinction between noise trading based on chartism/momentum trading (chartists) and trading based on economic fundamentals (fundamentalists) is made, not in terms of two distinct types of trading agents operating in markets, but in terms of trading rules, which can be combined in one agent and can prevail depending on market conditions. Seen from this perspective, it is shown that markets are characterized by two different kinds of equilibria: a *fundamental* equilibrium, where the exchange rate is kept close to its fundamental value, and a *bubble* equilibrium, where destabilizing noise trading dominates. It is conjectured that as a market condition shifts from the former to the latter, the exchange rate becomes disconnected from its fundamental value and experiences higher short-term volatility than fundamentals warrant.

We argued in this context that the interaction between heterogeneous trading strategies is not placed in a vacuum, but influenced by what we refer to as *objective* and *subjective* market conditions. In this context, the exchange rate regime is viewed as the most important institutional setting, wherein subjectively and objectively perceived risk parameters are determined, which in turn shape the interaction between stabilizing and destabilizing trading strategies. While leaving a fuller analysis of objective market conditions, i.e., *fundamentals* and their effects on exchange rate dynamics to our future research agenda, this paper focused on the role of subjective market conditions in shaping the critical interface between heterogeneous traders. These in turn, we argued, will critically depend on the particular exchange rate regime in operation, which will

shape the behaviour of foreign exchange market participants and effectively change market structure. For example, a *credible* exchange rate regime in the form of target zones or Williamson's BBC regime (basket, band and crawl) will impede destabilizing noise traders to enter the market, and hence will stabilize exchange rates at no cost.

We applied our theoretical conjectures to an empirical study of Brazil's foreign exchange market. Brazil switched from a managed band regime to market-based floating regime after experiencing a speculative currency attack at the end of 1998. Since then the central bank has followed an inflation-targeting regime, under which exchange rate movements should only enter the bank's objective function if at odds with its inflation target. As a result, its current floating exchange rate regime has been characterized by substantial volatility. With our comparative empirical analysis of Brazil's foreign exchange market under different exchange rate regimes we thus aimed at acquiring some valuable insights into how foreign exchange markets are structured and performed in an era of financial globalization, as the outcome of interactive forces among heterogeneous market traders/participants as well as between market traders on the one hand and the central bank on the other.

Our analysis of exchange rate dynamics with explicitly endogenizing market structures could have important implications for exchange rate policy. While mainstream economics has settled on the two corner consensus, policymakers in emerging countries acknowledge the need for an intermediate exchange rate regime, which provides stability while leaving enough flexibility to react to internal and external shocks and adjust to changing structural characteristics. However, although acknowledging the importance of stabilized exchange rates, policymakers shy away from any renewed institutional commitment to an exchange rate target due to the fear of speculative attacks. Hence, existing *de facto* pegs are supported by a war-chest of foreign exchange reserves which aim to prevent a run on the currency. However, as has been argued in this paper institutional commitment will be crucial to change foreign exchange market structures and effectively drive destabilizing noise traders from the system. The credible commitment to an exchange rate band should make the holding of large reserves for self-insurance purposes unnecessary and allow investing valuable foreign exchange reserves into productive projects.

While this paper focused on the importance of subjective market conditions in shaping exchange rate dynamics, a deeper understanding of exchange rate behaviour will need a critical analysis of objective market conditions, or so-called fundamentals. Although touched upon only briefly in the present paper, we suggest that an analysis of motivations and behaviour of asset market players incorporating a fuller study of fundamentals will allow us to further deepen our knowledge of how markets function under different exchange rate regimes. This will also require a thorough consideration of the role of the central bank in the price formation process. Finally, although the analysis of exchange rate dynamics provided preliminary evidence on the existence of noise trading, research effort has to be directed towards identifying the specific actors and their strategies applied. These questions are subject of our on-going research efforts.

## References

- Agénor, P.-R., and P. J. Montiel (1996). *Development Macroeconomics*. Princeton: Princeton University Press.
- Allen, H., and M. Taylor (1992). 'The Use of Technical Analysis in the Foreign Exchange Market'. *Journal of International Money and Finance*, 11 (3): 304-14.
- Alvés, A. J., F. Ferrari-Filho, and L. de Paula (2000). 'The Post Keynesian Critique of Conventional Currency Crisis Models and Davidson's Proposal to Reform the International Monetary System'. *Journal of Post Keynesian Economics*. 22 (2): 207-26.
- Andersen, T. G., T. Bollerslev, F. X. Diebold, and C. Vega (2003). 'Micro Effects of Macro Announcements: Real Time Price Discovery in Foreign Exchange'. *American Economic Review*, 93 (March): 38-62.
- Bacchetta, P., and E. van Wincoop (2004). 'A Scapegoat Model of Exchange Rate Fluctuations'. *American Economic Review*, 94 (2): 114-18.
- BIS (Bank for International Settlement) (2005). 'Triennial Central Bank Survey. Foreign Exchange and Derivatives Market Activity in 2004'. Basel: BIS.
- Barberis, N., A. Shleifer, and R. Vishny (1998). 'A Model of Investor Sentiment'. *Journal of Financial Economics*, 49: 307-43.
- Bauer, C., and C. Herz (2005). 'Technical Trading, Monetary Policy, and Exchange Rate Regimes'. *Global Finance Journal*, 15 (3): 281-302.
- Baxter, M., and A. Stockman (1989). 'Business Cycles and the Exchange Rate System'. *Journal of Monetary Economics*, 23: 377-400.
- Bordo, M., and M. Flandreau (2001). 'Core, Periphery, Exchange Rate Regimes and Globalization'. Paper presented at the NBER conference on Globalization in Historical Perspective, 4-5 May, Santa Barbara.
- Brock, W., and C. Hommes (1997). 'A Rational Route to Randomness'. *Econometrica*, 65 (5): 1059-95.
- Brock, W., and C. Hommes (1998). 'Heterogeneous Beliefs and Routes to Chaos in a Simple Asset Pricing Model'. *Journal of Economic Dynamics and Control*, 22 (8-9): 1235-74.
- Calvo, G. A. (2000). 'The Case for Hard Pegs in the Brave New World of Global Finance'. Paper presented at the World Bank ABCDE-Europe Conference, 26-28 June, Paris.
- Calvo, G. A., and C. Reinhart (2002). 'Fear of Floating'. *Quarterly Journal of Economics*, 117 (May): 379-408.
- Campbell, J. Y., A. W. Lo, and A. C. MacKinlay (1997). *The Econometrics of Financial Markets*. Princeton: Princeton University Press.
- Cheung, Y. W., and C. Y. P. Wong (2000). 'A Survey of Market Practitioners' View on Exchange Rate Dynamics'. *Journal of International Economics*, 51 (2): 401-19.
- Chow, V. K., and K. C. Denning (1993). 'A Simple Multivariate Variance Ratio Test'. *Journal of Econometrics*, 58: 385-401.

- Cutler, D., J. Poterba, and L. Summers (1990). 'Speculative Dynamics and the Role of Feedback Traders'. *The American Economic Review*, 80 (2): 63-68.
- Daniel, K., D. Hirshleifer, and A. Subrahmanyam (1998). 'Investor Psychology and Security Market Over and Underreactions'. *The Journal of Finance*, 53 (6): 1839-85.
- Davidson, P. (2002a). 'Policies for Fighting Speculation in Foreign Exchange Markets: The Tobin Tax versus Keynes's Views'. In S. Dow and J. Hilard (eds), *Keynes, Uncertainty and the Global Economy*. Cheltenham: Edward Elgar, 201-22.
- Davidson, P. (2002b). *Financial Markets, Money and the Real World*. Cheltenham: Edward Elgar.
- De Grauwe, P., and M. Grimaldi (2006). *The Exchange Rate in a Behavioural Finance Framework*. Princeton: Princeton University Press.
- DeLong, B., A. Shleifer, L. Summers, and R. Waldmann (1990a). 'Positive Feedback Investment Strategies and Destabilizing Rational Speculation'. *The Journal of Finance*, 45 (2): 379-95.
- DeLong, B., A. Shleifer, L. Summers, and R. Waldmann (1990b). 'Noise Trader Risk in Financial Markets'. *The Journal of Political Economy*, 98 (4): 703-38.
- Dornbusch, R. (1976). 'Expectations and Exchange Rate Dynamics'. *Journal of Political Economy*, 84 (6): 1161-76.
- Eichengreen, B. (1999). *Toward A New International Financial Architecture: A Practical Post-Asia Agenda*. Washington, DC: Institute for International Economics.
- Eichengreen, B., and R. Hausmann (1999). 'Exchange Rates and Financial Fragility'. Paper presented at the Pacific Basin Conference: Financial Crises in Emerging Markets, September.
- Engle, R., T. Ito, and W.-L. Lin (1990). 'Meteor Showers or Heat Waves? Heteroscedastic Intra-Day Volatility in the Foreign Exchange Market'. *Econometrica*, 58 (3): 525-42.
- Fama, E. (1965). 'The Behaviour of Stock Market Prices'. *Journal of Business*, 38 (1): 34-105.
- Farmer, D., and S. Joshi (2002). 'The Price Dynamics of Common Trading Strategies'. *Journal of Economic Behaviour and Organization*, 49 (2): 149-71.
- Flood, R. and A. Rose (1995). 'Fixing Exchange Rates: A Virtual Quest for Fundamentals'. *Journal of Monetary Economics*, 36 (1): 3-37.
- Flood, R., and A. Rose (1999). 'Understanding Exchange Rate Volatility without the Contrivance of Macroeconomics'. *The Economic Journal*, 109 (459): 660-72.
- Fong, W. M., S. K. Koh, and S. Ouliaris (1997). 'Joint Variance-Ratio Tests of the Martingale Hypothesis for Exchange Rates'. *Journal of Business & Economic Statistics*, 15 (1): 51-9.
- Frankel, J. (1996). 'How Well Do Foreign Exchange Markets Work: Might a Tobin Tax Help?'. In M. ul Haq, I. Kaul and I. Grunberg (eds), *The Tobin Tax: Coping with Financial Volatility*. Oxford: Oxford University Press.
- Frankel, J. (1999). 'No Single Currency Regime is Right for All Countries or At All Times'. NBER Working Paper 7338. Cambridge, MA: National Bureau of Economic Research.

- Frankel, J. and K. Froot (1990). 'Chartists, Fundamentalists and the Demand for Dollars'. In A. S. Courakis and M. P. Taylor (eds), *Private Behaviour and Government Policy in Interdependent Economies*. Oxford: Clarendon Press, 73-126.
- Friedman, M. (1953). 'The Case for Flexible Exchange Rates'. In M. Friedman (ed.), *Essays in Positive Economics*. Chicago: Chicago University Press, 157-203.
- Galati, G., and M. Melvin (2005). 'Why Has Foreign Exchange Trading Surged?'. Supplement to the Bank of International Settlement, Triennial Central Bank Survey: Foreign Exchange and Derivatives.
- Goodhart, C. (1988). 'The Foreign Exchange Market: A Random Walk with a Dragging Anchor'. *Economica*, 55 (220): 437-60.
- Goodhart, C., and L. Figliuoli (1991). 'Every Minute Counts in Financial Markets'. *Journal of International Money and Finance*, 10 (1): 23-52.
- Harvey, J. (2001). 'Exchange Rate Theory and "the Fundamentals" '. *Journal of Post Keynesian Economics*, 24 (1): 3-15.
- Heimonen, K. (2006). 'Time-Varying Fundamentals of the Euro-Dollar Exchange Rate.. *International Economic Journal*, 20 (4): 385-407.
- Husain A. M., A. Mody, and K. Rogoff (2005). 'Exchange Rate Regime Durability and Performance in Developing Versus Advanced Economies'. *Journal of Monetary Economics*, 52 (1): 35-64.
- Jeanne, O. (2007). 'International Reserves in Emerging Market Countries: Too Much of a Good Thing?'. *Brookings Papers on Economic Activity*, 1: 1-55.
- Jeanne, O., and A. Rose (1999). 'Noise Trading and Exchange Rate Regimes'. NBER Working Paper 7104. Cambridge, MA: National Bureau of Economic Research.
- Jeanne, O., and A. Rose (2002). 'Noise Trading and Exchange Rate Regimes'. *The Quarterly Journal of Economics*, 117 (2): 537-69.
- Keynes, J .M. (1936/1997). *The General Theory of Employment, Interest and Money*. Amherst: Prometheus Books.
- Kilian, L., and M. Taylor (2001). 'Why Is It so Difficult to Beat the Random Walk Forecast of Exchange Rates?'. Tinbergen Institute Discussion Paper 01-031/4. Amsterdam: Tinbergen.
- Kim, J. (2004). 'Testing for the Martingale Hypothesis in Asian Stock Prices: Evidence from a New Joint Variance Ratio Test'. Caulfield East: Department of Econometrics and Business Statistics, Monash University.
- Krugman, P. (1991). 'Target Zones and Exchange Rate Dynamics'. *Quarterly Journal of Economics*, 106 (3): 669-82.
- Krugman, P., and M. Miller (1993). 'Why have a Target Zone?'. *Carnegie-Rochester Conference Series on Public Policy*, 38: 279-314.
- Lee, C., A. Liu, and M.-S. Pan (2001). 'On Market Efficiency of Asian Foreign Exchange Rates: Evidence from a Joint Variance Ratio Test and Technical Trading Rules'. *Journal of International Financial Markets, Institutions and Money*, 11 (2): 199-214.

- Lewis, K. (1995). 'Puzzles in International Financial Markets'. In G. M. Grosman and K. Rogoff (eds), *Handbook of International Economics*, vol. 3. Amsterdam: North Holland.
- Leroy, S. (1973). 'Risk Aversion and the Martingale Property of Stock Returns'. *International Economic Review*, 14: 436-46.
- Levy-Yeyatis, E., and F. Sturzenegger (2002). 'Classifying Exchange Rate Regime: Deeds versus Words. Buenos Aires: Universidad Torcuato di Tella. Mimeo.
- Lo, A. W., and C. MacKinlay (1988). 'Stock Market Prices Do Not Follow Random Walks: Evidence form a Simple Specification Test'. *The Review of Financial Studies*, 1 (1): 41-66.
- Lo, A. W., and C. MacKinlay (1989). 'The Size and Power of the Variance Ratio Test in Finite Samples: A Monte Carlo Investigation'. *Journal of Econometrics*, 40 (2): 203-38.
- Lucas, R., Jr. (1978). 'Asset Prices in an Exchange Economy'. *Econometrica*, 46 (6): 1429-45.
- Lux, T., and M. Marchesi (2000). 'Volatility Clustering in Financial Markets: A Micro-Simulation of Interacting Agents'. *International Journal of Theoretical and Applied Finance*, 3 (4): 675-702.
- Mankiw, H. G., and L. H. Summers (1984). 'Do Long-term Interest Rates Over-react to Short-term Interest Rates?'. *Brookings Papers on Economic Activity*, 1: 223-47.
- Mark, N. (1995). 'Exchange Rates and Fundamentals: Evidence on Long-Horizon Predictability'. *American Economic Review*, 85 (1): 29-52.
- Mark, N., and Y. Wu (1998). 'Rethinking Deviations from Uncovered Interest Parity: The Role of Covariance Risk and Noise'. *The Economic Journal*, 108 (451): 1686-1706.
- Meese, R., and K. Rogoff (1983). 'Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample?'. *Journal of International Economics*, 14 (1-2): 3-24.
- McKinnon, R., and G. Schnabl (2004). 'The East Asian Dollar Standard, Fear of Floating and Original Sin'. *Review of Development Economics*, 8 (3): 331-60.
- Menkhoff, L. (1997). 'Examining the Use of Technical Currency Analysis'. *International Journal of Finance and Economics*, 2 (4): 307-18.
- Miller, M., and L. Zhang (2007). 'Fear and Market Failure: Global Imbalances and Self-Insurance'. CSGR Working Paper 216/07. Warwick: Centre for the Study of Globalization and Regionalization.
- Myrvin, A., and R. MacDonald (1998). 'On the Mean-Reverting Properties of Target Zone Exchange Rates: Some Evidence from the ERM'. *European Economic Review*, 42 (8): 1493-1523.
- Neely, C. J. (1997). 'Technical Analysis in the Foreign Exchange Market: A Layman's Guide'. *Review of the Federal Reserve Bank of St. Louis*, September: 23-38.
- Nissanke, M. (2005). 'Revenue Potential of the Tobin Tax for Development Finance: A Critical Appraisal'. In A. B. Atkinson (ed.), *New Sources of Development Finance*. Oxford: Oxford University Press for UNU-WIDER.

- Obstfeld, M. (1996). 'Models of Currency Crises with Self-Fulfilling Features'. *European Economic Review*, 40: 1037-47.
- Poterba, J., and L. Summers (1988). 'Mean Reversion in Stock Prices: Evidence and Implications'. *Journal of Financial Economics*, 22 (1): 27-59.
- Rose, A. (1996). 'Explaining Exchange Rate Volatility: An Empirical Analysis of the "Holy Trinity" of Monetary Independence, Fixed Exchange Rates, and Capital Mobility'. *Journal of International Money and Finance*, 15 (6): 925-45.
- Schulmeister, S. (2006). 'The Interaction between Technical Currency Trading and Exchange Rate Fluctuations'. *Finance Research Letters*, 3 (3): 212-33.
- Shleifer, A., and L. Summers (1990). 'The Noise Trader Approach to Finance'. *Journal of Economic Perspectives*, 4 (2): 19-33.
- Smith, G. (2007). 'Variance Ratios'. Lecture Note Handout. London: School of Oriental and African Studies, University of London.
- Smith, G., K. Jefferis, and H.-J. Ryoo (2002). 'African Stock Markets: Multiple Variance Ratio Tests of Random Walks'. *Applied Financial Economics*, 12 (7): 475-84.
- Spahn, P. B. (2002). 'On the Feasibility of a Tax on Foreign Exchange Transactions'. Report to the Federal Ministry for Economic Cooperation and Development. Frankfurt am Main: Goethe-Universität.
- Svensson, L. (1992). 'An Interpretation of Recent Research on Exchange Rate Target Zones'. *The Journal of Economic Perspectives*, 6 (4): 119-44.
- Takagi, S. (1988). 'On the Statistical Properties of Floating Exchange Rates: A Reassessment of Recent Experience and Literature'. IMF Working Paper 88/11. Washington, DC: International Monetary Fund.
- Taylor, J. B. (2001). 'The Role of the Exchange Rates in Monetary-Policy Rules'. *AEA Papers and Proceedings, American Economic Review*, 91 (2): 263-67.
- Westerhoff, F. (2003). 'Heterogeneous Traders and the Tobin Tax'. *Journal of Evolutionary Economics*. 13 (1): 53-70.
- Williamson, J. (1983). *The Exchange Rate System*. Policy Analyses in International Economics 5. Cambridge, MA: MIT Press for the Institute for International Economics.
- Williamson, J. (ed.) (1994). *Estimating Equilibrium Exchange Rates*. Washington, DC: Institute for International Economics.
- Williamson, J. (2000). *Exchange Rate Regimes for Emerging Markets: Reviving the Intermediate Options*. Washington, DC: Institute for International Economics.
- Xu, J. (2005). 'Noise Traders, Exchange Rate Disconnect Puzzle and Tobin Tax'. Discussion Paper Series. Hong Kong: School of Economics and Finance, University of Hong Kong.
- Yilmaz, K. (2003). 'Martingale Property of Exchange Rates and Central Bank Intervention'. *Journal of Business and Economic Statistics*, 21: 383-95.

## Appendix: Variance ratio tests

### A1 Lo and MacKinlay Variance ratio test

The variance ratio is given by

$$VR(q) = \frac{\sigma^2_c(q)}{\sigma^2_a}$$

Lo and MacKinlay (1988) consider a sample size of  $nq+1$  observations  $(X_0, X_1, \dots, X_{nq})$ . Unbiased estimators of  $\sigma^2_c(q)$  and  $\sigma^2_a(q)$  are given by

$$\hat{\sigma}^2_a = \frac{1}{nq-1} \sum_{k=1}^{nq} (X_k - X_{k-1} - \hat{\mu})^2$$

and

$$\hat{\sigma}^2_c(q) = \frac{1}{m} \sum_{k=q}^{nq} (X_k - X_{k-q} - q\hat{\mu})^2$$

where  $\hat{\mu}$  is the sample mean of  $(X_t - X_{t-1})$  and

$$m = q(nq - q + 1) \left(1 - \frac{q}{nq}\right)$$

The test-statistic is defined as

$$\hat{M}_r(q) \equiv V\hat{R}(q) - 1$$

The asymptotic variance of the test-statistic under homoscedasticity is

$$\hat{\sigma}^2_0(q) = \frac{2(2q-1)(q-1)}{3q}$$

The standard normal test-statistic under homoscedasticity,  $Z(q)$ , is then

$$Z(q) = \frac{\sqrt{nq} \hat{M}_r(q)^a}{[\hat{\sigma}^2_0(q)]^{\frac{1}{2}}} \sim N(0,1)$$

Using the result that  $\hat{M}_r(q)$  is asymptotically equal to a weighted sum of autocorrelation coefficient estimates,

$$\hat{M}_r(q) \stackrel{a}{=} \sum_{j=1}^{q-1} \frac{2(q-j)}{q} \hat{\rho}(j)$$



The asymptotic variance of the test statistic under heteroscedasticity is

$$\hat{\sigma}^2_e = \sum_{j=1}^{q-1} \left[ \frac{2(q-j)}{q} \right]^2 \hat{\delta}(j)$$

where

$$\hat{\delta}(j) = \frac{\sum_{k=j+1}^{nq} (X_k - X_{k-1} - \hat{\mu})^2 (X_{k-j} - X_{k-j-1} - \hat{\mu})^2}{\left[ \sum_{k=1}^{nq} (X_k - X_{k-1} - \hat{\mu})^2 \right]^2}$$

The heteroscedasticity-consistent standard normal test-statistic,  $Z^*(q)$  is then given by

$$Z^*(q) = \frac{\sqrt{nq} \hat{M}_r(q)^a}{[\hat{\sigma}^2_e]^{\frac{1}{2}}} \sim N(0,1)$$

## A2 Chow and Denning's multiple variance ratio tests

The serial correlation tests presented in the paper are joint tests that no serial correlation is present at any lagged return under consideration. In essence, a set of multiple subhypotheses

$$H_{0i} : M_r(q_i) = 0 \quad \text{for } i = 1, 2, \dots, m \quad (10)$$

$$H_{1i} : M_r(q_i) \neq 0 \quad \text{for any } i = 1, 2, \dots, m \quad (11)$$

is tested.

In this context it has been argued that it is inappropriate to focus on the significance of individual variance ratios without controlling for the joint test size. This could give rise to the problem of multiple comparisons among test statistics, which in turn causes an inappropriately large probability of Type I error (Chow and Denning 1993).

The authors propose a multiple variance ratio (MVR) test, based on the maximum absolute value of a set of Lo and MacKinlay's test statistics, and studentized maximum modulus (SMM) critical values to control for the overall test size and define a joint confidence interval for the variance ratio estimates. The core of their test is based on the result

$$PR[\max(|Z(q_1)|, \dots, |Z(q_m)|) \leq SMM(\alpha; m; T)] \geq 1 - \alpha \quad (12)$$

in which  $SMM(\alpha; m; T)$  is the upper  $\alpha$  point of the SMM distribution with parameters  $m$  and  $T$  (sample size) degrees of freedom.

Asymptotically, when  $T$  is finite

$$SMM(\alpha; m; \infty) = Z_{\alpha^*/2} \quad (13)$$

If the maximum absolute value of either  $Z(q)$  or  $Z^*(q)$  is greater than the SMM critical value at a predetermined significance level, then the null hypothesis of no serial correlation in any of the returns considered is rejected (see also Smith, Jefferis and Ryoo 2002).

### Critical values

#### SMM( $\alpha, m, \infty$ )

$\alpha$	m		
	3	4	5
0.1	2.11	2.23	2.31
0.05	2.39	2.49	2.57
0.01	2.93	3.01	3.09

Source: Smith (2007).