Exchange Rate Expectations, Uncertainty and Output in the Southern Cone

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Declaration

I hereby declare that this thesis has not been and will not be submitted in whole or in part to another University for the award of any other degree.

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Summary

In this thesis we investigate the effects of real exchange rate (RER) uncertainty on output in the context of Southern Cone economies. The first chapter provides a framework to analyze the output effects of RER uncertainty when firms contract dollar-debt and no hedging instruments are available, by focusing on the channel uncertainty-output operating through the firms financial strategy. An increase in uncertainty increases the probability of bankruptcy, raising expected marginal bankruptcy costs, and reducing optimal output of a risk-neutral firm. We find the output response to uncertainty shocks to depend on firms' liquidity balances, trade orientation and perceptions about government assistance if large exchange rate movements occur. The second chapter examines empirically RER uncertainty effects on sectoral output for 28 manufacturing sectors in the Southern Cone over 1970-2002. We use alternative uncertainty measures allowing different degrees of sophistication in agents' expectation mechanisms to estimate a supply function. We use instrumental variable techniques to address potential simultaneity problems. Results suggest a negative non-negligible effect of uncertainty on output, threshold effects, and sectoral heterogeneity, explained by trade orientation, the intensity with which sectors trade within Mercosur and by sectoral productivity. The fourth chapter investigates the importance of past exchange rate behaviour when forming expectations and tests for the uncovered interest parity (UIP) hypothesis in Uruguay. Using interest rate differentials over 1980-2010 we identify a strong extrapolative component in expectations, following an inverted-U pattern over time. Agents internalise announcements and shocks that may affect fundamentals. Deviations from UIP are low for high-inflation periods, and high for low-inflation periods and freely floating regimes. As long as what it takes to predict well is simple (look backwards, follow announcements), interest rate differentials perform well. Once exchange rate determination becomes intricate, agents fail at predicting. This finding remains unchanged when survey data are used for the period 2005-2010.

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Acronyms

ADF	Augmented Dickey Fuller
AIC	Akaike Information Criterium
ARCH	Autoregressive Conditional Heteroscedasticity
ARIMA	Autoregressive Integrated Moving Average
BCDI	Banking, Currency, Default, Inflation Indicator
BCRA	Central Bank of the Republic of Argentina
BCU	Central Bank of Uruguay
BIC	Bayesian Information Criterium
CARA	Constant Absolute Risk Aversion
CD	Cross-sectional Dependence
CPI	Consumer Price Index
DARA	Decreasing Absolute Risk Aversion
ECM	Error Correction Mechanism
ECLAC	Economic Commission for Latin America and the Caribbean
EII	Export Intensity Index
FGLS	Feasible Generalized Least Squares
GARCH	Generalized Autoregressive Conditional Heteroscedasticity

GLS	Generalized Least Squares
GMM	Generalized Method of Moments
HAC	Heteroscedasticity - Autocorrelation Consistent
HP	Hodrick-Prescott
IARA	Increasing Absolute Risk Aversion
ISIC	International Standard Industrial Classification
IV	Instrumental Variables
KP	Kleibergen and Paap Statistic
MBC	Marginal Bankruptcy Cost
MERCOSUR	Southern Common Market (*Mercado Comun del Sur*)
OLS	Ordinary Least Squares
PADI	Program of Analysis of Industrial Dynamics
REER	Real Effective Exchange Rate
RER	Real Exchange Rate
RMSE	Root Mean Squared Error
SUR	Seemingly Unrelated Regressions
SURE	Seemingly Unrelated Regressions Estimation
TZ	Target Zone
UIP	Uncovered Interest Parity
2SLS	Two Stages Least Squares

Introduction

This thesis analyses exchange rate expectations and the impact of real exchange rate uncertainty on manufacturing output in Southern Cone countries. It begins from the premise that because production takes time, output decisions are in effect risky investment decisions. Firstly, it investigates the channels through which uncertainty affects optimal output. It then empirically explores the effect of changes in real exchange rate uncertainty on sectoral output, over the period 1970-2002, paying close attention to sectoral characteristics that may drive heterogeneous responses. With a generalized perception about the central role played by real exchange rate variations on firm profitability and thus output decisions, this thesis provides evidence from the Southern Cone economies supporting the hypothesis that uncertainty has sizable effects on production, that the effects are non-linear and sector-specific.

This is followed by an examination of exchange rate expectations and the extent to which these are determined by past trends of the exchange rate, by changes in the economic environment that may affect fundamentals, or by other mechanisms, as well as exploring whether they have been accurate and unbiased.

The two issues are strongly related. Identifying the output effects of exchange rate uncertainty requires measuring uncertainty in the first place. For these purposes we need firstly, a model of how the expectations themselves are being formed. This model will provide us with forecasts. On the basis of this, expectation errors will be used to construct a measure of uncertainty. Understanding the model behind expectation formation mechanisms allows us to assess the validity of imposing a particular one on the representative agent.

The choice of countries and that of the source of uncertainty to be analysed is jointly determined. The thesis draws on the case of Southern Cone countries over the period 1970-2002 and focuses on exchange rate uncertainty. Southern Cone countries have exhibited a particularly high record of exchange rate volatility over the period, and in addition, have become more integrated through trade, a phenomenon which has further increased their exposure to uncertainty. In these economies, the expected value of the exchange rate and the uncertainty surrounding that expectation are constantly on the agenda of manufacturer lobbies, and in the speeches of policy makers. The words of Enrique Iglesias illustrate this point:[1]

> "During my first years as a civil servant, as a researcher, as the Secretary of the Commission for Investment and Economic Development, but especially, as the President of the Central Bank, I perceived the extent to which the value of the exchange rate was a key element both in the distributive struggle among groups of agents, and in the economic dynamics in general. It is for these reasons that on several occasions I have expressed my conviction that the history of the political economy, and to a large extent, the political history of the country could be reconstructed around the debates and viscissitudes of exchange rate policy."

There are several reasons why agents attach so much importance to exchange rates in

[1] Iglesias (2003). Enrique Iglesias has been President of the Central Bank of Uruguay, Secretary-General of the Economic Commission for Latin America and the Caribbean (ECLAC) and twice President of the Inter-American Development Bank. His words refer to the Uruguayan case, but as argued by Frieden and Stein (1999) the extreme importance attached to the exchange rate evolution among manufacturers and policymakers is not restricted to Uruguay, but includes also Brazil and Argentina.

these economies. First, because these are, to different extents, relatively open economies, and so exchange rates affect the price of tradable goods sold by manufacturers. Second, because during much of the 1980s and 1990s a large portion of firms contracted dollar debt to finance their production plans irrespective of their trade orientation, introducing important mismatches in their balance sheets and making them vulnerable to exchange rate movements. Third, because hedging instruments to cover against exchange rate risk have been largely unavailable in these economies until recent years. In fact, a pilot survey we conducted on Uruguayan firms at the beginning of the research confirmed that the evolution and predictability of the exchange rate were among the top concerns of manufacturers.

The research presented in this thesis is organised in two parts. Part I focuses on the impact of exchange rate uncertainty on output and comprises two chapters. Part II is fundamentally about exchange rate expectations and consists of three chapters.

Chapter 1 presents a conceptual framework to analyze the impact of exchange rate uncertainty on the supply of output of manufactured goods. In the first part of the chapter we review the textbook approach to analysing firms' output decisions under uncertainty. Typically, assumptions are made on either the probability distribution of the source of randomness or on the preferences of the decision-makers, and the effects of changes in uncertainty on optimal output will depend on the attitude towards risk displayed by the firm's managers. In the second part of the chapter we discuss the limitations of the standard approach given the context under which firms in the Southern Cone operate. First, we challenge the pertinence of the assumptions made by the textbook approach on the probability distribution of the real exchange rate — this variable has been subject to extreme jumps in several occasions during the period of analysis. Then, we discuss the importance of incorporating the financial strategy of the firm into the analysis. The fact that firms in the Southern Cone contract dollar debt introduces an additional channel through which real exchange rate uncertainty affects output decisions. In light of this discussion, we adapt Greenwald and Stiglitz (1993) to the case in which uncertainty arises from exchange rate randomness, and introduce three extensions. A simple production model with bankruptcy costs allows us to investigate the output response to a rise in the degree of exchange rate uncertainty faced by competitive firms. The main result of the model is that when firms exhibit currency mismatches, obtaining revenue in pesos and repaying dollar debt, an increase in exchange rate uncertainty reduces optimal output, as the marginal bankruptcy costs increase. These are part of total marginal costs, to be equated to expected prices. The first extension of the model shows that when risk-neutral firms do not exhibit currency mismatches, say, because they produce tradable goods whose prices move in line with exchange rate and international price changes, optimal output will be unaffected by an increase in uncertainty. The second extension considers firms facing soft budget constraints, and shows that if firms are aware of the possibility of generalized government financial assistance in the event of drastic exchange rate movements, the output effect of an increase in uncertainty on output is ambiguous. The third extension provides an informal discussion, and contends that in spite of the analytical ambiguity, in the event of high uncertainty, firms will not take government financial assistance for granted and will act cautiously, most probably disengaging from risky activities.

In Chapter 2 we empirically explore the impact of real effective exchange rate (REER) uncertainty on the output of the manufacturing sectors in Southern Cone countries (Argentina, Brazil and Uruguay). Alternative measures of REER uncertainty are constructed, allowing for different degrees in sophistication of the forecast model assumed for the representative agent. Our contribution in this paper is threefold. First, we identify the average effect of REER on output in the manufacturing sectors of Southern Cone countries. We estimate an output supply function using data from 28 manufacturing sectors in Argentina, Brazil and Uruguay over the period 1970-2002, tackling the output-price simultaneity problem with instrumental-variable techniques, and using alternative sets of instruments to check the robustness of our results. We also allow for heterogeneous effects across countries. Second, we test for the presence of threshold effects on the relationship between REER uncertainty and output. Third, we test for sectoral heterogeneity in the output response to REER uncertainty and try to identify whether trade orientation, the intensity with which the sector trades within Mercosur, and labour productivity are drivers of that heterogeneity. We present new evidence suggesting that REER uncertainty has on average negatively affected the level of output produced in the manufacturing sectors in Southern Cone countries over the period 1970-2002. This finding is robust to the choice of the uncertainty measure. Further to this, we find that the average effect masks significant specificities in the relationship. Although the effect seems to be stable when allowing for country heterogeneity in the response, there seems to be a threshold above which uncertainty affects output negatively, but below which the effect may even be positive. Moreover, those sectors that exhibit a higher exposure to export markets tend to be less responsive to REER uncertainty, although the opposite is true for those that trade intensively with Mercosur member countries. In addition, those sectors displaying a higher degree of labour productivity are less sensitive to REER uncertainty. Last but not least, we find that output is not only responsive to the first two moments of the distribution of REER (mean and variance), but also to higher moments such as skewness and kurtosis.

The choice of the uncertainty measures we use in Chapter 2 is driven by data constraints. These measures impose a backward looking expectation formation mechanism in which the representative agent uses an autoregressive forecast model. The question that arises is how reasonable is this assumption? For these reasons, in Part II we focus on exchange rate expectations.

Chapter 3 is intended to bridge Parts I and II. We review the literature on uncertainty measures and classify them into two groups: those that impose assumptions on the agents' expectation formation mechanisms (like that of Chapter 2), and those that do not impose any assumptions on these mechanisms. We find that the choice of which measure to use tends to be driven by data availability and, generally, lacks conceptual or empirical justification.

In an attempt to understand how reasonable it is to impose an autoregressive forecast model for the representative agent, the following two chapters investigate key elements of exchange rate expectations.

In Chapter 4 we examine expectation formation mechanisms, and their evolution over time and test for unbiasedness of expectations, using data on Uruguayan interest rate differentials over the period 1980-2010. The shift of focus from the real exchange rate to the nominal exchange rate is motivated by data constraints. Although there is no guarantee that agents use the same mechanisms to forecast nominal and real exchange rates it seems likely that some lessons could be learned. Uruguay provides an interesting and representative case. Since it is a small, open and highly dollarized economy in which agents are proficient users of financial instruments denominated in both domestic and foreign currency, it serves as a good approximation to the required assumption of perfect capital mobility. During this period it went from high to low inflation levels, as well as different exchange rate regimes: a period of short-lived and non-credible stabilization plans with the exchange rate as a nominal anchor (Pre-TZ), a period of credible target zones for the exchange rate (TZ), and a subsequent period in which the Central Bank had no target for the exchange rate, and this was largely determined by market forces (Post-TZ). This raises the question of how expectation formation mechanisms have responded to the changes in the environment. Two regularities in the literature motivate this chapter. First, most of the tests done on the deviations from the interest parity and on expectation formation mechanisms have been applied to major currencies and developed economies. Second, that most of the tests done on expectation generating mechanisms implicitly assume that the mechanisms are stable over time. Our contribution in this chapter is twofold. First, we test and identify a time-variant exchange rate expectations formation mechanism in the context of Uruguay over the period 1980-2010, and second, we test the Uncovered Interest Parity (UIP) across different exchange rate regimes. New evidence is presented suggesting that, on average, the autoregressive (or extrapolative) component in expectations has been substantial. The importance attached to the past exchange rate behaviour explains why agents tend to under predict in the event of large depreciations, but after these occur, they tend to over predict new changes in the exchange rate. We also find the importance attached to the past evolution of the exchange rate to have changed over time, following an inverted-U shape pattern. Given that for about two thirds of the period considered, the Central Bank announced some sort of target for the exchange rate, that identified evolution is likely to be related to the credibility of the Central Bank's announcements. Furthermore, we find that apart from an autoregressive component, agents also display adaptive and regressive components in expectation formation and also internalise the potential effects of policy announcements on the path of exchange rates. In addition, we present evidence of deviations from UIP, although these are relatively small compared to those typically reported in the literature. The size of the deviations from the UIP is larger when looking at sub-periods than when looking at the whole period, pointing to the importance of the 'peso problem' in our data. Across sub-periods, the largest deviations are found during the last period of freely floating exchange rates, in which the economy experienced low inflation.

In Chapter 5 we use unexploited survey data on foreign exchange rate expectations for the Uruguayan Peso/US dollar rate available for the last five years of the post target zone period (Post TZ). We examine firstly, expectation formation mechanisms, and secondly, how much of the "puzzle" found in the previous chapter can be explained by expectational failures. These survey data are useful in providing direct information on expectations, and allowing us to understand the extent to which the strong rejection of unbiasedness found when using interest rate differentials is attributable to expectational failures. The motivation for this chapter is twofold. Firstly, as mentioned, using interest rate differentials for the Uruguayan case, we have rejected the hypothesis of unbiasedness more strongly when looking at the Post TZ period that goes from 2003 until 2010. This period is atypical since the Central Bank abandoned the policy of announcing a target for the exchange rate (*de jure*, the regime is claimed to be one of floating), and because CPI inflation records were low by historical standards. If one looks back at the past fifty years, the period considered in this chapter is where the foreign exchange market most resembles that of a small open, developed economy. To the best of our knowledge, the survey data on the Uruguayan Peso/Dollar exchange rate expectations made available by the Central Bank of Uruguay since June 2005 have been unexploited to date. Secondly, in a recent contribution to the literature Frankel and Poonawala (2010) show that the bias in expectations is lower for developing countries' currencies than for major currencies. The authors conjecture that relatively high inflation in developing countries may make it easier for agents to predict the evolution of the exchange rate. We argue that, besides the point made by Frankel and Poonawala (2010), Central Bank intervention in the foreign exchange market, pervasive in emerging economies, is another factor that may explain the differences in the biases. When Central Bank intervention is substantial and has a clear and known rationale — e.g.: keeping a "competitive" exchange rate — the forecast exercise is simplified. In order to shed light on this issue and given that Argentina and Brazil have been undergoing a similar adaptation process to a new foreign exchange regime (also the Argentinean Peso and the Brazilian Real were also floated around the beginning of the 2000s, although to different extents), and that the three countries have exhibited relatively low levels of inflation since then, we use available survey data on expectations for the evolution of the Argentinean Peso and the Brazilian Real. We incorporate these markets in the analysis and test for expectational failures in the three markets. We construct indicators of Central Bank intervention à la Calvo and Reinhart (2000) and examine if patterns can be extracted in the relationship between expectational failures and intervention. When the focus is placed on the Uruguayan survey data we test for extrapolative, adaptive and hybrid expectation formation mechanisms, with inconclusive results. Although there is some evidence of extrapolative and adaptive mechanisms when investigated in isolation, this vanishes when a hybrid mechanism is allowed. We present new evidence suggesting expectational failures. In fact, unbiasedness of exchange rate forecasts is rejected at the three time horizons considered (one, six and twelve months), although forecasts perform well at predicting the direction of the exchange rate movement over a one-month horizon. When looking at the three Southern Cone countries, we find that unbiasedness of expectations cannot be rejected only for the Argentinean Peso/Dollar market. One explanation for this result is that systematic Central Bank interventions — as they occur in Argentina — make the forecast exercise simpler.

In light of the findings of the last two chapters, both on the drivers of expectations mechanisms and on the tests of unbiasedness of expectations, we can claim that as long as what it takes to predict well is rather simple — i.e. look backwards, follow policy announcements, agents predict well. However, once the exchange rate determination model becomes intricate, or at least unfamiliar — regimes in which the Central Bank does not pre-announce a target for the exchange rate have not been frequent in the Southern Cone — agents fail in their attempt to accurately predict exchange rate depreciations. The "puzzle" often reported in the literature about the biases in expectations does not seem so puzzling in this case.

Finally, in the concluding chapter, we summarise the findings of the earlier chapters, present lessons learnt from the research carried out for this thesis and identify avenues for future research.

Part I

Uncertainty and Output

Chapter 1

A Framework to Analyze Production Decisions Under Uncertainty

1.1 Introduction

Imagine a situation of permanent long-run static equilibrium. Agents trade at equilibrium prices, which become known by experience. There would be no uncertainty in such a world. Producers would know how much they would get for their produce, how much they would pay for their inputs, in which conditions they would obtain credit, and consumers would know how much they would have to pay.

Economic decisions, however, almost invariably carry an important component of uncertainty. Decisions taken by agents in the present will have an unknown impact in the future. Therefore, the optimization processes through which these decisions are taken must incorporate the fact that some of the relevant variables are not deterministic but random. In this thesis we are concerned with a particular source of uncertainty, that with respect to the real exchange rate, in the effect that it has had on determining sectoral output supply levels in Mercosur countries, over the period 1970-2002.

This chapter presents a conceptual framework through which we will analyze the impact of uncertainty with respect to the real exchange rate on the supply of output of manufactured goods, and is structured in two parts.

In the first part, we present and discuss the literature on firm behaviour under uncertainty. For these purposes, we first need to identify the channels through which real exchange rates are relevant for the supply of output. Output of manufactured, tradable goods will be affected by real exchange rates because the latter variable will affect profits obtained by producers, via effects on the price they receive, the cost of inputs they pay, and the cost and availability of credit to finance working capital that they face. These effects on profits will in turn affect investment decisions made by producers, determining the production capacity of the firm. In addition, for a given production capacity, these will affect optimal output to be produced.

Then, we define what we understand for "uncertainty". Broadly speaking, uncertainty exists when there is randomness associated with an outcome. If a random process governs how much the producer will receive for its produce, or how much it will have to pay for inputs, or credit, then, profits will also be random.

To construct our framework, we need to capture the notion of uncertainty in a particular measure. We analyze how randomness governing profits affects utility and how that randomness can be picked up analytically. It is known that under certain restrictions imposed on a) preferences or b) the distribution of the random variable, the variance proves to be a good way of capturing the notion of uncertainty.

We present the main known results of the textbook approach on the behaviour of the firm under uncertainty — which assumes that a) or b) above are valid, and which uses the usual taxonomy of attitudes toward risk. These are: first, that if the firm is risk-averse, optimal output in the presence of price uncertainty will be lower than it would be the case in a context of certainty, and second, that under certain plausible conditions on the type of risk-aversion faced by the firm, an increase in the degree of perceived uncertainty reduces optimal output.

In the second part of the chapter we look at the particular context of the economies considered in this thesis, and discuss critically the limitations of the standard approach. On one hand, we discuss the pertinence of assumptions a) and b) in the particular context of Southern Cone economies during the period analysed in this thesis. On the other, we discuss the limitations of the standard theory of the firm. In light of this discussion, we introduce a simple production model, adapting Greenwald and Stiglitz (1993). We investigate the output response to a rise in the degree of exchange rate uncertainty faced by competitive firms, and consider as separate cases firms producing non-tradable and firms producing tradable goods. We focus on the effects of increases in uncertainty that increase the probability of extreme exchange rate outcomes. Most of the literature on the link between uncertainty and economic activity overlooks the effects of the financial strategy of the firm, relies on exogenously determined attitudes to risk and on distributional assumptions that mainly reduce uncertainty to the variance of the random variable. This model focuses on the channel linking uncertainty and output that operates through the financial strategy of the firm. In our model, firms rely on credit markets to finance working capital, and contract dollar-debt. The firm faces bankruptcy in the event of an exchange rate outcome that raises debt repayment above output proceeds. Therefore, it internalizes the expected bankruptcy costs when making the optimal output decision, thus showing aversion to bankruptcy risk. To identify the pure-risk effect on output we focus on changes in perceptions that lead to a higher probability of extreme exchange rates, keeping a constant mean. Our analysis does not rely on distributional assumptions on the exchange rate.

Our main results are the following. First, when firms exhibit currency mismatches, obtaining revenue in pesos and repaying dollar-debt, an increase in exchange rate uncertainty reduces optimal output, as the marginal bankruptcy costs increase. The anticipation of generalized government financial assistance in the event of drastic exchange rate movements exerts the opposite effect on output. However, our contention is that in the event of high uncertainty, firms will not take government financial assistance for granted and will act cautiously, hoarding liquidity and disengaging from risky activities. Second, firms' liquidity balances matter for the choice of output: firms with high liquidity balances will face low bankruptcy risks, which leads them to produce more than the average firm. This introduces persistence in the output effects of shocks to profits because any shock to profits, such as a reduction in output prices, or a depreciated exchange rate, will decrease firm's next period liquidity balances, and so, next period's output.

Although this model draws heavily from Greenwald and Stiglitz (1993), it contributes to the literature by adapting it to the case in which uncertainty arises from exchange rate randomness, and by presenting three extensions, namely, a) the case in which firms exhibit currency-matched balance sheets, b) the case in which firms perceive the possibility of government financial assistance in the event of drastic exchange rate movements, and c) the case of firms facing high uncertainty.

The remainder of the chapter is structured as follows. Section 1.2 discusses the channels through which real exchange rates affect output decisions. Section 1.3 presents the situations in which uncertainty arises in a production process and discusses the distinction between risk and uncertainty. Section 1.4 reviews the literature on the effects of uncertainty on output, firstly by looking at the effects on investment, and secondly, by looking at the effects on optimal output, for a given production capacity. Section 1.5 focuses on the limitations of the standard approach to the analysis of production under uncertainty. Section 1.6 introduces a simple production model to analyse firm behaviour under uncertainty that overcomes some of the shortcomings of the standard approach. In Section 1.7

we present some extensions of that model, and Section 1.8 concludes.

1.2 Real Exchange Rates and Output

We argue that uncertainty with respect to the real exchange rate affects output of manufacturing sectors in Southern Cone countries. For that to be true, the **level** of the real exchange rate (RER) itself must have an effect on output in the first place. Here we define $RER = EP^*/P$, where E is the nominal exchange rate expressed as domestic currency (pesos) per unit of foreign currency (dollar), P^* and P are the foreign and domestic prices respectively.

What are the channels through which real exchange rates affect output supply under competition?[1]

1. **Price channel**: If manufactured goods are tradable, then the price faced by the producer will move with international prices and nominal exchange rates. Increases in international prices or domestic currency (peso) depreciations (i.e. increases in the RER) will increase supply.

2. **Costs of Inputs channel**: the cost of intermediate imported inputs, or wages that are indexed to foreign inflation or exchange rates will increase with a depreciation of the peso or with an increase in international prices (i.e. increases in the RER). This will reduce supply. The net effect of channels 1+2 should be to increase supply as long as value added is positive.

3. **Availability (and therefore cost) of Credit channel**: firms use credit markets to obtain working capital. Depreciations will affect credit supply both for tradable and non tradable firms. This is particularly relevant when considering drastic

[1]Note that the focus here is put on the channels through which real exchange rates affect the aggregate supply of output. In addition to these supply channels, output will be affected by demand factors that will not be considered here.

depreciations as Southern Cone economies exhibit two characteristics: a) Capital markets are imperfect, and so, firms face an external finance premium, defined as the gap between the opportunity cost of using own funds and recurring to external funds, and dependent on borrowers' net worth. b) Firms typically exhibit a currency mismatch in their balance sheets. Dollar liabilities exceed dollar assets. Therefore, depreciations of real exchange rate lower firms' real net worth, raising the external finance premium and so the cost of credit, and thereby reducing supply. However, this effect depends on the composition of the firm's net worth. For firms producing in the tradable sector, a real depreciation increases the expected present value of profits after a real depreciation at the same time that increases the burden of the dollar debt. These firms will be less affected in their ability to obtain credit (if at all) than those producing in the non-tradable sector.[2]

1.3 Uncertainty and Risk: Definitions and Measures

Uncertainty arises when the consequence of a decision is not a single sure outcome, but a number of possible outcomes. Figure 1.1 shows three production timing scenarios to visualise the sources of uncertainty associated with production decisions.

(Sc1) **Certainty**: The firm produces in period one, when inputs are transformed into output instantaneously, with known output and input prices. The proceeds of the output are used to pay inputs. Everything is known with certainty.

(Sc2) **Two Periods, No Working Capital Needs**: In period one the firm makes a commitment to produce and fixes input prices. In period two, inputs are transformed into output instantaneously. Output prices are revealed, output is sold and the proceeds are used to pay for the inputs. Firms do not need working capital. When

[2]For a full discussion of the credit channel, see Bernanke and Gertler (1995)

making the production decision they only face uncertainty with respect to output prices.

(Sc3) **Two Periods, Working Capital Needs**: Here, production takes time. The production process starts in period one, when inputs are purchased, but it is only in period two when output can be sold. Working capital needs arise. Firms contract dollar debt in period one at the risk-free interest rate (we assume no default risk). In period two, output prices and exchange rates are revealed. When making the production decision firms face uncertainty with respect to output prices and the peso cost of the dollar debt. Under these conditions, output decisions are risky investment decisions.

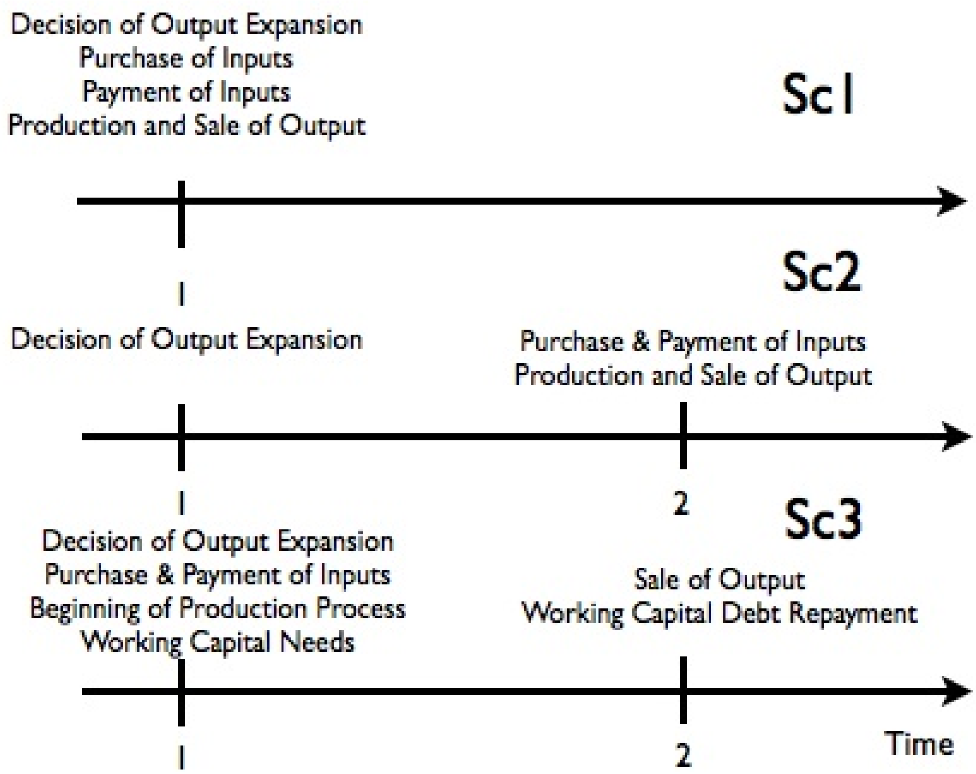

Figure 1.1: Timing of the Production Decision

Sc2 and Sc3 seem to better describe reality than Sc1. Forward contracts are a way to reduce exposure to real exchange rate risk. However, these have not been available for most of the period of analysis, and when they have, their costs have been prohibitive.[3]

We make three assumptions in the analysis that follows:

(1) All agents have in mind the same set of states of the world.

(2) When the future arrives, they all recognize and agree on the state of the world that prevailed.

(3) Agents are able to assign probabilities to the states of the world occurring in the future, and these probabilities satisfy probability laws.

Thus agents are, in Knight's sense, exposed to risk rather than uncertainty (Knight (1921)). Knightian 'risk' refers to situations in which mathematical probabilities can be assigned to the random variable that is faced. Knightian 'uncertainty' refers to situations in which the agent can't assign probabilities. This was later expressed by Keynes:

> *"By uncertain knowledge, let me explain, I do not mean merely to distinguish what is known for certain from what is only probable. The game of roulette is not subject, in this sense, to uncertainty...The sense in which I am using the term is that in which the prospect of a European war is uncertain, or the price of copper and the rate of interest twenty years hence...About these matters there is no scientific basis on which to form any calculable probability whatever. We simply do not know."* (Keynes, 1937, pp.213-214)

This distinction has been disputed. It could be argued that there is not much difference between uncertainty and risk if we believe probabilities are only subjectively defined. In

[3]This assertion is based on an informal discussion with the Secretariat of the Uruguayan Union of Exporters. In addition, as argued in Borensztein et al. (2008) this seems to apply to Argentina as well. In Brazil, only large firms use forward contracts, and still it is a recent trend. It is argued that because these countries have had fixed or predetermined exchange rate regimes for long periods, firms frequently have not internalized exchange rate risk as an additional cost, given that the Central Bank was implicitly offering an insurance against variations. That could help explaining absence of a better developed forward market for the exchange rate.

any case, and as Keynes argues later in the same text, the necessity for action and for decision compels us to do our best to overlook the impossibility of assigning objective probabilities to the occurrence of an array of possible states of the world. This necessity, he claims, makes us behave as if we could. For these reasons, in what follows, uncertainty and risk will be considered as interchangeable. These terms will be used to describe a situation in which there are multiple possible outcomes, and we will proceed as if probabilities of occurrence could be assigned.

Having defined what it is understood here by uncertainty, it is necessary to choose how to capture that concept in one measure before turning to the analysis of optimal output choice. The measure of uncertainty most commonly found in the literature is the variance. This measure considers all the possible outcomes of a given random event and its associated probabilities. To explore in the context of uncertain profits, if the variance fully captures the notion of uncertainty we follow the exposition of Gravelle and Rees (1992). Take a firm with profits (π_s) that have a deterministic ($\bar{\pi}$) plus a stochastic component (ϵ), where ϵ is the deviation of profits about its mean, and $E(\epsilon) = 0$. The utility function of this firm, U, could be written as a Taylor's series expansion around $\bar{\pi}$, as follows:

$$U(\pi_s) = \frac{U(\bar{\pi})}{0!} + \frac{U'(\bar{\pi})}{1!}\epsilon + \frac{U''(\bar{\pi})}{2!}\epsilon^2 + \frac{U'''(\bar{\pi})}{3!}\epsilon^3 + ... + \frac{U^n(\bar{\pi})}{n!}\epsilon^n \tag{1.1}$$

And if we take expectations:

$$E[U(\pi_s)] = U(\bar{\pi}) + U'(\bar{\pi})E[\epsilon] + \frac{U''(\bar{\pi})}{2!}E[\epsilon^2] + \frac{U'''(\bar{\pi})}{3!}E[\epsilon^3] + ... + \frac{U^n(\bar{\pi})}{n!}E[\epsilon^n] \tag{1.2}$$

Equation 1.2 shows that expected utility depends on the mean of the distribution of profits, and on all other higher moments about the mean, which characterize the distribution: variance, skewness, kurtosis, and so on. This suggests that in general, all of the moments of the distribution matter for the decision-maker when she faces uncertainty.

However, focusing only on the mean and variance is appropriate when we place restrictions on preferences (utility function) or the distribution of the random variable. These are:

(A1) **On Preferences**: The utility function is such that the n-th order derivatives are zero ($n \geq 3$).

(A2) **On the Distribution**: The probability distributions of the random variable, differ only by parameters of scale and location, with parameters of shape that are constant or a function of those of location and scale.[4]

To prove that A1 would reduce the expected utility analysis to a scrutiny of mean and variance, take a quadratic utility function. As the higher order derivatives are zero, the last terms in equation (1.2) are zero. Thus, expected utility would only depend on the mean and the variance of the distribution.

A2 will hold for any family of distributions (however complex these are) that could be fully characterized by measures of location and scale, which implies that its shape is either constant or a definite function of location and scale. Gravelle shows that A2 would also reduce the expected utility analysis to an examination of mean and variance (Gravelle and Rees, 1992, pp. 577-9). Take a probability distribution π_0 and another one, π_i. If these belong to a set that only differ by location and scale, with constant shape parameters, then:

$$\pi_i \sim \alpha_i + \beta_i \pi_0 \tag{1.3}$$

[4] A location parameter shifts a distribution without changing standard deviation or shape. A scale parameter is a multiple of the standard deviation. A shape parameter is neither a location nor a scale parameter, that affects the shape of a distribution (determining for example, skewness and kurtosis of a distribution, see Everitt (2002)).

For equation 1.3 to hold, then,

$$F(\pi_i) = Pr[\pi_i \leq \pi] = Pr[\alpha_i + \beta_i \pi_0 \leq \pi] = Pr[\pi_0 \leq \frac{(\pi - \alpha_i)}{\beta_i}] = F_0(\frac{\pi_0 - \alpha_i}{\beta_i}) \tag{1.4}$$

If μ_i and σ_i are the mean and standard deviation of the $i-th$ member of the set of probability distributions, then z, a standardized variable could be constructed from π_0:

$$\tilde{z} = \frac{\pi^0 - \mu_0}{\sigma_0} \tag{1.5}$$

which has the distribution function:

$$G(z) = Pr[\tilde{z} \leq z] = Pr[\frac{\pi^0 - \mu_0}{\sigma_0} \leq z] = Pr[\pi^0 \leq \mu_0 + \sigma_0 z] = F_0(\mu_0 + \sigma_0 z) \tag{1.6}$$

with probability density $g(z)$, zero mean and unit variance. If we use equation (1.5) to substitute for $\pi^0 = \mu_0 + \sigma_0 z$ we can rewrite equation (1.3) as:

$$\pi^i \sim \alpha_i + \beta_i \mu_0 + \beta_i \sigma_0 z = \mu_i + \sigma_i z \tag{1.7}$$

since $\mu_i = \alpha_i + \beta_i \mu_0$ and $\sigma_i = \beta_i \sigma_0$.

Then, the expected utility of the agent can be written, using equation 1.7 as:

$$\int U(\pi_i) f_i(\pi_i) d\pi_i = \int U(\mu_i + \sigma_i z) g(z) dz = u(\mu_i, \sigma_i) \tag{1.8}$$

The ordering of prospects of the decision-maker, which differ only in location and scale parameters, depends only on their mean and standard deviation.

A1 and A2 impose restrictions on the domain of applicability of the variance as an appropriate measure for capturing the notion of uncertainty. It is, however, a convenient measure, and therefore, widely used in the literature. We discuss the implications and the soundness of these assumptions in Section 1.5.1, and now proceed taking A1 or A2 as acceptable. The analysis of expected utility of profits is thus reduced to the analysis of mean and variance of profits. How do changes in mean and variance of profits affect utility?

Increases in the mean of π_i will increase expected utility, as can be seen in (1.9), while the effect on expected utility of an increase in its standard deviation will depend on the sign of $Cov[U'(\mu_i + \sigma_i z), z]$, as can be seen in (1.10).

$$\frac{\partial u}{\partial \mu_i} = \int U'(\mu_i + \sigma_i z) g(z) dz = E[U'(\mu_i + \sigma_i z)] > 0 \tag{1.9}$$

$$\begin{aligned} \frac{\partial u}{\partial \sigma_i} &= \int U'(\mu_i + \sigma_i z) z g(z) dz = E[U'(\mu_i + \sigma_i z) \times z] \\ &= E[U'(\mu_i + \sigma_i z)] \times E[z] + Cov[U'(\mu_i + \sigma_i z), z] \\ &= Cov[U'(\mu_i + \sigma_i z), z] \end{aligned} \tag{1.10}$$

Ceteris paribus, an increase in the standard deviation leaves the risk-averse agent worse-off, the risk-lover better-off, and keeps the utility of the risk-neutral unchanged.[5]

1.4 Uncertainty and Output

The effects of real exchange rate uncertainty on output take place through two channels. Uncertainty affects investment decisions, thus potential output in the economy. Then, for a given production capacity, uncertainty will affect output decisions. There is extensive literature on the first link both at a theoretical and empirical level in which the irrevers-

[5]This is because $E(z) = 0$, as implied by equation 1.5 and $Cov[U'(\mu_i + \sigma_i z), z] < 0$ for the risk-averse, $Cov[U'(\mu_i + \sigma_i z), z] > 0$ for the risk-lover, and $Cov[U'(\mu_i + \sigma_i z), z] = 0$ for the risk-neutral.

ibility of investment plays a key role. We review that literature in section 1.4.1 and in section 1.4.2 we focus on the effects of real exchange rate uncertainty on output, for a given production capacity.

1.4.1 The Effects of Uncertainty on Production Capacity

Hartman (1972) and Abel (1983) pioneered this literature and argue that increased uncertainty could affect investment positively. The authors showed that the combination of a perfectly competitive environment, constant returns to scale and symmetric capital adjustment costs implied a convex relationship between the expected profitability of capital and prices. This convexity implies that a mean-preserving increase in price uncertainty will raise expected profitability of capital (applying Jensen's inequality, $E(\Pi(P)) \geq \Pi(E(P))$), thus increasing the optimal capital stock, which stimulates investment. (Hartman, 1972, pp.: 262-263)

These conclusions have been challenged by a number of authors who emphasize the role asymmetric capital adjustment costs play in the links between uncertainty and investment. Dixit and Pindyck (1994), for example, argue that downward adjustment is costlier than upward adjustment due to irreversibilities in the investment process. Irreversibility may arise because of the "lemons problem"[6], because of the specificity of capital[7], or because of industry-wide shocks.[8] In this context, and if it is possible to postpone the investment decision, price uncertainty will bring about an asset for the firm, a call option originated by the chance the firm has to postpone carrying out the investment plan awaiting for more information on output prices. That call option is valuable because in a context of

[6] If there is asymmetry of information on the quality of the second-hand machinery being sold, incentives will exist for the seller to try to sell a good of low quality as one of higher quality. Aware of this incentive, the buyer will take the quality of the good to be average. As a consequence, high-quality goods will not be traded in this market.

[7] If there are not many firms in a particular sector, and the machinery is specific, the chances of re-selling it decrease.

[8] If a sector is affected by a negative shock, then, the chances of finding a buyer for the a specific unit of capital at a price close to its replacement value decreases.

uncertainty, waiting to invest may give a better picture of the market conditions. This implies that for an investment project to be carried out, it is not enough for the expected discounted profit flow to exceed the initial investment, it should now exceed the sum of the initial investment plus the opportunity cost of exercising the option (i.e.: the value of the option). This depresses investment at a given point in time.[9]

Further contributions to the literature have built upon the irreversibility argument, adding the possibility of costly upward adjustment of the capital stock. One example is the work done by Abel et al. (1996). These authors consider investment to be reversible, but attach a cost to that reversibility. The resale price of capital may be less than its current acquisition price. In addition, they consider expandability to be costly as well. The firm can continue to invest later, but the price of capital may be higher than its current acquisition price. If uncertainty on returns (due to say, output price uncertainty) is incorporated, two options arise: a call option that is generated by the possibility of expandability the firm faces, and a put option, which lies in the chance the firm has of a future sale of the machinery. An increase in uncertainty will have ambiguous effects on investment. This is because it increases the benefits of waiting for further information in order to invest, i.e.: it increases the value of the call option, thus reducing the current incentive to invest. At the same time, it also increases the benefits of waiting for further information in order to disinvest, i.e.: it increases the value of the put option, thus increasing the current incentive to invest. The net effect, according to the authors, will depend on the values of these two options.

The apparent ambiguity in the theoretical literature has encouraged significant empirical research on the links between uncertainty and investment. The work by Pindyck and Solimano (1993) , that of Aizenman and Marion (1999) and Serven (2003) is of particular

[9]It is worth mentioning that these effects could be economically significant. For example, McDonald and Siegel (1986) show, in a model of irreversible investment, that moderate uncertainty could significantly increase the required rate of return for investments to be carried out.

interest, as it focuses on developing countries. Pindyck and Solimano (1993) explore the empirical relevance of irreversibility and uncertainty for aggregate investment behaviour on a sample of 29 developed and developing countries, performing a comparison between this relevance between the former and the latter group. The authors found a negative relationship between uncertainty and investment, of a moderate size, and "of greater magnitude for developing countries" (Pindyck and Solimano, 1993, p33). They also related the volatility of the marginal profitability of capital to indices of economic and political stability. They found that inflation was the only robust explanatory variable of the marginal profitability of capital.[10] Then, Aizenman and Marion (1999) work on a sample of forty African, Asian and Latin American developing countries. These authors found a significant negative correlation between several measures of uncertainty and aggregate private investment, while they found that some evidence of public investment spending being positively correlated with uncertainty.[11] They explore the role of market imperfections in the link between uncertainty and private investment. In particular, they argue that investment expansions in good times are restricted by the existence of credit ceilings, while the drops in bad times are not, which contributes to a negative relationship between uncertainty and investment. These authors use volatility and uncertainty as interchangeable concepts. However, for their result to be explained by market imperfections as they claim, investors would need to perceive whether what is approaching are good times, and in that case invest - and be potentially constrained by credit ceilings, or bad times, and then disinvest with no restriction. In that case, the distinction between uncertainty and foreseen fluctuations would seem necessary. Serven (2003) assesses the effect of real

[10] As indices of economic stability they considered inflation, the volatility of inflation, the volatility of the real exchange rate, and the volatility of the real interest rate. As indices of political stability they considered an estimate of the probability of a change in government within one year, the average number of assassinations, government crises, strikes, riots, revolutions, and constitutional changes per year.

[11] They considered uncertainty over government expenditure, money growth, real exchange rates, and an index of the previous three variables.

exchange rate uncertainty on private investment in a sample of sixty-one countries over twenty-four years. The author finds a strong negative effect of uncertainty on aggregate private investment. In addition, he finds evidence of threshold effects in the link between uncertainty and investment. Higher levels of uncertainty exert larger effects on investment than lower levels of uncertainty - which showed to have no significant effects.[12]

1.4.2 Uncertainty, Risk Aversion, and Output Decisions, Given Production Capacity

Sandmo (1971) has shown that firms behave differently under certainty than under uncertainty. Then Hawawini (1978) has used a geometric approach to show firm's behaviour under uncertainty relying on a mean-variance framework, first introduced by Markowitz (1952) and extended by Tobin (1958). Here we follow Hawawini (1978)'s exposition. Optimal output levels of a firm operating in Sc1 (of certainty) are compared with those of one operating in Sc2 (of output price uncertainty).[13] Second, the output effects of changes in uncertainty, starting with positive uncertainty are presented.

When the firm operates in Sc1, the producer will choose output to maximise a profit function as in (1.11), where p is deterministic.

$$\Pi = pq - c(q) \tag{1.11}$$

$$\frac{d\Pi}{dq} = p - c'(q) = 0 \tag{1.12}$$

[12]"Higher" and "lower" are arbitrarily defined by the author: countries are ranked according to their uncertainty score. Those above the median of the distribution are considered high-uncertainty countries. Those below are considered low-uncertainty countries.

[13]The analysis of the firm operating in Sc3 is presented in Section 1.6.

$$\frac{d^2\Pi}{dq^2} = -c''(q) < 0 \quad \text{if} \quad c'' > 0 \tag{1.13}$$

The standard result is obtained, in which the firm maximises profits when q^* is chosen such that $p = c'(q)$.

Let us now move to a situation in which there is risk.

1.4.2.1 The locus of opportunity for risk and expected profits

When we move to Sc2, we introduce price uncertainty. The choice of output entails risk in terms of profits. Here, the locus of opportunity for risk and expected profits when agents face output price uncertainty is identified. This locus shows the terms under which the producer can obtain greater expected profits at the expense of greater risk.

Consider a profit function as in equation (1.11). Prices are randomly distributed. Its distribution is assumed to be fully characterized by two parameters: μ_p and σ_p, which implies that A2 holds. Thus, the mean-variance approach to be introduced in what follows is fully compatible with utility maximization, regardless of producer preferences, as discussed in Section 1.3.[14]

Expected profits can be expressed as:

$$\mu_\Pi = \mu_p q - c(q) \tag{1.14}$$

The risk associated to profits, Π, is measured by its standard deviation, σ_Π. Take the standard deviation of equation (1.11). The standard deviation of Π depends on the

[14] Hawawini (1978) assumes prices being normally distributed. We believe that is an unnecessary restriction as **any** distribution that can be fully characterized by location and scale parameters (the normal is one case) would make a mean-variance analysis fully compatible with utility maximization, regardless of producer preferences.

standard deviation of p and on the quantity produced, q in the following manner:

$$\sigma_\Pi = q\sigma_p \tag{1.15}$$

The quantity of output produced, q, determines both the expected return μ_Π, and the risk σ_Π. As output increases, so does the standard deviation of profits, for a given σ_p[15]. Line OB in the bottom part of Figure (1.2) shows the relation between output and σ_Π. The slope of that line is given by $1/\sigma_p$.

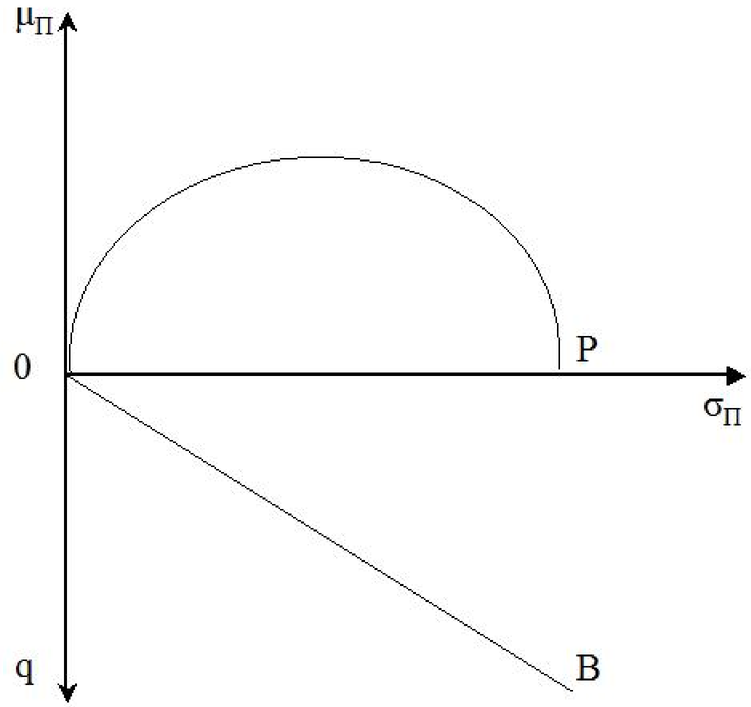

Figure 1.2: Locus of Opportunity for Expected Profits and Risk

The curve OP in the upper part of Figure (1.2) shows the terms under which the producer can obtain greater expected profits at the expense of assuming more risk. This is presented analytically in equation (1.16), which is obtained by substituting (1.15) into

[15]We are assuming firms being price-takers. Their output decisions affect neither μ_p, nor σ_p

(1.14). To explore the shape of this locus, we differentiate equation (1.16) with respect to σ_Π. If $c''(q) > 0$, μ_π is a concave function of σ_π as indicated in Figure 1.2, with a maximum consistent with $\mu_p = c'(q)$ (see equations 1.16 and 1.17).

$$\mu_\Pi = \mu_p \frac{\sigma_\Pi}{\sigma_p} - c(\frac{\sigma_\Pi}{\sigma_p}) \tag{1.16}$$

$$\frac{d\mu_\Pi}{d\sigma_\Pi} = \frac{\mu_p}{\sigma_p} - c'(\frac{\sigma_\Pi}{\sigma_p})(\frac{1}{\sigma_p}) \tag{1.17}$$

$$\frac{d\mu_\Pi}{d\sigma_\Pi} = 0 \quad \text{if} \quad c' = \mu_p \tag{1.18}$$

$$\begin{aligned} \frac{d^2\mu_\Pi}{d\sigma_\Pi^2} &= 0 - \frac{1}{\sigma_p} c''(\frac{\sigma_\Pi}{\sigma_p})\frac{1}{\sigma_p} \\ &= -\frac{1}{\sigma_p^2} c''(\frac{\sigma_\Pi}{\sigma_p}) < 0 \quad \text{if} \quad c'' > 0 \end{aligned} \tag{1.19}$$

1.4.2.2 The loci of indifference between combinations of risk and expected profits

To identify the effect of uncertainty on the quantity of output produced, the preferences of the producer need to be considered, which reflect her attitude toward risk.

The producer is assumed to have preferences between expected profits, μ_Π and its standard deviation, σ_Π. Because A2 holds, these preferences can be represented by a map of indifference curves in the $\mu_\Pi - \sigma_\Pi$ plane as illustrated in Figure (1.3). The usual taxonomy with respect to attitude to risk is considered: risk-neutral, risk-averse and risk-loving producers.

The first are those who only care about expected profits, and do not attach any weight to the amount of risk. For these producers, the indifference curves will be horizontal. Higher expected profits are preferred over lower, irrespective of the risk associated with profits. So, I_3 is preferred to I_2, which in turn is preferred to I_1.

The risk-averters will not accept more risk unless they can also expect greater profits. They trade off expected profits with profit-risk. Their indifference curves will be positively sloped and convex (we provide a proof in Appendix A, not available in Hawawini (1978)).

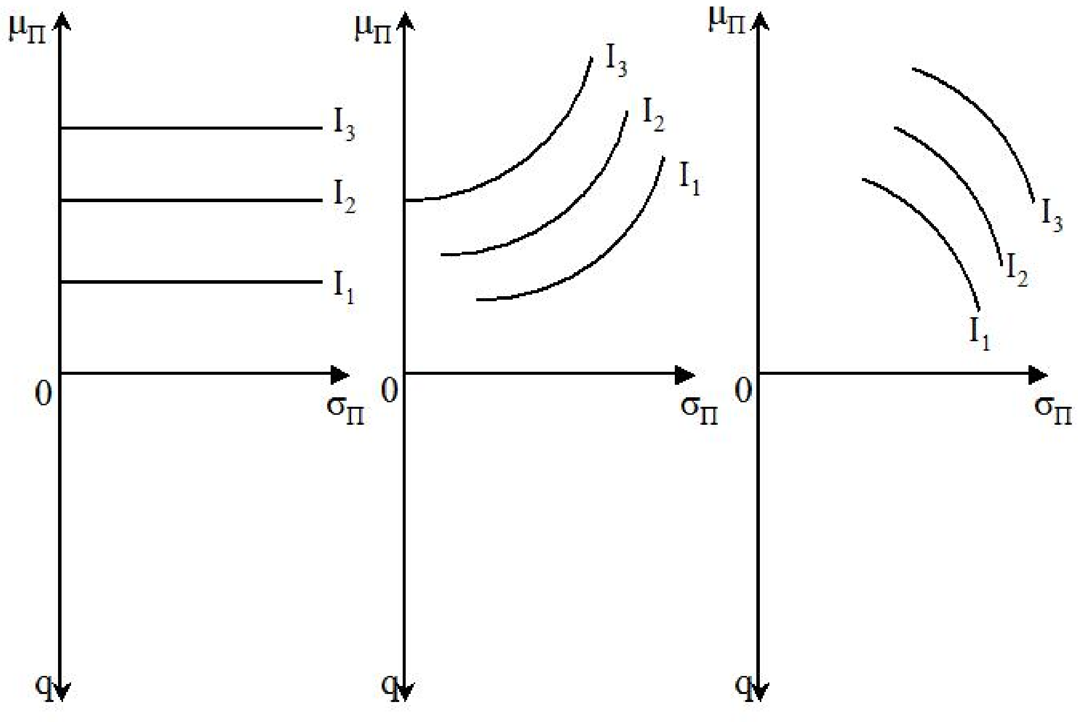

Figure 1.3: Indifferences Curves between μ_Π and σ_Π and Attitude to Risk

The risk-lovers, instead, are willing to accept lower expected profits in order to have the chance of unusually high profits, afforded by high values of σ_Π. Their indifference curves will be negatively sloped and concave (we provide a proof in Appendix A, not available in

Hawawini (1978)).

From this framework, the first result is derived:

Proposition 1. *Comparing with a certainty environment, the introduction of a mean-preserving increase in uncertainty leads the risk-neutral agent to produce the same amount of output, the risk-averter to produce a lower amount and the risk-lover to produce a larger amount. (Conclusion i in Hawawini (1978))*

Combine the locus of opportunities with the preferences of the agents. This can be seen in Figure (1.4). Panel A shows the case of the risk neutral producer. The producer will decide the combination of expected profits and risk so as to reach the highest indifference curve permitted by the opportunity locus. This indifference curve is tangent to the opportunity locus in its maximum. That maximum point is consistent with $\mu_p = c'(q)$, as can be seen in equation (1.18). By projecting the maximum of the opportunity locus OP into the output-risk line OB, we can see the level of output produced, q^*_{RN}. Thus, a mean-preserving increase in uncertainty (i.e.: one which leaves the *expected* price equal to the price in the absence of uncertainty), starting from a situation of zero risk, will not affect the output decision of this risk-neutral agent, as the producer will choose output such that $\mu_p = c'(q)$ and $\mu_p = p$.

The case of the risk-averter is shown in Panel B of Figure 1.4. Assume that she is willing to trade off higher risk for higher expected profits in the terms given by the map of indifference curves "I". Again, this producer decides the amount to produce so as to reach the highest indifference curve permitted by her opportunity locus. The tangency point implies a level of output q^*_{RA}. This level of output is found by projecting the tangency point into the output-risk line OB, in the lower half of the graph. Output here is lower than that produced by the agent in a context of certainty ($p = c'(q)$).

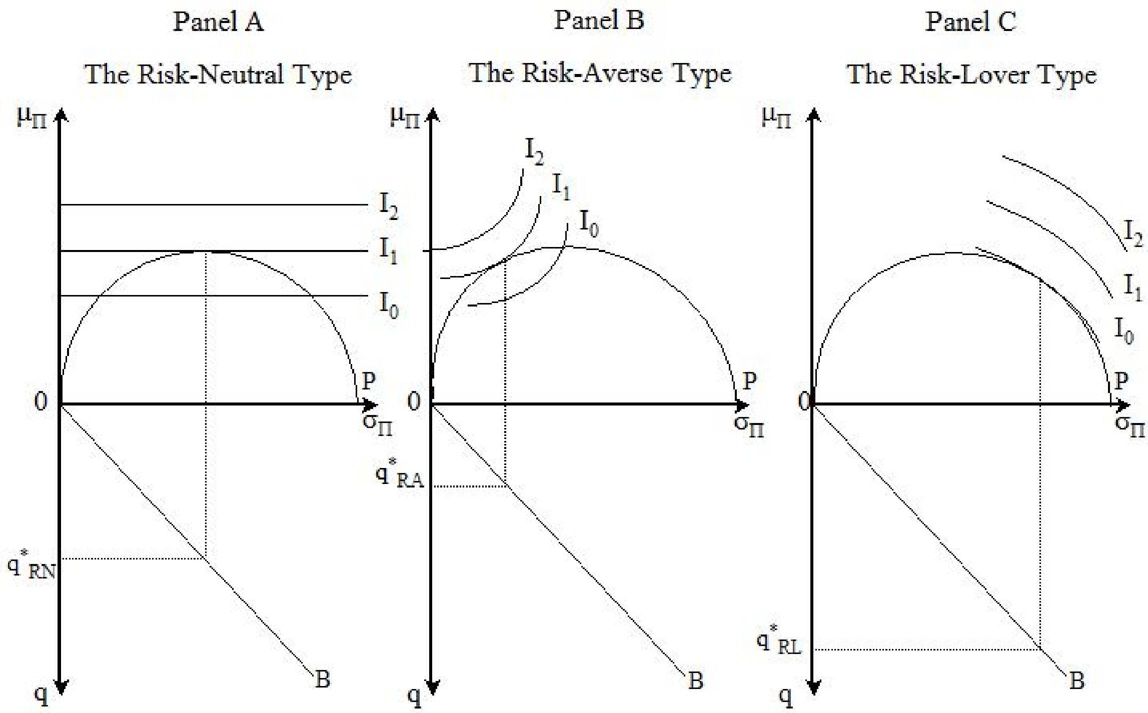

Figure 1.4: Output and Uncertainty

Finally, the case of the risk-loving type is illustrated in Panel C of figure 1.4.[16] This producer will trade off the prospect of unusually high profits that are afforded by higher levels of σ_Π for lower expected profits, and will maximise her utility subject to the constraint given by the opportunity locus OP by choosing the indifference curve that is tangent to OP. The tangency point is located in the downward sloping section of OP. The corresponding level of output produced, q^*_{RL}, is found by projecting the tangency point into the output-risk line OB, in the lower half of the graph. Output is higher than that produced in a context of certainty.[17]

[16] This is not presented in Hawawini (1978).

[17] Note that given the slope and curvature of the indifference curves of the risk-lover type, multiple equilibria may arise. Slopes and curvatures of the indifference curves are derived in Appendix A.

1.4.2.3 Effects of Increases in Risk, starting from Positive Risk

"Conclusion vi" of Hawawini (1978) expresses that the firm with decreasing absolute risk aversion will decrease its level of output when risk is revised upwards. We extend slightly that conclusion and provide a geometric proof for it in what follows.

Proposition 2. *An increase in perceived risk will lead to a decrease in output produced by the agent exhibiting constant absolute risk aversion or decreasing absolute risk aversion. The effect on output for the agent exhibiting increasing absolute risk aversion is ambiguous.*

To prove this proposition, Hawawini (1978) uses the concepts of decreasing, constant and increasing absolute risk aversion defined by Pratt (1964) and Arrow (1965). An agent is said to display increasing absolute risk aversion (IARA) if her aversion increases with increasing profit. This means that given the trade off between expected profits and risk, an increase in profits makes this agent less willing to accept more risk for the same extra expected profits than before the increase (Panel (A) of Figure 1.5). Constant absolute risk aversion (CARA) is displayed if risk aversion remains constant as profits increase, whereas decreasing absolute risk aversion (DARA) is displayed when her degree of risk aversion decreases with increasing profits (Panels (B) and (C) of Figure 1.5).[18]

If there is an increase in the perceived risk, σ_p, then the profit-opportunity locus will shift to the right, from OP to OP'. This is shown in Figure 1.6. This locus, OP' has the same shape and same maximum while being more spread out than OP.

We examine what happens to the slope of the locus after an increase in price-risk, for a fixed level of output. Notice that if q is constant, then $\mu_\Pi = \mu_p \times q - c(q)$ is constant, but $\sigma_\Pi = q\sigma_p$ will have risen, after the increase in σ_p. So, the question can be rephrased as: what happens to the slope of the locus at a given value of μ_Π. This is presented in

[18]The type of aversion to risk reflects the form of concavity of the utility function. Algebraically, these measures of risk aversion considered here are defined as $r(\pi) = -u''(\pi)/u'(\pi)$. If IARA, then $r' > 0$. If DARA, , then $r' < 0$, If CARA, then $r' = 0$. See Pratt (1964) and Arrow (1965) for a detailed discussion on this subject.

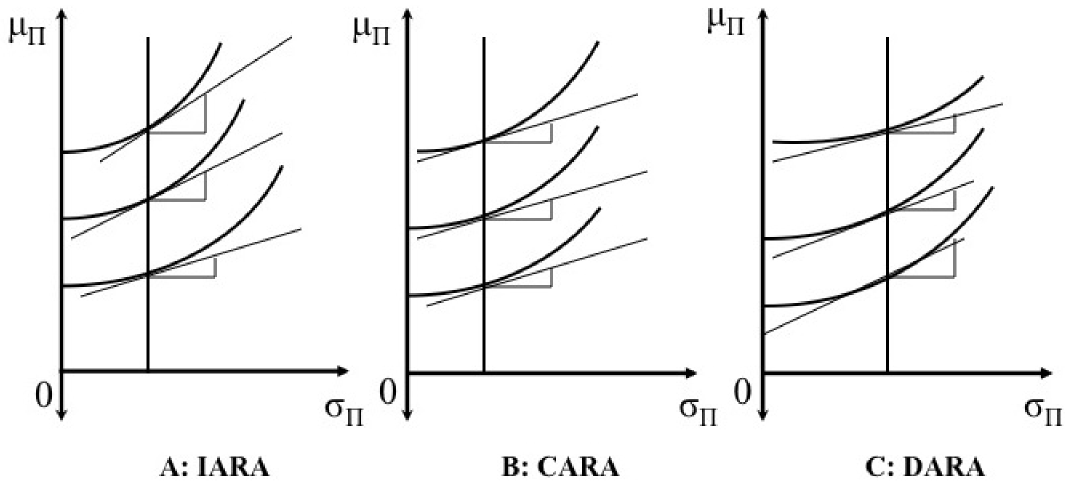

Figure 1.5: Types of Risk Aversion

equation 1.20

Remember that:

$$\frac{d\mu_\Pi}{d\sigma_\Pi} = \frac{\mu_p}{\sigma_p} - c'(\frac{\sigma_\Pi}{\sigma_p})(\frac{1}{\sigma_p}) \quad \text{and} \quad \frac{d\sigma_\Pi}{d\sigma_p} = q$$

So,

$$\frac{d}{d\sigma_p}\Big(\frac{d\mu_\Pi}{d\sigma_\Pi}\Big)\Big|_{dq=0} \quad = \quad -\frac{\mu_p}{\sigma_p^2} + c'\frac{1}{\sigma_p^2} - \frac{c''}{\sigma_p}\Big[- \frac{\sigma_\Pi}{\sigma_p^2} + \frac{1}{\sigma_p}\frac{\sigma_\Pi}{\sigma_p}\Big] \tag{1.20}$$

The term in brackets of (1.20) is zero because $d(\sigma_\Pi/\sigma_p) = 0$ if $dq = 0$. Thus, for q constant, an increase in risk leads to a decrease in the slope of the locus, if the agent is risk averse (as $(c' - \mu_p) < 0$). Now, compare points A and A' in Figure (1.6). The (') optimum has to lie to the left of A' if the intersection at A' is as drawn. That can only **not** be true if the indifference curve that passes through A' (I'(A')) is flatter than that one passing through I(A). From the geometry, that implies IARA. Agents displaying CARA or DARA will produce less after an increase in perceived risk.

The intuition behind these results can be understood by trying to decompose the change in output into what can be called an income and substitution effect. For all risk averse agents, an increase in risk increases the risk-cost of any level of output, and then, they will decrease it, to decrease their exposure to risk. This is the substitution effect.

The income effect, however, works in different directions depending on the type of risk-aversion displayed. For an agent with CARA an increase in risk makes her worse off, but that does not change her degree of risk aversion. The income effect will be zero in this case. So, the effect of an increase in risk on output is negative. For the agent displaying DARA, the increase in risk leaves her worse-off, and the worse-off she is, the more risk averse she becomes. Therefore, she will now reduce output to reduce her exposure to risk. Both income and substitution effects lead to a reduction in output after an increase in risk. For the agent displaying IARA being worse-off makes her become less risk-averse, and so, she'll be prone to increase her risk exposure. The income effect here leads her to produce more, but the substitution to produce less. The final effect for this agent is ambiguous.

1.4.3 Do Agents Display DARA, CARA or IARA?

Is it reasonable to assume that absolute risk aversion is non-increasing? Arrow (1974), for example, argues that the assumption of risk aversion can be defended both from personal introspection and from its success in explaining economic phenomena, and in particular, that wealth moderates an individual's risk aversion. After this hypothesis, a significant portion of the empirical literature on signs and magnitudes of measures of attitudes to risk has focused on testing the effect of wealth on an individual's risk aversion.[19]

[19] Arrow's hypothesis was that agents display DARA and increasing relative risk aversion (IRRA). While the measure of absolute risk aversion is pertinent when describing situations in which total wealth has a stochastic fixed portion (income), and a variable non-stochastic portion (wealth), the measure of relative risk aversion is appropriate when both stochastic and non stochastic parts are changing proportionally. Our focus here is on absolute risk aversion, as that's what determines the direction of the change in output after an increase in perceived risk, in our conceptual framework.

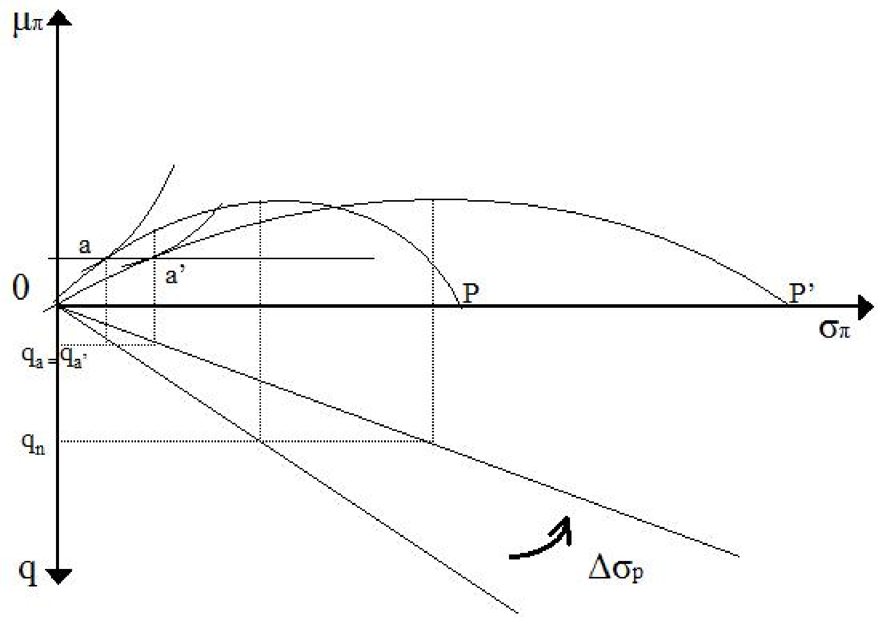

Figure 1.6: Effects of an Increase in Risk

In general, the literature follows a two-stage procedure, first measuring attitudes to risk, then, exploring their determinants. For the first stage, the available evidence can be divided into those that follow an experimental approach, generally based on simulations in which individuals answer questionnaires or face gambles with real or hypothetical gains or losses, and those that follow an econometric approach, generally assuming expected utility maximization (with an assumption on the functional form), obtaining estimable parameters of risk-aversion with data on past actual economic decisions on the subject of analysis. None of the approaches is without criticism. Assuming external validity of lab-based experiments is heroic. Econometrics, on the other hand, generates identification problems when probabilities individuals face need to be estimated with variables that also affect attitudes to risk. In addition, in the presence of imperfections, this approach is likely to confound risk behaviour with other factors, such as resource constraints that may affect behaviour in a similar way as attitudes to risk (Eswaran and Kotwal (1990), Lybbert and Just (2007)). Still, there seems to be significant evidence produced using either of the approaches, suggesting that agents' risk aversion decreases with wealth. A thorough discussion on this literature is out of the scope of this thesis. For this reason, we focus on four key contributions.[20]

A seminal contribution in this field is that of Binswanger (1980). The author's experiment consists of eight gambles that a set of Indian farmers are confronted with, whose outcome is determined by a coin toss. These gambles ranged from a certain amount of money obtained regardless of the result of the coin toss, to a large gain with 50% probability, and a zero gain with 50% probability.[21] Individuals then played the gambles at different payoff levels. Given budget restrictions, some of the gambles were hypothetical, and some offered real payoffs for the individual. Their choices allowed the researcher to assign a particular measure of risk aversion. In a second stage, these measures were regressed on a set of demographic characteristics for each payoff level. The author finds that at high payoff levels, almost all individuals are moderately risk-averse, with little variation associated to personal characteristics. He finds some evidence in favour of DARA, but only at low payoff levels. A recent contribution using a similar approach is that of Wik et al. (2004). The authors analyze risk attitude patterns among households carrying out farming activities in Northern Zambia using repeated gambling experiments, thus generating a panel dataset. Gains-only and gains-and-losses gambling experiments with real payoffs are used here. In the second stage, exploiting the panel structure of the data by using random-effects interval regression, the authors found evidence of DARA. Two often-cited papers that use econometrics are those of Chavas and Holt (1996) and Bar-Shira et al.

[20]Although most of the empirical work on this subject deals with farming decisions, and they refer to non Latin American contexts, it can still offer us some useful insights.

[21]None of the gambles involves losses to the farmers. The maximum gains were close to a farmer's daily wage.

(1997). The former uses simultaneous equations' techniques in order to estimate jointly the parameters of a risk preference function and those of a production function, in the context of corn-soybean acreage decisions in the U.S. The authors find evidence of DARA. The latter focuses on farming decisions in Israel, and uses a Taylor-series approximation of an expected utility function around the mean wealth level, which produces estimable risk aversion coefficients. Their results suggest that absolute risk aversion decreases with wealth, thus supporting Arrow's hypothesis.

1.5 The Limitations of the Standard Approach

Here we discuss the limitations of the approach we have just outlined. In Section 1.5.1 we focus on the validity of a mean-variance analysis, and in Section 1.5.2 on the implicit assumptions the standard theory of the firm makes on the capital structure.

1.5.1 Is the Variance a Good indicator of Uncertainty?

The analysis of the impact of uncertainty on output that was presented above reduced the concept of uncertainty to the variance of the random variable. That implies that either A1 or A2 holds. Here we discuss how reasonable these restrictions are.

> *"In economics, the relevant probability distributions are not nearly Gaussian, and quadratic utility in the large leads to well-known absurdities".* Samuelson (1970)

To illustrate the problems associated with A1 take a quadratic utility as in equation (1.21):

$$U(\pi) = a + b\pi + c\pi^2 \tag{1.21}$$

(where $a > 0$, $b > 0$, $c < 0$).

(1) Agents display negative marginal utility of profits when these exceed $-b/2c$.

(2) Agents display IARA. Pratt (1964) defines absolute risk aversion (ARA) as $r(\pi) = -u''(\pi)/u'(\pi)$. If $r'(\pi) > 0$, agents display IARA. For a function as in (1.21), $r(\pi) = -2c/b + 2c\pi$, and $r'(\pi) = 4c^2(b + 2cx)^{-2} > 0$.

Instead, what seems to be widely accepted is that agents typically display DARA. Pratt (1964), for example, suggests that "people might generally pay less for insurance against a given risk the greater their assets" [pp. 122-3], implying DARA. The common findings in the empirical literature support the hypothesis of DARA, as discussed in Section 1.4.3.

Let us turn the attention to the implications of A2. Distributions that differ only by location or scale will have shape parameters that are functions of location and scale (or constants). An example is the Normal, in which the parameters of location (μ) and scale (σ) fully characterize the distribution, and measures of shape, such as skewness and kurtosis are constants (= 0 and = 3 respectively). In the context of financial studies, it is generally claimed that probability distributions of asset returns cannot be fully parameterized by measures of location and scale. These distributions may also exhibit differences in measures of shape, implying that A2 does not hold.[22]

An example helps to illustrate why reducing the analysis of uncertainty to that of mean and variance of the random variable is inadequate if distributions also differ in shape.

Figure 1.7 shows the behaviour of two series: "Fixed" and "Flexible". Fixed exhibits an extreme episode in periods $t = 23$ and $t = 24$, and it takes a constant value equal to one for the rest of the period. Flexible shows permanent and mild variation. Would agents

[22]In fact, an unpublished manuscript of Samuelson suggests "Full-Scale Optimization" (FSO), a methodology in which return distributions are used in their entirety (Hagstromer et al. (2007)). The computational burden of this method is significant, and will not be considered here. For more on FSO, see Cremers et al. (2005). Another advocate against the assumption of distributions that only differ by location or scale in the context of economic analysis is Taleb (2007), and in fact, focuses his criticism on the extensive use of gaussian distributional assumptions in economics. The author argues against the validity of these assumptions, as economic data seems to be subject to what he calls "wild randomness". The author gives the example of the German Mark, which has seen its value change from four per dollar to four trillion per dollar in a period of a few years during 1920, suggesting that the bell curve is not well-suited to describe the randomness associated with, for example, currency fluctuations. Anecdotically, the 10-German-Mark note of the 1989 series shows a photo of Gauss and the bell curve in the obverse. (Taleb, 2007, p. 230)

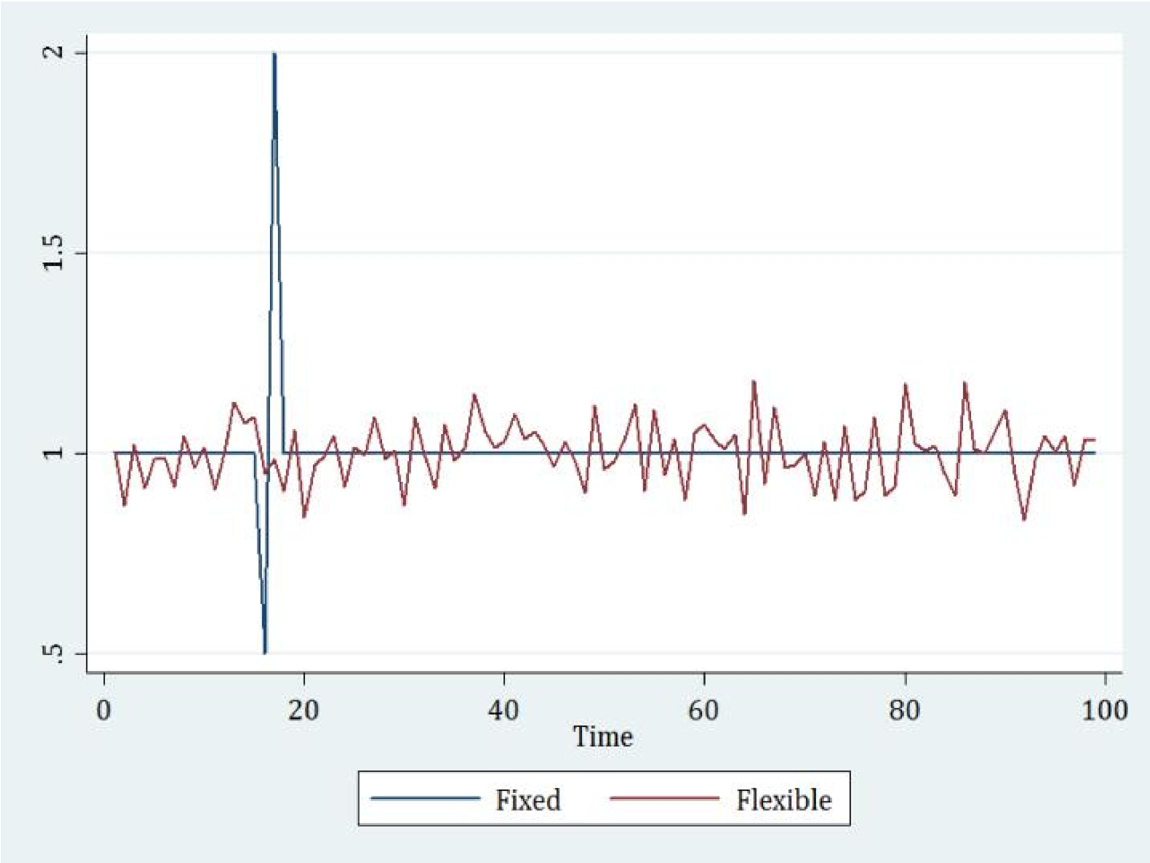

Figure 1.7: Volatility that "breaks" versus volatility that "bends"

perceive the same degree of uncertainty with respect to the value that "Fixed" will take tomorrow and with respect to the value that "Flexible" will take tomorrow? Probably not. Assume now that "Fixed" and "Flexible" are prices of two goods. The behaviour of Fixed has more scope for large effects on, say, accumulated profits than that of Flexible. The producer facing Flexible faces mild or "bounded randomness" whereas that facing Fixed faces "substantial randomness". Uncertainty associated with the former is somehow controllable by averaging while that associated with the latter is less so. Using a M-V approach, we would consider both series as equivalent ($E[u(Fixed)] = E[u(Flexible)]$), as "Flexible" has been constructed by drawing random numbers from a normally distributed population, such that the obtained series follows a normal distribution and $E(Flexible) = E(Fixed)$, and $V(Flexible) = V(Fixed)$ ($\mu = 1.005$ and $\sigma = 0.08$). It is possible to have a change in which location and scale do not alter, but shape does (kurtosis in our example).

Then, a M-V analysis will give the wrong answer. When distributions differ by location, scale **and** shape, the decision maker will not only look at mean and variance, but also at higher moments of the distribution. (In this case, for example, the kurtosis of "Fixed" is 66, while that of "Flexible" is 2.6.)

Take two countries, with different real exchange rate generating processes. In one, the process is consistent with low-probability extreme events (such as the series "Fixed" in figure 1.7), in the other, is consistent with a low, constant variance (such as the series "Flexible" in the same figure). If uncertainty affects the behaviour of producers, then it is reasonable to expect a larger effect, and therefore a more cautious behaviour of producers in the former country than in the latter, even if during a particular time period, the series shows to be stable.[23]

We cast doubt on the validity of A2 for the random variable being the RER in Argentina, Brazil and Uruguay, as these countries have had fixed nominal exchange rate regimes, with mild variations in RER, and then, collapses of these regimes with extreme RER movements in several occasions during the period of analysis. In Table 1.1 we present the first four central sample moments of the distribution of the growth rate of the RER over four different time periods.[24] The variation in the estimates of the parameters of shape (skewness and kurtosis) are evident. For illustrative purposes, we take two subperiods for Uruguay (last three rows of Table 1.1) in which mean and variance of RER growth are similar, but skewness and kurtosis change significantly, suggesting that these

[23]Daniel Heymann has coined a distinction between the volatility that "breaks" and the volatility that "bends". This distinction came up in the context of an informal discussion on exchange rate uncertainty generated by fixed versus flexible exchange rate regimes in Southern Cone countries, where currency crises are relatively frequent. Then, Heymann claimed that, frequently, fixed exchange rate regimes experience "underlying volatility". This is unobservable until it is so large that "breaks" the regime and generates an extreme episode. Underlying volatility in the context of flexible exchange rate regimes, on the other hand, manifests immediately, no matter how large it is, through movements in the exchange rate. Thus, it is less likely to accumulate and generate an extreme episode.

[24]We have arbitrarily chosen the time periods to illustrate the likely inadequacy of A2.

Country	Period	Mean	Variance	Skeweness	Kurtosis
Argentina	1970m1-1978m12	0.006	0.021	4.428	25.334
	1979m1-1991m12	0.013	0.048	7.230	68.257
	1992m1-1998m12	-0.001	0.000	-0.743	3.646
	1999m1-2004m12	0.012	0.005	3.866	19.327
Brazil	1970m1-1978m12	0.001	0.000	-0.895	5.346
	1979m1-1991m12	0.003	0.002	1.315	7.152
	1992m1-1998m12	-0.001	0.000	0.335	5.845
	1999m1-2004m12	0.007	0.003	1.616	8.200
Uruguay	1970m1-1978m12	0.003	0.009	7.791	74.843
	1979m1-1991m12	0.002	0.007	7.475	78.328
	1992m1-1998m12	-0.004	0.000	0.949	7.816
	1999m1-2004m12	0.005	0.001	2.012	14.909
	1996m1-2002m12	0.003	0.001	2.998	23.099
	2003m1-2004m12	0.003	0.001	-0.596	4.881
H_o:**Same** μ, σ	p-value	0.4413	0.3196		

Table 1.1: Sample moments for the Growth Rate of the REER

distributions do exhibit changing patterns in their shape.[25] Thus, the M-V approach seems inappropriate to deal with the randomness of the RER. To capture uncertainty, we will need to take into account higher moments of the distribution of the relevant random variable, besides the analysis of mean and variance.

1.5.2 Are the firm's financing decisions innocuous?

All references to the capital structure of the firm were ignored in our initial exposition of the effects of real exchange rate uncertainty on output, which relied on tools of the standard theory of the firm. When the firm operates in Sc3, in which there is a lag between the moment in which the production decision is taken and inputs are purchased, and the moment in which the revenue from the sale of output is obtained, working capital needs will arise. The financial strategy of the firm may add extra uncertainty, and will not be innocuous for optimal output, as we will show in Section 1.6. Here we discuss some of the options the firm may face in terms of its capital structure, and some of their implications.

Firms could finance working capital needs in excess of the available internally generated

[25] We test equality in means, and equality in variances and report the p-values in the last row of the table.

funds by issuing equity, or borrowing. When they choose the first alternative, the firm diversifies risk. However, as argued by Myers and Majluf (1984), firms generally do not issue equity to finance working capital needs. The authors find that the announcement of equity offerings reduces stock prices in a significant manner. They argue that informational imperfections are a plausible explanation for this finding. The manager of a firm has inside information about the value of the firm. For this reason, if the manager decides to issue stock at a given market price, the investors are only going to be willing to buy it at a lower price, exerting downward pressure on stock prices. That reduction in firm value would be a substantial "cost to false signalling", to be avoided if firms can rely on debt-financing — neglecting default risk.[26] In this case, creditors will not interfere with managerial decisions, but risk will not be diversified, and if the firm cannot meet its financial obligations due to adverse market conditions or poor management, debt will be unforgiving, and the firm will face bankruptcy. Bankruptcy is to be avoided by managers. This is because if it happens, they will suffer a stigma as it is difficult to distinguish whether the financial distress is due to poor management or due to adverse market conditions. This is why, as Greenwald and Stiglitz (1993) argue, managers are averse to bankruptcies and will internalize its expected costs when making the production decision.

Now, if firms tend to use debt as a source of financing, the currency structure of that debt needs to be considered, for in the countries under analysis and over a large portion of the period considered, liability dollarization has been a common phenomenon, largely independent of the trade orientation of the firm.[27] The existence of liability dollarization brings us to Scenario 3 presented in Section (1.3), in which there is another channel through which real exchange rate uncertainty will affect production decisions.

[26]Another explanation for the reduction in stock prices after equity issues is that there is a downward sloping demand for a firm's shares. (See Myers and Majluf (1984))

[27]For example, Galiani et al. (2003) argue that in Argentina, debt dollarization was "the rule rather than the exception", and found no relationship between the production mix, or the probability of a sudden nominal devaluation and the degree of debt dollarization.

The reasons behind liability dollarization are debatable. In general, banking lending rate differentials between domestic and foreign currency were significantly above devaluation expectations - at least those devaluation expectations that explained the banking borrowing rates' differentials (Licandro and Licandro (2003)). A myopic financial manager would then choose to borrow in foreign currency, as it is the apparent cheaper option. However, even if the agent is forward looking and foresees a large exchange rate depreciation, he may be tempted to borrow in foreign currency. This is because if all other agents are doing the same (and he's aware of that), a large depreciation would generate chained bankruptcies, and a collapse in the payment system of the economy. Because the social costs of that outcome are socially undesirable, then a debtor bailout could be ex-post optimal for the government. This induces firms not to internalize the exchange rate risk, and instead, rely on an implicit "free insurance" provided by a lender of last resort (the government) (see Burnside et al. (2001)).[28] Another view argues that dollarization was deliberately fostered by the governments in these countries in order to show a commitment to the fixed exchange rate regimes. By making the costs of a devaluation extremely high, the government tried to gain credibility (for a review of the literature on dollarization determinants, see Levy-Yeyati (2006)). Whatever the reasons behind this, the existing data reveals that it was a widespread phenomenon in Argentina and Uruguay, and though less prevalent, still significant in Brazil. Kamil (2004) offers some indicators in this respect. His database provides unique information on the currency and maturity structure of firms' liabilities for 10 Latin American countries.[29] The debt-dollarization ratio, calculated as dollar-linked debt as a percentage of total liabilities, is for Argentina during the 1990s, well above 50%; for Brazil, it was lower but still significant and in the range 11-20% during the decade, while for Uruguay the same ratio was in the range 74-

[28]The optimal output implications of this are discussed in Section 1.7.2

[29]The dataset covers a wide variety of firms, of different size and trade orientation.

84%. It is also possible to see that dollar debt seems to be longer term than non-dollar debt. In the case of Argentina, for example, the ratio of long-term dollar liabilities to total dollar liabilities is in the range of 30-55%, while the ratio of long-term non-dollar liabilities to total non-dollar liabilities is in the range of 11-21%. For Uruguay, the former ratio is in the range 23-54%, while the latter in the range 3-17%.[30]

A framework for the analysis of output decisions under real exchange rate uncertainty should incorporate these elements into account. This is what we do in next section.

1.6 An Alternative Approach: A Production Model with Bankruptcy Costs and Liability Dollarization

Here we present a simple production model with two key characteristics: production takes time, and firms finance working capital using dollar debt contracts. The firm operates in Sc(3). We start by considering the output effects of increases in expected depreciation, then we introduce bankruptcy costs, and attempt to answer what is the output effect of mean-preserving increases in exchange rate risk. We start by looking at the case of a firm producing non-tradable goods, and then discuss the implications for one producing tradable goods. Our model owes most to Greenwald and Stiglitz (1993).

The main result of the analysis that follows is that in a world of liability dollarization, in which firms face bankruptcy costs and exhibit mismatches in their balance sheets, even assuming away risk-aversion, exchange rate uncertainty will decrease optimal output. This is because an increase in uncertainty increases expected marginal bankruptcy costs, which are a component of expected marginal costs, to be equated to expected prices. Instead, when firms have matched balance sheets, say, because they produce tradable goods, whose prices are linked, via the law of one price, with the exchange rates and international prices,

[30] There is no data available for Brazil in this respect.

so that both their assets and liabilities expressed in pesos are affected symmetrically by currency movements, then, exchange rate uncertainty has no effect on optimal output of a risk-neutral firm, as it exerts no effect on expected marginal bankruptcy costs.

1.6.1 The Model

The firm is neutral to risk and produces a non-tradable good whose price is determined domestically. The firm operates in Sc(3). A single input is used to produce. It is bought at the beginning of the period in a perfectly competitive market. Output is only sold in the period after production, in a perfectly competitive market. For these reasons, the firm needs working capital to buy inputs. Working capital can only be borrowed in foreign currency from financial markets. The exchange rate is expressed as dollars per peso, and it is a random variable.

At the beginning of the period, the firm inherits liquidity balances of size a. These balances are generated by last period's difference between the revenue from the sale of output, and debt repayment.

The price of the only input equals w and is determined in a perfectly competitive input market.

This leads to a level of foreign-currency denominated debt B, along with a nominal interest rate to be paid to the lender, R, which is inherited at the beginning of next period. The peso-value of the debt repayment is unknown today, and will depend on the exchange rate prevailing in the next period.

The following assumptions are made:

(A1) **Production Technology**: Firms produce using only one input, and the production process exhibits diminishing returns. The input requirement function is $\phi(q)$, with $\phi'(q) > 0$, and $\phi''(q) \geq 0$. Note that the input requirement function is the inverse of a production function. Let A be the efficiency parameter of this production function.

For simplicity, we assume A=1.

(A2) **The Source of Randomness**: The exchange rate, measured as dollars per peso, is a random variable $\tilde{e}$. The expected depreciation over the period, $\delta^e = e_0/\tilde{e}_1 - 1 = 0$. $\tilde{e}$ is distributed with distribution function $F_{\tilde{e}}(.)$ and density function $f_{\tilde{e}}(.)$

(A3) **Dollar debt**: The level of debt is determined by the difference between the value of the input bill, and the liquidity balances of the firm at the beginning of the period. Debt can only be contracted in dollars. The peso-value of the repayment to the creditor in the next period is random, as so is the exchange rate.

(A4) **Prices**: There is only one good produced in the economy. To be able to focus on exchange rate uncertainty only, we exclude price uncertainty, and assume a fixed price. The fact that exchange rate volatility tends to be substantially greater than price volatility supports this assumption.

(A5) **Bankruptcy**: Default risk is zero. Firms don't go bankrupt.

(A6) **Creditors' market**: Creditors are risk neutral and perfectly informed.

Expressed in pesos, firms borrowing needs, B, are given by today's difference between the input bill and the inherited liquidity balances:

$$B = (w\phi(q) - a) \tag{1.22}$$

In foreign currency, $B^{\$} = B \times e_0$. What is to be paid back to the creditor in pesos, is known once the exchange rate is revealed next period, and equals: $B^{\$} = B \times \dfrac{e_0}{\tilde{e}_1} = B \times (1 + \delta)$.

To choose the level of output to be produced, managers will maximize an expected end-of-the-period wealth function which can be re-expressed as in (1.23):

$$max_q E\Big\{pq - (1+\delta)(1+R)(w\phi(q) - a)\Big\} \tag{1.23}$$

The first order condition is:

$$p - (1+R)(1+\delta^e)w\phi'(q) = 0 \tag{1.24}$$

Profits are a concave function of q when $\phi''(q) > 0$. The second order condition is:

$$-(1+R)(1+\delta^e)w\phi''(q) < 0 \quad \text{if} \quad \phi''(q) > 0 \tag{1.25}$$

1.6.2 Increases in Expected Depreciation

Proposition 3. *Optimal output is a decreasing and convex function of depreciation expectations, the dollar-return, and the input price if $\phi'(q) > 0$ and $\phi''(q) > 0$.*

Proof.

$$\frac{dq^*}{d\delta^e} = -\frac{\phi'(q)}{(1+\delta^e)\phi''(q)} < 0 \tag{1.26}$$

$$\frac{d^2q^*}{d(\delta^e)^2} = \frac{\phi'(q)\phi''(q)}{[(1+\delta^e)\phi''(q)]^2} > 0 \tag{1.27}$$

$$\frac{dq^*}{d(1+R)} = -\frac{\phi'(q)}{(1+R)\phi''(q)} < 0 \tag{1.28}$$

$$\frac{d^2q^*}{d(1+R)^2} = -\frac{\phi'(q)}{(1+R)^2\phi''(q)} > 0 \tag{1.29}$$

$$\frac{dq^*}{dw} = -\frac{\phi'(q)}{w\phi''(q)} < 0 \tag{1.30}$$

$$\frac{d^2q^*}{d(w)^2} = \frac{\phi'(q)\phi''(q)}{[w\phi''(q)]^2} > 0 \tag{1.31}$$

□

Higher depreciation expectations increase the expected peso-cost of working capital, and induce firms to decrease output to produce at lower marginal costs. The relationship is shown in Figure (1.8).[31]

An increase in efficiency, A, increases optimal output (the rate at which q increases depends on the structure of ϕ'):

$$\frac{dq^*}{dA} = -\frac{d\phi'(q)/dA}{\phi''(q)} > 0 \tag{1.32}$$

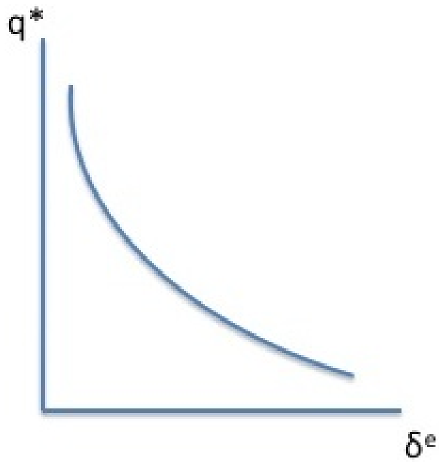

Figure 1.8: Optimal Output - Expected Depreciation

[31]The figures for input price and dollar-cost of borrowing are analogous.

1.6.3 Bankruptcies

We now relax A5. When firms' capital structure relies on debt, as argued here, the risk of bankruptcy emerges. Bad states of the world may prevent the firm from meeting its financial obligation due to what Baxter (1967) calls a state of "financial embarrassment". Bankruptcy is costly for firms, and thus to be avoided. We divide costs into direct and indirect costs:

(1) Direct (administrative and restructuring costs): these entail trustees' fees, legal fees, referees' fees as well as the time spent by the managers in litigation, plus, if the firm is forced into receivership by creditors, then costs associated with production disruptions, etc. These are likely to be increasing in firm's size.

(2) Indirect (opportunity cost of lost managerial energies): "financial embarrassment" may affect the stream of operating earnings because of difficulties in obtaining trade credit, disruption in customer relationships, etc. In addition, as argued by Greenwald and Stiglitz (1993), bankruptcies will affect the future prospects by managers, and that effect is likely to be increasing in output. This is because the choice of output levels is a significant role of managers. Bankruptcy with high levels of output should reflect unfavourably on their ability to do this. It implies bad judgement by managers and may thus be unusually costly to their future prospects.

Firms will take the probability of bankruptcy into account when making operating decisions, if the costs associated with that outcome are of sizable magnitudes. Warner (1977), for example, argues that bankruptcy costs are insignificant. He uses data on railroad firms in the US and calculates the ratio of bankruptcy costs to the market value of the firm, and finds this to be at around 1% when the firm's value is considered seven years before bankruptcy, and rising to about 5% when the firm's value is considered one year before bankruptcy. However, his focus is mainly on direct costs. In an attempt to quantify both direct and indirect costs, Altman (1984) compares predicted profits (using data corresponding to three years before bankruptcy) with actual profits and obtains an estimate of bankruptcy costs for industrial firms close to 17.4% of their value three years before bankruptcy. Opler and Titman (1994) reported that during downturns, highly leveraged firms facing financial distress tend to lose substantially more market share than their more conservatively financed competitors — this points to a significant indirect cost of financial distress.

The specification of bankruptcy costs is a moot point, but it seems reasonable to think they are increasing in output, because a) direct costs depend on firm's size, and b) indirect costs — and mainly those related to the manager's reputation, are likely to increase as output increases. In addition, as argued by Greenwald and Stiglitz (1993), for the possibility of bankruptcy not to be ever ignored, bankruptcy costs must increase in output. Otherwise, if, say, they are a fixed cost, profits (increasing in output) may grow so large relative to bankruptcy costs that these are eventually ignored.

In what follows we assume that the associated costs are increasing in output in the form described in equation (1.33), for the reasons outlined here:

$$Bankruptcy \quad Costs = cq \tag{1.33}$$

1.6.4 Solvency Exchange Rate and Ouptut

Because the firm borrows in foreign currency to finance working capital, there is a bankruptcy risk associated with exchange rate levels that would make the debt repayment higher than the output proceeds (the firm operates now in a modified Sc3, with default risk). Lenders can invest their wealth at the risk-free dollar-rate, r, so their expected return from lending to the firms must be, in dollars, at least r. The contracted interest rate at which firms borrow in the debt-market is R. The bankruptcy condition is:

$$\frac{(1+R)Be_0}{\tilde{e}_1} \geq pq$$
$$\frac{(1+R)(w\phi(q)-a)e_0}{\tilde{e}_1} \geq pq \tag{1.34}$$

A critical value for the exchange rate in period 1, $\bar{e}_1$, that leaves the firm just solvent, assuming $e_0 = 1$, for simplicity can be obtained from (1.34):

$$\bar{e}_1 = \frac{(1+R)(w\phi(q)-a)}{pq} \tag{1.35}$$

If in period 1 the exchange rate turns out to be lower (more depreciated) than $\bar{e}_1$, the firm goes bankrupt, while if it is higher (less depreciated) than $\bar{e}$ the firm remains solvent. Notice that the solvency exchange rate, $\bar{e}_1$, is the promised repayment per unit of revenue.

Firms in better than average financial shape (i.e. those with above average inherited liquidity balances (a)) will survive relatively more depreciated exchange rates than the average firm before becoming bankrupt. The lower the portion of working capital that is financed through debt, the larger the depreciation needed to make the firm bankrupt: $\bar{e}_1$ is decreasing in a.

$$\frac{d\bar{e}_1}{da} = -\frac{(1+R)}{pq} < 0 \tag{1.36}$$

The relationship between $\bar{e}_1$ and output is explained by whether production technology exhibits diminishing, constant or increasing returns. We discuss the cases of diminishing and constant returns (both consistent with competitive equilibrium, and the former, with A1). We don't consider the case of increasing returns as that case would lead to a monopolistic outcome, with endogenous prices, which is out of the scope of this model. Note that $\bar{e}_1$ is a ratio between costs and revenue. Look first the case of $a = 0$, in which firms do not inherit liquidity balances. All input purchases are financed through debt. If as output increases, costs increase at a slower rate than revenue, then, a more depreciated exchange rate is needed to bring the firm to bankruptcy (and conversely).

For any production technology the relationship between the solvency exchange rate and output is given by:

$$\frac{d\bar{e}_1}{dq} = \frac{(1+R)wp\big[\phi'(q)q - \phi(q)\big] + pa}{(pq)^2} \tag{1.37}$$

To be able to sign equation (1.37), we will assume a Cobb-Douglas production technology. That implies $\phi(q) = q^{1/\alpha}$. We focus on situations in which firms borrow, i.e.: $w\phi(q) - a > 0$, and $a \geq 0$. Let us consider two cases:

(1) If $\alpha < 1 \Rightarrow$ Diminishing Returns $\Rightarrow \phi'(q)q > \phi(q) \Rightarrow de/dq > 0$. As output increases, working capital requirements increase at an increasing rate $\phi'(q)$ ($\phi''(q) > 0$), while revenues increase at a rate p. This implies that increases in output increase exposure to bankruptcy because they increase the size of debt relative to that of expected revenue. It follows that less depreciated exchange rate realizations will bring firms to bankruptcy, as output increases.

(2) If $\alpha = 1 \Rightarrow$ Constant Returns $\Rightarrow \phi'(q)q = \phi(q) \Rightarrow de/dq \geq 0$. If $a = 0$, then, $\bar{e}$ is constant. Both costs and revenue increase at a constant rate (w and p respectively), and the ratio remains constant (red line in Figure (1.9)).

Figure (1.9) shows the relationship between $\bar{e}_1$ and output for the two cases discussed. In each case, we consider three different levels of liquidity balances (zero, "low", "high").

1.6.4.1 Lenders' Return and Equilibrium Solvency Exchange Rate

The solvency exchange rate defined in equation (1.35) can be used to define the dollar-return of lenders, $(1 + \tilde{r})$, as function of the random variable $\tilde{e}_1$, as in equation (1.38):

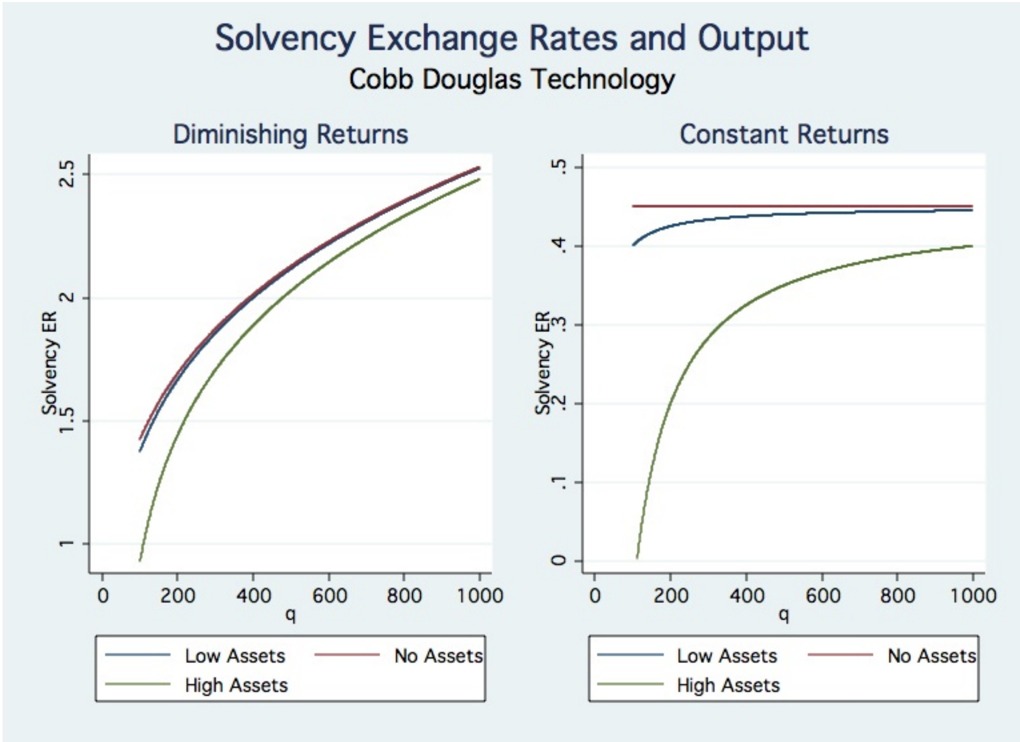

Figure 1.9: Solvency-Exchange Rate and Output

$$(1+\tilde{r}) = \begin{cases} (1+R) & \text{if } \tilde{e}_1 > \bar{e}_1 \quad (Solvency) \\ \dfrac{pq}{(w\phi(q)-a)}\tilde{e}_1 & \text{if } \tilde{e}_1 \leq \bar{e}_1 \quad (Bankruptcy) \end{cases} \tag{1.38}$$

Its expected value, $(1+r)$ equals the sum of the promised return times the probability of solvency plus the output proceeds relative to the debt, valued at the expected exchange rate conditional on bankruptcy (which equals $\int_{-\infty}^{\bar{e}_1} xdF(x)$, where x is the exchange rate and $F(x)$ its distribution function). This is presented in equation (1.39):

$$\begin{aligned} (1+r) &= (1+R)(1-F(\bar{e}_1)) + \frac{pq}{(w\phi(q)-a)}\int_{-\infty}^{\bar{e}_1} xdF(x) \\ (1+r)\frac{(w\phi(q)-a)}{pq} &= \frac{(w\phi(q)-a)}{pq}(1+R)F(\bar{e}_1) + \int_{-\infty}^{\bar{e}_1} xdF(x) \end{aligned} \tag{1.39}$$

We re-arrange equation (1.39), and consider the case of constant returns to scale, with $\phi(q) = q$. This yields equation (1.40), which shows, on the left-hand side, $(h(q))$, the expected repayment per unit of revenue as a function of output, and on the right-hand side, $(z(\bar{e}_1))$, the expected repayment per unit of revenue as a function of the solvency exchange rate, which in turn is equal to the promised repayment per unit of revenue. Thus, (1.40) expresses the implicit relationship between the level of output produced by the firm and the corresponding exchange rate that leaves the firm just solvent.

$$h(q) = \left\{ (1+r)\frac{(wq-a)}{pq} \right\} = \left\{ \bar{e}_1(1-F(\bar{e}_1)) + \int_{-\infty}^{\bar{e}_1} x dF(x) \right\} = z(\bar{e}_1) \tag{1.40}$$

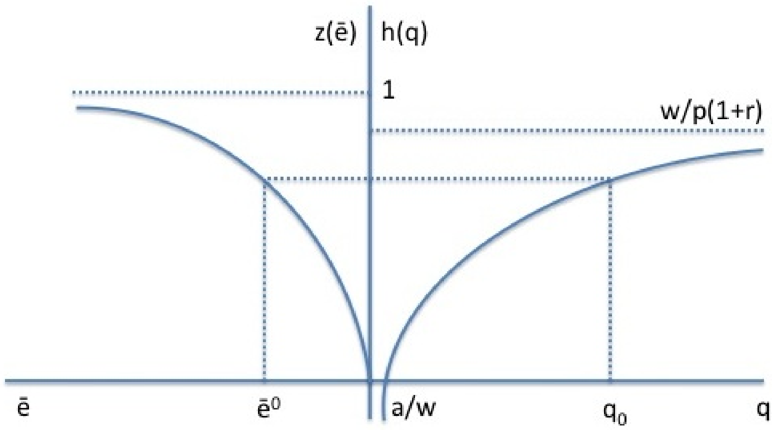

Figure 1.10: Output-Solvency Exchange Rate

A plot of that implicit relationship between output and the solvency exchange rate is useful, as it allows a more intuitive understanding of the link. This is what we do in Figure (1.10). The left quadrant of the figure maps the relationship between the firm's promised repayment per unit of revenue (the solvency exchange rate), and the *expected* repayment per unit of revenue. The right quadrant shows the relationship between the level of output and the expected repayment per unit of revenue. Now, consider an increase in the level of output. That will increase the expected repayment per unit of revenue. Consequently, the promised repayment per unit of revenue must increase as well. And that promised repayment equals the solvency exchange rate, $\bar{e}_1^*$. Therefore, $\bar{e}_1^*$ increases in q. Given constant returns, an increasing production makes the firm vulnerable to less depreciated exchange rate outcomes. Notice that as q increases towards infinity, h tends to $(1+r)w/p$ (which must be lower than 1, if output is positive), while $\bar{e}_1$ approaches a finite limit $\bar{e}_1^0$, which solves equation (1.41).

$$\frac{w}{p}(1+r) = \left\{ \bar{e}_1^0(1 - F(\bar{e}_1^0)) + \int_0^{\bar{e}_1} xdF(x) \right\} \tag{1.41}$$

At the same time, the promised repayment per unit of revenue must be 1 when the firm is insolvent for any realization of the exchange rate: as $\bar{e}_1^0$ tends to infinity, $z(\bar{e}_1)$ tends to $E(\tilde{e}_1) = 1$. This means that as q tends to infinity, the probability of bankruptcy tends to a finite limit, $F(\bar{e}_1^0)$. For a profit maximum to exist, then at equilibrium levels of w and r, $p - (1+r)w - cF_0 < 0$, otherwise, q could be increased without bound. This condition holds for a sufficiently large value of c.

Proposition 4. *The solvency exchange rate of equilibrium is an increasing function of q, convex and increasing of w, and a convex decreasing function of p and a.*

Proof. To find the equilibrium response of $\bar{e}_1$ to changes in q, w, p or a we use the implicit function differentiation rule, which expresses that (take the case of $d\bar{e}_1/dq$):

$$\frac{d\bar{e}_1^*}{dq} = \frac{1}{z'} \times \frac{dh}{dq} \tag{1.42}$$

Using equation (1.42) we confirm that in equilibrium, the sign of the responses of $\bar{e}_1$ to changes in a and in q are consistent with those showed in equations (1.36) and (1.37) respectively. In equilibrium, the more the firm produces, the less depreciated exchange rates needed to bring it to bankruptcy (equation (1.43)). Increases in output increase their exposure to bankruptcy, because the rate of change of debt is higher than the rate of change of expected revenue as output increases. Second, that the higher the firm's liquidity balances, the more depreciated exchange rate is needed to bring the firm to bankruptcy (equation (1.44)). And $\bar{e}_1^*$ decreases at an increasing rate with a, because higher values of a not only decrease the size of the debt, but they also decrease the required promised interest payment to lenders, as they reduce the probability of bankruptcy (and conversely for q):

$$\frac{d\bar{e}_1^*}{dq} = \frac{(1+r)a}{(1-F(\bar{e}_1^*))pq^2} > 0 \tag{1.43}$$

$$\frac{d\bar{e}_1^*}{da} = -\frac{(1+r)}{(1-F(\bar{e}_1^*))pq} < 0 \tag{1.44}$$

$$\frac{d^2\bar{e}_1^*}{da^2} = -\frac{(1+r)f(\bar{e}_1^*)d\bar{e}_1^*/da}{[(1-F(\bar{e}_1^*))pq]^2} > 0 \tag{1.45}$$

Analogously we show that a higher output price takes more depreciated exchange rates for the firm to go bankrupt, while the converse applies for a higher input price in equations (1.46) and (1.48).

$$\frac{d\bar{e}_1^*}{dp} = -\frac{(1+r)(wq-a)}{(1-F(\bar{e}_1^*))q} < 0 \tag{1.46}$$

$$\frac{d^2\bar{e}_1^*}{dp^2} = -\frac{f(\bar{e}_1^*)d\bar{e}_1^*/da(1+r)(wq-a)}{[(1-F(\bar{e}_1^*))q]^2} > 0 \tag{1.47}$$

$$\frac{d\bar{e}_1^*}{dw} = \frac{(1+r)q}{(1-F(\bar{e}_1^*))} > 0 \tag{1.48}$$

$$\frac{d^2\bar{e}_1^*}{dw^2} = \frac{f(\bar{e}_1^*)d\bar{e}_1^*/da(1+r)q}{(1-F(\bar{e}_1^*))^2} > 0 \tag{1.49}$$

□

The probability of bankruptcy, illustrated in Figure (1.11) can be expressed by substituting the solution value of $\bar{e}_1$, $\bar{e}_1^*$ into $F(\bar{e}_1)$.

$$P(Bankruptcy) = 1 - F(\bar{e}_1^*(.)) \tag{1.50}$$

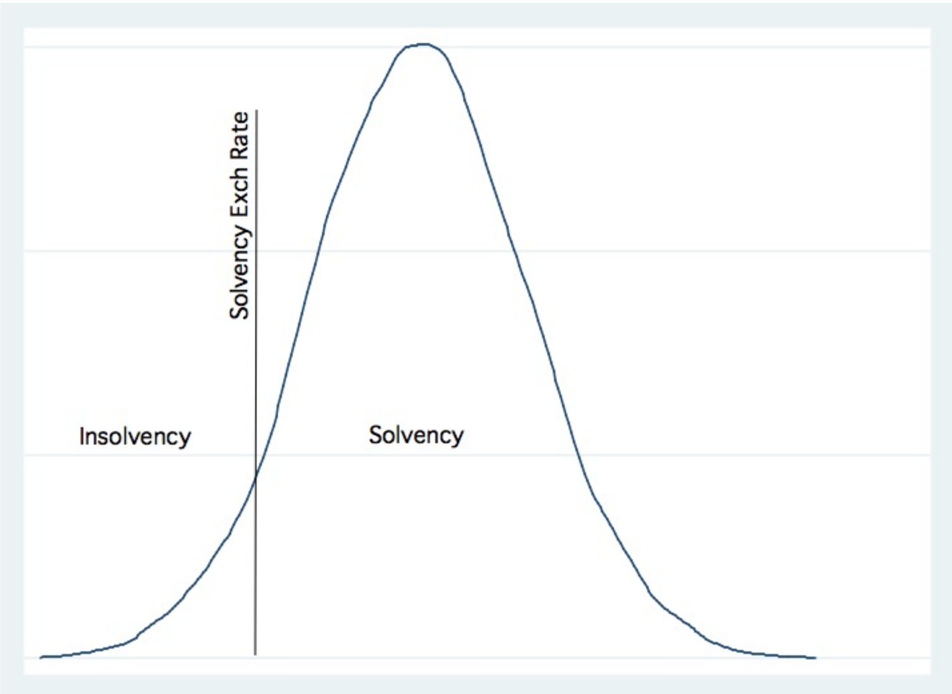

Figure 1.11: Exchange Rate Distribution: Solvency and Insolvency Zones

1.6.4.2 Optimal Output Decision

To choose the level of output to be produced, managers will maximize expected wealth at the end of the period (akin to an expected profit function) as presented in equation (1.51) that incorporates the standard components (i.e.: expected revenue from output sale minus expected repayments to lenders) minus an expected cost of bankruptcy, subject to equation (1.40). Bankruptcy costs are as in equation (1.33) for the reasons argued in Section (1.6.3).

$$max_q E\left\{pq - (1+R)(wq-a)\frac{e_0}{\tilde{e}_1} - cq\right\} \tag{1.51}$$

Equation (1.51) can be re-expressed as in equation (1.52), given that expected depreciation is zero (so, $E(e_0/\tilde{e}_1) = (1+\delta^e) = 1$)

$$max_q \left\{pq - (1+r)(wq-a) - cqF(\bar{e}_1)\right\} \tag{1.52}$$

The first order condition can be expressed as:

$$p = (1+r)w + MBC \tag{1.53}$$

where MBC is the marginal bankruptcy cost:

$$\begin{aligned} MBC = \frac{dE(BC)}{dq} = \frac{dcq(F(\bar{e}_1^*))}{dq} &= cF(\bar{e}_1^*) + cqf(\bar{e}_1^*)\frac{d\bar{e}_1^*}{dq} \\ &= cF(\bar{e}_1^*) + cf(\bar{e}_1^*)\frac{a(1+r)}{(1-F(\bar{e}_1^*))pq} \end{aligned} \tag{1.54}$$

Increases in output increase expected bankruptcy costs for two reasons: first, for a given probability of bankruptcy, higher output means higher bankruptcy costs, at a rate c. Second, increases in output increase the probability of bankruptcy. This is because increases in output increase the critical exchange rate at which firms are just solvent. Note that if the production technology exhibited increasing returns, then the sign of MBC would be *a priori* ambiguous. An increase in output would increase the costs of bankruptcy for a given probability, but the effect on the probability of bankruptcy would be ambiguous.

The optimal level of output, q^* can be found just by plugging in equation (1.54) in (1.53) and solving for q. This gives:

$$q^* = \frac{cf(\bar{e}_1^*)a(1+r)}{p(1-F(\bar{e}_1^*))(p-(1+r)w-cF(\bar{e}_1^*))} \tag{1.55}$$

The second order condition equals the opposite of $dMBC/dq$. q^* consistent with equation (1.55) corresponds to a profit maximum if and only if $dMBC/dq > 0$, which is true under certain conditions, and shown in equation (1.56).

$$\begin{aligned}
\frac{dMBC}{dq} &= c\left[f\frac{de}{dq} + \frac{a(1+r)}{p}(f'\frac{de}{dq}(1-F)^{-1})q^{-1} + f(1-F)^{-2}f\frac{de}{dq}q^{-1} - f(1-F)^{-1}q^{-2})\right] \\
&= c\left[\frac{a(1+r)}{p}f'\frac{a(1+r)}{p}(1-F)^{-2}q^{-3} + f^2(1-F)^{-3}\frac{[a(1+r)]^2}{p^2}q^{-3}\right] \\
&= c\left[\frac{[a(1+r)]^2}{p^2}\frac{1}{(1-F)^2q^3}f' + \frac{a^2}{p^2}\frac{f^2(1-F)^{-1}}{(1-F)^{-2}q^3}\right] \\
&= c\frac{[a(1+r)]^2}{p^2(1-F)^2q^3}\left[f' + \frac{f^2}{(1-F)}\right]
\end{aligned} \tag{1.56}$$

The sign of equation (1.56) depends on the sign of $[f' + f^2/(1-F)]$. Given that bankruptcies are rare, it is reasonable to think that solvency exchange rates tend to be on the lower tail of the exchange rate distribution (as illustrated in Figure (1.11)). We discuss this further in Section 1.6.5.1 and here we make that assumption. If the distribution is unimodal, then f' is positive at relevant levels of output. That implies $dMBC/dq > 0$. Marginal bankruptcy costs increase in output, and the second order condition of a maximum holds. Figure (1.12) shows the equilibrium where the MBC curve cuts from below the net marginal revenue curve (net marginal revenue= $p-(1+r)w$).

Irrespective of where in the distribution are the firm's solvency exchange rates, if the hazard function of the exchange rate distribution is monotonically increasing, then $dMBC/dq > 0$. This is because, as shown in equation (1.57), an increasing hazard function implies $f' + f^2/(1-F) > 0$. The hazard rate can be thought as the probability of a value of the exchange rate, e_1, occuring, given that a set of values $\{e\} < e_1$ have not occurred. An increasing hazard function means that the likelihood of a realization of the exchange rate e_1, conditional on no lower values having occurred is increasing in e.

$$\begin{aligned} \frac{d}{de}[\frac{f}{(1-F)}] &= \frac{f'}{(1-F)} + \frac{f^2}{(1-F)^2} > 0 \quad \text{which implies} \\ (1-F)\frac{d}{de}[\frac{f}{(1-F)}] &= f' + \frac{f^2}{(1-F)} > 0 \end{aligned} \tag{1.57}$$

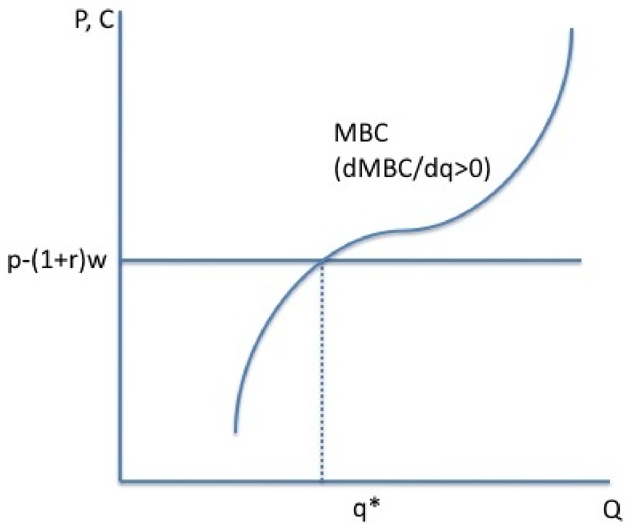

Figure 1.12: Firm maximising behaviour with costs of bankruptcy

Proposition 5. *Optimal output increases with prices and with liquidity balances if the firm operates with solvency exchange rates in the lower portion of a unimodal exchange rate distribution.*

Proof. Proposition (4) expresses that $\bar{e}_1^*$ is decreasing in output prices, which implies that also MBC are decreasing in output prices:

$$\begin{aligned} \frac{dMBC}{dp} &= cf(e)\frac{de}{dp} + cf'(e)\frac{de}{dp}\frac{a}{pq(1-F)} - \frac{cf(e)}{(1-F(e)}\frac{aq}{[pq(1-F)]^2} \\ &+ cf(e)\frac{a}{pq}\frac{f(e)de/dp}{[pq(1-F(e)]^2} < 0 \end{aligned} \tag{1.58}$$

The output effect of an increase in output prices, can be seen in Figure 1.12. It increases net marginal revenue at the same time as it decreases the MBC. Both effects lead to an increase in optimal output. Analytically, we find the optimal output response to changes in the price by totally differentiating the first order condition, which yields:

$$\frac{dq}{dp} = \frac{1 - \dfrac{dMBC}{dp}}{\dfrac{dMBC}{dq}} > 0 \tag{1.59}$$

Optimal output is increasing in a. By inspection of equation 1.53, it is possible to see that dq/da is the quotient of $-dMBC/da$ and $dMBC/dq$. Because higher liquidity balances reduce bankruptcy costs, it follows that output increases in a. (See Figure 1.12)

$$\begin{aligned}\frac{dMBC}{da} &= \frac{d\bar{e}_1}{da}\left[cf(\bar{e}_1) + \frac{cf'(\bar{e}_1)a}{pq(1-F(\bar{e}_1))} + \frac{cf^2(\bar{e}_1)a}{pq(1-F(\bar{e}_1))^2}\right] + \frac{cf(\bar{e}_1)}{pq(1-F(\bar{e}_1))} \\ \frac{dMBC}{da} &= \frac{d\bar{e}_1}{da}\left[\frac{cf'(\bar{e}_1)a}{pq(1-F(\bar{e}_1))} + \frac{cf^2(\bar{e}_1)a}{pq(1-F(\bar{e}_1))^2}\right] < 0 \end{aligned} \tag{1.60}$$

$$\frac{dq^*}{da} = -\frac{dMBC}{da} / \frac{dMBC}{dq} > 0 \tag{1.61}$$

□

The last result is relevant because it implies **persistence**. Any shock that affects today's profits will have an effect on tomorrow's liquidity balances. Firms with higher liquidity balances will produce a higher level of output. So, shocks to today's profits will affect tomorrow's output.

1.6.5 Increases in Uncertainty

Our purpose is to identify a pure uncertainty effect on output. We explore the output effects of a change in firms' perception about the distribution of the exchange rate, from

$\tilde{e}$ to $\tilde{e}'$. As illustrated in Figure (1.13), the change considered, henceforth "increase in tail-risk", implies that the probability mass in the tails increases, and that in the centre of the distribution falls, while $E(\tilde{e}) = E(\tilde{e}')$. This makes extreme exchange rate outcomes more probable, while keeping the mean value constant.

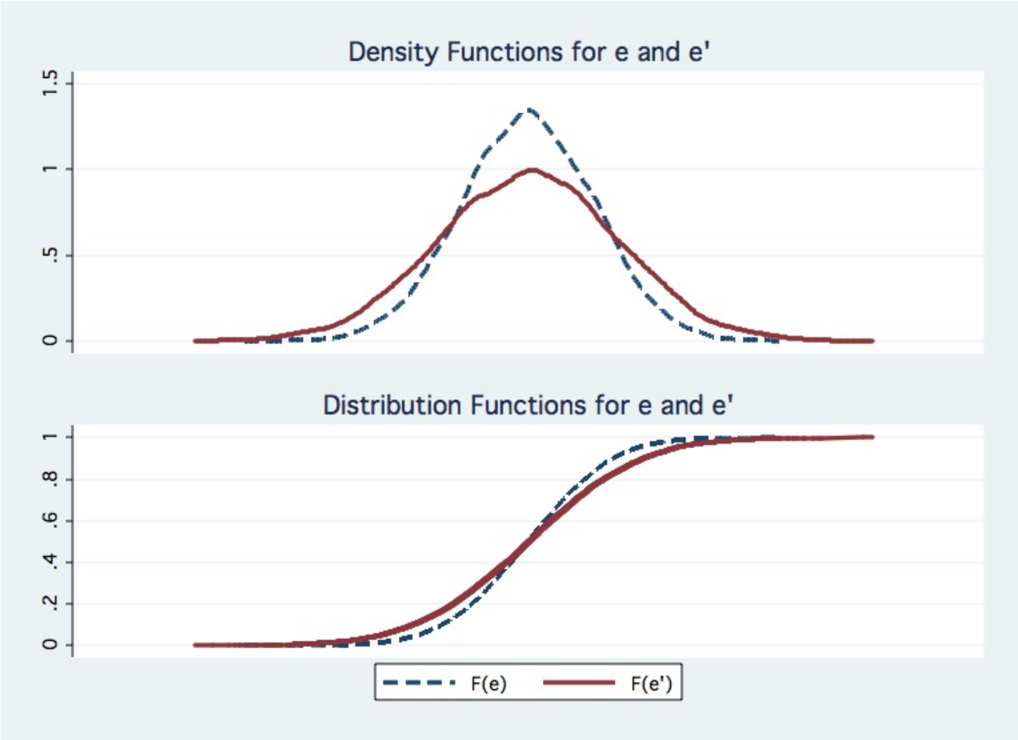

Figure 1.13: An Increase in Exchange Rate Uncertainty, from e to e'

Proposition 6. *Increases in exchange rate uncertainty lead to a decrease in the level of output produced.*

Proof. The output effect of an increase in uncertainty depends on what happens to the MBC. If the MBC increases after an increase in uncertainty, then output will fall. To observe that, see Figure (1.12): an increase in MBC leads to a decrease in output produced as the curve MBC shifts upwards (and conversely for a decrease in MBC).

The effect of increases in exchange rate uncertainty on the MBC at the optimum can be calculated by looking at a change in uncertainty that preserves the density function, f, but shifts the distribution F, and then looking at another change that preserves F, and alter f. We examine these changes in equations (1.62) and (1.63)[32]:

$$\begin{aligned} \frac{dMBC}{dF} &= c\frac{dF}{dF} + \frac{ca}{pq}\frac{d}{dF}[\frac{f}{(1-F)}] \\ &= c + [p-(1+r)w-cF]\frac{d}{dF}ln[\frac{f}{(1-F)}] \\ &= c + [p-(1+r)w-cF]\frac{1}{(1-F)} > 0 \quad \text{at the optimum.} \end{aligned} \tag{1.62}$$

$$\begin{aligned} \frac{dMBC}{df} &= c\frac{dF}{df} + \frac{ca}{pq}\frac{d}{df}[\frac{f}{(1-F)}] \\ &= [p-(1+r)w-cF]\frac{d}{df}ln[\frac{f}{(1-F)}] \\ &= [p-(1+r)w-cF]\frac{1}{f} > 0 \quad \text{at the optimum.} \end{aligned} \tag{1.63}$$

Both types of changes lead to an increase of the MBC, which implies that output falls after an increase in exchange rate uncertainty. □

1.6.5.1 Are Firms in Zone I or II?

We have argued that there is an ambiguity in the sign of $dMBC/dq$. If the hazard function of the exchange rate distribution is monotonically increasing or if the firms' solvency exchange rates are in the lower portion of a unimodal distribution, then $dMBC/dq > 0$. While the former condition is not easily interpretable, the likelihood of the latter condition holding can be scrutinized. As already argued, bankruptcies are not frequent in practice, and it seems reasonable to assume that solvency exchange rates are on the left tail of the distribution. De Brun et al. (2008) gives us a more accurate indication,

[32] If we denote the change in the distribution by dy, then we can write the total effect on MBC as $dMBC/dy = cdF/dy + (p-(1+r)w-cF)dln[f/(1-F)/dy]$

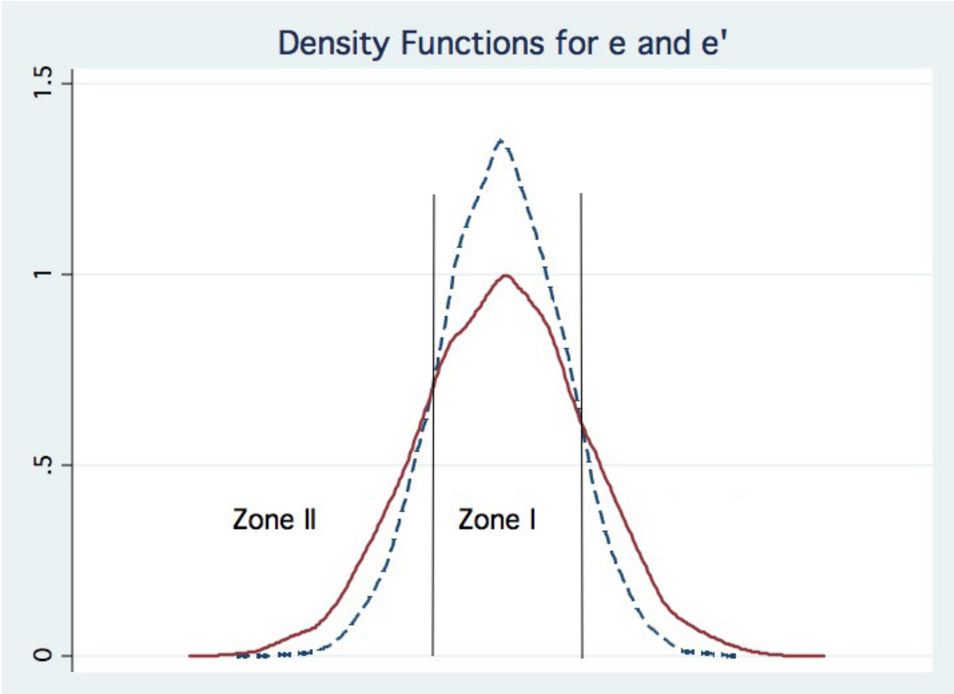

Figure 1.14: Two Zones: I $f'(\bar{e}_1^*) \leq 0$, II $f'(\bar{e}_1^*) \geq 0$

though only for Uruguay. The authors performed stress tests to a sample of manufacturing firms in Uruguay. They defined a firm as financially stressed "whenever an exchange-rate depreciation made it unable to meet its amortization and interest payments falling due and or whenever it pushed the firm into a negative equity position" (De Brun et al., 2008, p.229). In Figure (1.15) we combine the distribution of annual exchange rate changes (solid line, density measured in the axis on the left), with their data on the distribution of firms' solvency exchange rates (% of firms that would be financially distressed if the exchange rate was to change by $x\%$, measured on the axis on the right). It is possible to see that for the great majority of firms, the solvency exchange rates are well to the right of the distribution, probably corresponding to zone II, in our analysis.

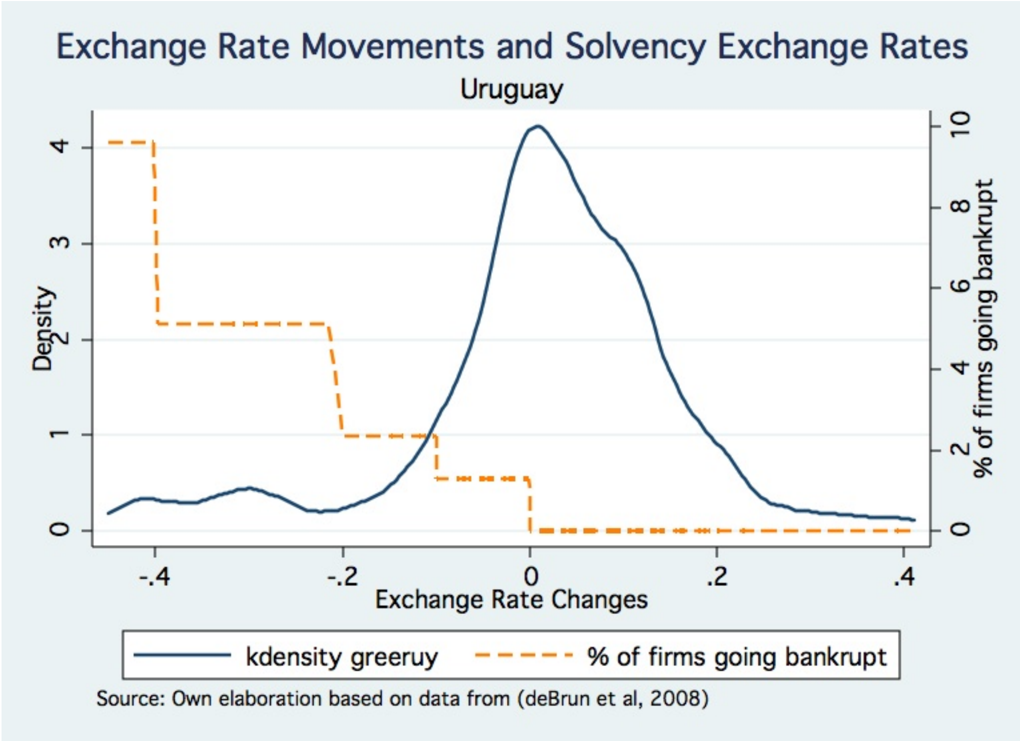

Figure 1.15: Distribution of actual and solvency exchange rates in Uruguay

1.7 Extensions

1.7.1 Firms Producing Tradable Goods

If the risk-neutral firm produces a tradable good 'T', with $p^T = p^{T*}/e$, where p^{T*} is the international price of the good 'T', expressed in foreign currency, then, the value of the exchange rate (and the riskiness of its distribution) is irrelevant for the probability of bankruptcy, as long as this firm has assets (revenue) and liabilities matched in terms of currency denomination. This can be seen by re-examining the bankruptcy condition, expressed by (1.34) in the light of the new setting, and assuming p^*=1, and $e_0 = 1$ for the sake of simplicity.

$$\begin{aligned} (1+R)B^{\$}e_0/\tilde{e}_1 &\geq pq \\ (1+R)(w\phi(q)-a)\times e_0/\tilde{e}_1 &\geq q/\tilde{e}_1 \\ (1+R)(w\phi(q)-a) &\geq q \end{aligned} \tag{1.64}$$

1.7.2 Soft Budget Constraints

If we examine the episodes of sharp depreciations in the countries under analysis, the line of argument proposed by this model, that relies on firms internalizing the costs of potential balance-sheet effects could be contested. This is because, as argued in Section 1.5.2, it may be ex-post optimal for the government to bailout debtors that are financially distressed as a consequence of the extreme exchange rate. In fact, governments have often acted in support of firms in order to relax the financial constraint they faced. For example, in Argentina, after a sharp real devaluation in 1982 that implied the collapse of a crawling peg system against the dollar, foreign currency denominated corporate debt was converted into domestic currency at the pre-devaluation exchange rate, at the expense of the Argentinean Central Bank. Something similar happened after the abandonment of the currency board regime in 2002, when the government enforced a compulsory conversion of dollar denominated liabilities up to 100,000 dollars into peso denominated liabilities at the one-to-one exchange rate, what is known as the "pesification" of debt. Any potential balance sheet effects were then eliminated (Galiani et al., 2003, p.344). In Uruguay, after the sharp devaluation in 2002, the state-owned bank, which is the main creditor to the manufacturing sector, called for a renegotiation of corporate debt in milder terms. This implied, for example, accepting government bonds as a means of debt-repayments at face value when their market price had plunged to about 60%.[33] Thus, sufficiently liquid firms faced a substantial reduction of their debt. At the same time, the government encouraged the private banking sector to offer debt renegotiation alternatives to the non-banking corporate sector. In Brazil, the "Banco do Brasil" provided some exchange rate risk hedging opportunities some days before the large devaluation of the currency in January 1999.[34]

[33]Source: Montevideo Stock Exchange.

[34]Personal communication with Pedro Bonomo, from Fundacao Getulio Vargas, Sao Paulo, Brazil.

These type of arrangements are akin to the notion of "soft budget constraints". According to Kornai et al. (2003), a firm faces a soft budget constraint if there is a support organization ready to alleviate part or all of the debt, and the firm managers or owners are aware of this possibility, and internalize it, when making decisions. In the context of our model, let us assume that the government is the support organization, and that it acts by exerting pressure on the banking sector for them to roll over corporate debt. That would mean that firms may only have to pay a portion λ of the debt they face at the beginning of next period.[35] Figure 1.16 shows the optimal output response to the possibility of a softening of the budget constraint. If firms only pay a portion λ of the debt, that increases the expected net marginal revenue, and at the same time reduces the MBC, as the soft budget constraint reduces the firm's solvency exchange rate. Both effects induce an increase in optimal output. The first order condition of the maximization problem of the firm is:

$$p = (1 + r)w\phi'(q)\lambda + MBC' \tag{1.65}$$

where $MBC' < MBC$.

If the government only intervenes when there is substantial exchange rate uncertainty, and so, important risks of economic and social disruptions, then, an increase in exchange rate risk will, on the one hand, increase the expected costs of bankruptcy, thus inducing a more "cautious" behaviour of firms (i.e.: reduce output), but on the other hand, will decrease λ, thus inducing the opposite effect on output. The final effect on output is therefore, ambiguous, depending on the relationship between the size of λ and the change in uncertainty.

[35] $0 < \lambda < 1$

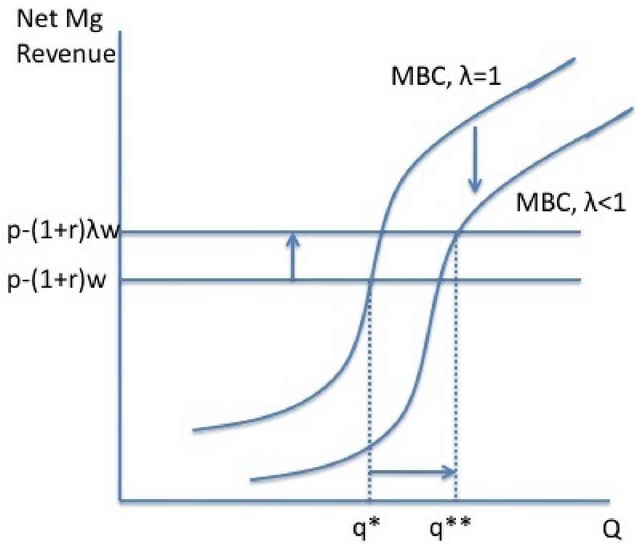

Figure 1.16: Firm maximising behaviour with costs of bankruptcy and soft budget constraints

1.7.3 High Uncertainty: The Unknown Unknowns

> "*...When, as today, the unknown unknowns dominate, and the economic environment is so complex as to appear nearly incomprehensible, the result is extreme prudence, if not outright paralysis, on the part of investors, consumers and firms. And this behaviour, in turn, feeds the crisis.*" Blanchard (2009)[36]

While Blanchard's quotation refers to the business environment in the financial crisis of 2008/9, it depicts well that of Southern Cone countries in episodes of high exchange rate uncertainty. Caballero and Krishnamurthy (2008) seems to give analytical support to Blanchard. While their focus is on financial risk management decisions instead of production decisions, their insight is relevant for our purposes. The authors show that in the presence of fundamental (or 'Knightian') uncertainty about the economic environment that leads agents to question their world-views and challenge their models used for decision-making, there will be an excessive demand for safety on the part of businesspeople, which

[36] The concept of the "Unknown unknowns" has been "coined" by former US Defense Secretary, Donald Rumsfeld, on February 12, 2002, referring to the unstable situation in post-invasion Afghanistan.

leads to disengagements with risky activities and liquidity hoarding.

We argue that in the context of the countries under analysis, high exchange rate uncertainty implies "structural" uncertainty. The concept of "structural" uncertainty is borrowed from Arza (2006) and refers to uncertainty about "the whole set of parameters that defines an economic system at a given time."[37] This set of parameters subject to uncertainty include the new exchange rate regime, if the current one actually collapses, but also other relevant parameters for the firm, such as the government reaction in terms of enforcement of property rights, the level of demand that the firm will face after the severe wealth effects of a possible depreciation, the access to credit, the access to marketing channels the firm may use in the event of possible chained bankruptcies, etc..[38]

Some anecdotal information on the communicational strategy of the government around (before and immediately after) drastic exchange rate movements illustrates how their actions actually tended to increase the perception of uncertainty among decision-makers, in the context of property rights enforcement. The regularity is that there is no discussion on the "reconstruction" agenda for the period after the large depreciation has actually taken place. In an attempt to grant credibility to the about-to-collapse system, governments tend to rule out the possibility of a depreciation in the first place, even when the rest of the actors in the economy (and the economic fundamentals) argue differently. This is likely to increase the degree of uncertainty faced by all agents in the economy, and paralyze those that make production decisions. In November 1982, journalists asked the General who was acting as de-facto president in Uruguay if there was going to be a devaluation. His answer was: "No, not even if Martians land here". Two days after, the dollar tripled its

[37](Arza, 2006, p. 6). This concept is better suited for our purposes than that of "Knightian uncertainty" used by Caballero and Krishnamurthy (2008). While latter one is related to immeasurable risk over a particular variable, the former is related to a *set* of parameters that are relevant for the decision-maker.

[38]It is worth mentioning that most of the episodes of extreme RER movements in the countries under analysis have had associated output contractions that were large enough to be called "rare disasters", by Barro (2006) in his analysis of rare disasters and asset markets. In particular, he identifies as disasters, the episodes in Argentina in 1979-1985 and in 1999-2002 and those of Uruguay in 1981-1984, and 1998-2002

value against the Uruguayan peso. Then, in 2001, months before the Uruguayan peso was to be devalued again, the President was encouraging people to borrow in foreign currency, arguing that they were not going to devalue. Something similar happened at the time in Argentina, where the President persistently claimed they were not going to devalue their currency. Just a few months later, the currency board was to be abandoned and the value of the dollar drastically increased. Uncertainty is also likely to increase if the strategies designed to deal with the potential balance-sheet problems lack credibility. On this respect, more anecdotal evidence can be presented: in January 2002, after a significant exchange rate depreciation and an ongoing banking crisis, the Argentinean government announced a plan according to which bank depositors were going to recover their deposits in the currency in which those had been originally denominated. At the same time, they announced that debtors would have their dollar-debts converted automatically into peso-debt (Clarin, 2002). The apparent incompatibility of both announcements, in a period in which the Argentinean government did not have access to credit markets to finance the cost of such a combination of proposals, and a depleted stock of foreign exchange reserves, is likely to have increased the degree of uncertainty perceived by agents in the economy.

How reasonable is it to assume that in this context, firms will internalize the behaviour that governments have had in the past and act as if they faced a soft budget constraint, deciding to increase their exposure to exchange rate risk?

Our conjecture is that firms do not take the soft budget constraint for granted. Instead, they will react to high uncertainty with conservatism and caution - or in Blanchard's words: "outright paralysis". Our contention is that the effects of high uncertainty on output decisions will be dominant over any possible effect of perceptions of soft budget constraints. Thus, firms will tend to defer production decisions in a context of high uncertainty.

1.8 Concluding Remarks

In this chapter we proposed a framework to analyze the impact of exchange rate uncertainty on output decisions when production takes time, and firms finance their working capital needs with dollar debt contracts. The framework seems to be well suited to understand the output implications of currency mismatches in the context of economies with undeveloped exchange rate risk hedging instruments, as it explains a stylized fact: output fluctuates significantly with exchange rate uncertainty.

The main results of this chapter are the following:

First, shocks to profits have persistent effects on output through their effects on liquidity balances. The financial "health" of the firm, understood as the size of the liquidity balances it holds at the beginning of the period matters for the output choice. Firms with higher liquidity balances face lower marginal bankruptcy risks. Thus, any shock that affects today's profits, will affect tomorrow's liquidity balances, and so, firms' output.

Second, when firms face bankruptcy risks, increases in exchange rate uncertainty will increase marginal bankruptcy costs if the firm produces non-tradable goods (i.e.: exhibits currency mismatches), thus inducing firms to reduce output. By internalizing the bankruptcy cost, the firm acts as averse to bankruptcy costs. Because firms are aware that most others are borrowing in dollars, it is reasonable to think that they may anticipate a government bailout in the event of drastic exchange rate depreciations. This is because it may be ex-post optimal for the government to intervene, so as to avoid chained bankruptcies and disruptions in the payment system. Under those circumstances, the effect of increases in uncertainty on output are analytically ambiguous, as the higher the likelihood of extreme exchange rate outcomes, the higher the probability of benefitting from a government bailout. However, our contention is that firms do not take bailouts for granted in the event of high exchange rate uncertainty, for those periods are characterized by lack of information with respect to possible reconstruction agendas, and a generalized state of “irreducible” uncertainty that leads firms to disengage with risky activities and hoard liquidity.

This framework can be extended either to explain other firms’ decisions in response to exchange rate uncertainty (e.g investment) or to analyse other uncertainty-output channels such as that operating through input or technology prices (i.e. imported inputs are not easily substitutable and firms may have signed contractual arrangements on foreign technology licenses).

Chapter 2

Real Exchange Rate Uncertainty and Output: A Sectoral Analysis

2.1 Introduction

It is a well established fact that developing countries have experienced a more uncertain economic environment than developed countries. Within developing countries, heterogeneity is quite marked, and it can be shown that Mercosur countries — Argentina, Brazil, Paraguay and Uruguay — have a particularly high volatility record, which in turn generates a more uncertain environment.[1] At the same time several trade agreements, and then the creation of Mercosur have resulted in an increase in intra-regional trade, which has been heterogeneous across sectors and countries, but generalized, and has therefore implied an increase in exposure to markets characterized by uncertainty.[2]

[1]For example, **?** document large cross-country differences in the long run volatility of the real exchange rate between developing and developed countries. In particular, they show that the real exchange rate of developing countries is approximately three times more volatile than the real exchange rate in industrial countries. We compare series on GDP growth, CPI inflation, and nominal exchange rate depreciations for Argentina, Brazil and Uruguay, with those for Australia, Canada, New Zealand and the United Kingdom and find that for the former group of countries, the standard deviation of the series is systematically larger than for the latter — this is reported in Table C.1 of the Appendix C.

[2]The heterogeneity across sectors in this process can be exemplified. For example, in Argentina, sector 311 (Food Processing) increases its participation of intra-region exports from 2.71 percent to 4.85 percent while sector 384 (transport materials) increases its share from 13.33 to 34.01 percent.

The extant literature on uncertainty and productive decisions has generally focused on investment, given the irreversibility that surrounds this decision, after the pioneering work of Hartman (1972), Abel (1983), and McDonald and Siegel (1986). Their theoretical contributions have been matched by extensive empirical research. However, less attention has been put on the impact of uncertainty on output — the textbook approach that follows from the seminal work of Hawawini (1978), predicts that the output response to price uncertainty will depend on the firm's attitude to risk. The relatively low interest in the uncertainty-output link is surprising given that production is also characterized by some degree of irreversibility, as firms have to pay for inputs before output is sold, thus making any decision to produce an inherently risky investment decision. This has been argued by Greenwald and Stiglitz (1993) who develop a production model in which firms finance working capital through borrowing and face bankruptcy costs. Then, an increase in price uncertainty will induce firms to contract output, even if firms are neutral to risk, as the probability of falling into bankruptcy will increase. In Chapter 1, we adapt their model to a context in which uncertainty comes from real exchange rates and firms contract dollar-debt, and show that the contraction of output after an increase in real exchange rate uncertainty depends both on how productive the firm is and on the size of the currency mismatch in the firm's balance sheet, which in turn depends on the trade orientation of the firm.

Given the aforementioned uncertain macroeconomic environment, the increase in the relative importance of Mercosur partners for the different manufacturing sectors, and the scant empirical literature on the effects of uncertainty on output, this chapter explores empirically the impact of uncertainty on the output of manufacturing sectors in Mercosur member countries, concentrating on one particular dimension of macro uncertainty: that of the Real Effective Exchange Rate (REER). In these countries the expected value of the REER and the uncertainty surrounding that expectation are key factors affecting most production decisions and not only those that imply cross-border transactions. There are three reasons for this. First, the REER has an effect on the price of tradable goods sold by manufacturers. Second, because during much of the 1980s and 1990s a large portion of firms contracted dollar-debt to finance their production plans, and third, because hedging instruments to cover against exchange rate risk have been largely unavailable. A pilot survey conducted on Uruguayan firms at the beginning of the research confirmed that the evolution and predictability of the REER are among the top concerns of manufacturers.[3]

Our contribution in this chapter is threefold. First, we identify the average effect of REER uncertainty on output in the manufacturing sectors of Mercosur countries. For these purposes, we estimate an output supply function using data from 28 manufacturing sectors in Argentina, Brazil and Uruguay over the period 1970-2002, tackling the output-price simultaneity problem with instrumental-variable techniques, and using alternative sets of instruments to check the robustness of our results, whilst also allowing for heterogeneous effects across countries.[4] Second, we test for the presence of threshold effects on the relationship between REER uncertainty and output. Third, we test for sectoral heterogeneity in the output response to REER uncertainty and try to identify whether trade orientation, the intensity with which the sector trades within Mercosur, and labour productivity are drivers of that heterogeneity.

We present new evidence suggesting that REER uncertainty has negatively affected, on average, the level of output produced in the manufacturing sectors in Southern Cone countries over the period 1970-2002. Further to this, we find that the average effect masks significant specificities in the relationship. Although the effect seems to be stable when allowing for country heterogeneity in the response, there seems to be a threshold above which uncertainty affects output negatively, but below which the effect may even be

[3]The importance attached to REER evolution among manufacturers and policymakers is not restricted to Uruguay, as discussed in Frieden and Stein (1999).

[4]Paraguay is excluded from the analysis as data for that economy are unavailable.

positive. Moreover, those sectors that exhibit a higher exposure to export markets tend to be less responsive to REER uncertainty, although the opposite is true for those that trade intensively with Mercosur member countries. In addition, those sectors displaying a higher degree of labour productivity are less sensitive to REER uncertainty. Last but not least, we find that output is not only responsive to the first two moments of the distribution of REER (mean and variance), but also to higher moments such as skewness and kurtosis.

The remainder of the chapter is structured as follows. Section 2.2 describes the sources for the data used in this chapter. Section 2.3 documents the stylized facts that motivate this chapter and the research questions. Section 2.4 presents the methodology to be used. Section 2.5 presents and discusses the results, and finally Section 2.6 concludes.

2.2 Data

To explore the empirical relation between output and REER uncertainty, we draw from the Industrial Dynamics Analysis Program dataset (PADI, in Spanish), complied by the Economic Commission for Latin America and the Caribbean (ECLAC), on yearly series of sectoral output, prices, exports and labour productivity for 28 manufacturing sectors at a 3-digit aggregation, for the period 1970-2002, for Argentina, Brazil and Uruguay. REER data are also obtained from ECLAC with monthly periodicity (the REER is defined such that increases correspond to real depreciations and it is calculated as the weighted average of the bilateral real exchange rates, with the trading partners, where the weights are defined according to the trade share explained by each of the partner). Other macro variables used, such as GDP and population growth are obtained from the IFS database of the IMF. We use Reinhart and Rogoff (2009)'s indicator of crises "BCDI" (banking, currency, default, and inflation). Data on exchange rate regimes ('fixed', 'floating' or 'intermediate') follow the classification of Levy-Yeyati and Sturzenegger (2005). A brief description of the main series used in the analysis and some descriptive statistics is presented in Appendix B.

2.3 Integration and REER Uncertainty

This chapter is motivated by two stylized facts: a) the increase in trade integration among Southern Cone countries during the period 1970-2005, and b) the high record of REER uncertainty exhibited over this period, by these economies. In this section we document trade integration among Mercosur member countries using export intensity indices (EII) at an aggregate level (defined below), and export shares to Mercosur at a sectoral level, as well as REER uncertainty using three alternative measures.[5]

2.3.1 Trade Integration: Measurement and Evolution

The increase in trade integration among Mercosur member countries is documented using export intensity indices (EII), a measure of intra-bloc export penetration introduced by Anderson and Norheim (1993) that adjusts the traditional regional export shares, using as a parameter the relevance of the region in world exports, by simply dividing the regional export share by the region's share of the world imports.[6]

$$\left(\frac{X_{i,m}}{X_{i,w}}\right) \Big/ \left(\frac{M_{m-,w}}{X_{w,w}}\right) = EII_{i,m} \tag{2.1}$$

where $X_{i,m}$ are exports from country 'i' to Mercosur, $X_{i,w}$ are exports from country 'i' to the world (including Mercosur), $M_{m-,w}$ are imports of the world from Mercosur excluding country 'i', $X_{w,w}$ are the world's total.

As can be seen in Equation 2.1, the EII yields the quotient of the ratio of openness of country 'i' to Mercosur and that of Mercosur to the world. If trade was frictionless

[5] In this chapter we use "Southern Cone countries" and "Mercosur member countries" interchangeably referring to Argentina, Brazil and Uruguay. Only trade data are available for Paraguay. For this reason, we excluded it from the analysis in the rest of the chapter.

[6] The use of export shares is avoided as these could give a misleading message. Take a scenario in which Mercosur is expanding much faster than the rest of the world economies, it will naturally account for more of everybody's exports through time, quite independently of any policy interventions aimed at increasing trade integration. Data are obtained from the Comtrade Database of the World Bank.

and balanced, and if goods were homogeneous, then, these two ratios should be equal. If, for example, the value of Uruguayan exports to Mercosur is 10, while the value of total Uruguayan exports are 90, then trade would not be regionally biased if the weight of Mercosur in the world is one ninth, measured as the participation of Mercosur exports (excluding Uruguay) on total world exports. Thus, $EII = 1$. This will be our benchmark for comparison.

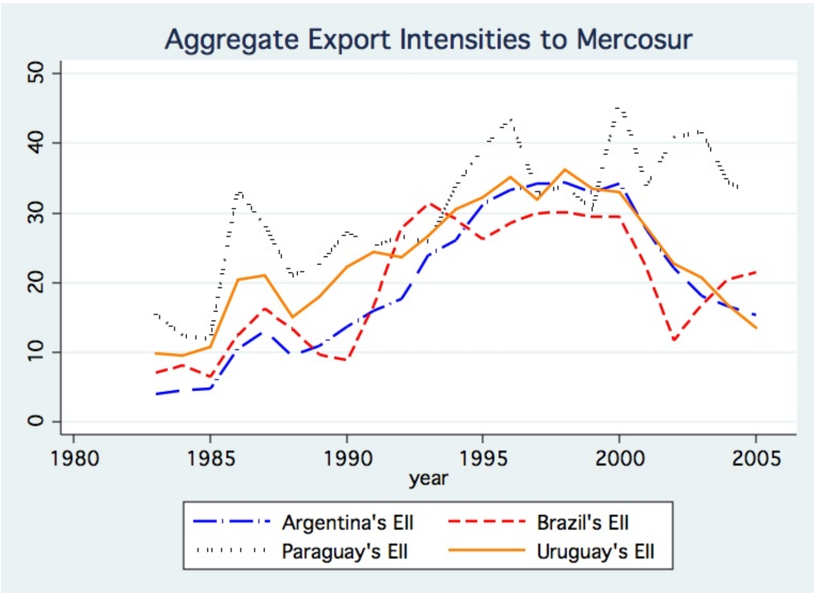

Figure 2.1: Mercosur - Aggregate Export Intensities (Source: Comtrade)

The evolution of the EII over the period 1983-2005 is presented in Figure 2.1.[7] During the nineties, the intra-bloc export intensity indices exhibit an inverted-U shape for Argentina, Brazil and Uruguay.[8]

The increase the EII exhibit for the first part of the 1990s can be attributed to a systematic decrease in intra-bloc trade protection, including reductions of both tariff and non-tariff barriers to intra-bloc trade. Plausible explanations for the trade reversal observed in the late 1990s are: a) the important rise in ad-hoc within-bloc tariff and non-tariff barriers that were imposed after 1999 — this rise corresponds to an attempt to counteract

[7]The choice of the period of analysis was constrained by data availability.

[8] For Paraguay the evolution of the index is irregular. This is likely to be related to problems with reported data.

the enhanced competitiveness of the trading partners whose currencies had been devalued[9] — and b) trade agreements that Mercosur as a bloc, or each of its member countries individually subscribe with third parties will affect the relative importance of Mercosur for each of its members, thus decreasing the EII. [10]

Despite the inverted-U shape, the comparison of the average EII in the period before the formation of the trading bloc (1983-1990) and after (1991-2005) shows a significant increase in the indicator.[11] At the same time, the share of Mercosur exports on world exports decreased significantly. In other words, the regional bias in Mercosur exports increased over the period 1983-2005.

We also calculated Mercosur export shares, at 2-digit aggregation using the ISIC 2nd Rev. classification. These shares are calculated as the ratio between the exports of a sector in a given country to a Mercosur country and the total exports of that sector/country. Difference-in-means tests to compare the average EII over the period 1983-1990 against the average over the period 1991-2005 for each of the three countries suggest unambiguous increases in the share of exports with destination Mercosur for all sectors considered in Argentina and Brazil. In Uruguay, increases in the share of exports over the period are identified for sectors 31, 32, 33, 34 and 38. When focusing on the average levels for the period, the lowest regional bias is displayed by sector 31, while sector 38 displays the

[9]ECLAC (2003), for example, argues that the shocks experienced by Mercousur countries had negative effects on the integration process. An example of this is the rate of 3% on all imports that was introduced by Uruguay as a service charge of the "Banco de la Republica". It also demanded funding for accepting Argentinean exports and implemented specific import duties in 2002. These led to a complaint lodged by Argentina to the Common Market Group. On the other hand, Paraguay established an import levy in 2001, on the basis of what it refers to as the "shortcomings and inadequacy" of the Group's macroeconomic coordination. (pp:74-78) Furthermore, Fernandez-Arias et al. (2002) claims that "*The Brazilian devaluation of 1999 did produce substantial protectionist pressures, as well as a drastic drop in public opinion's surport for Mercosur in these countries.*". (p.6)

[10]ECLAC (2003), for example, claims that "*the mediocre results of the Doha Round of WTO negotiations mean that more emphasis is placed on the group's external relations*" (p. 80). One example, is the complementary agreement reached with Mexico (Economic Complementarity Agreement No 55), which laid the foundations for free trade between Mercosur and Mexico in some specific sectors. More information on this and other agreements of Mercosur with third countries can be found in ECLAC (2003).

[11]The significance of the increase should be understood in the statistical sense. This comparison is performed using a difference-in-means' test. We compare the average intra-bloc EII over the period 1980-1990 against the average over the period 1991-2005. The null hypothesis is that the two values are equal.

highest.

The size and evolution of the EII calculated at aggregate and the export shares calculated at the sectoral levels reveal three patterns. First, there was an increase in the participation of Mercosur on total trade of its member countries. That this increase was not related to an increase in the importance of Mercosur in world markets, but to an increase in the importance of Mercosur for its member countries. Second, there are important regional biases, as the size of the EII is systematically larger than unity. The region is a key export destination for each of its members. Third, the picture is quite heterogeneous when looking at sectoral shares. The sectors that account for the largest share in manufacturing do increase their regional biases in the period. In terms of the size of the bias, sector 31 shows the lowest, while 38 shows the highest.

2.3.2 REER Uncertainty: Measurement and Evolution

We use three alternative measures to proxy uncertainty with respect to REER changes that differ on the degree of sophistication assumed for the agent's expectation formation mechanism. The three measures assume that agents are backward-looking, and forecast using an autoregressive model. This model is estimated using monthly data on the REER as constructed by the Economic Commission for Latin America and the Caribbean. Although the assumption of backward-looking expectation formation mechanisms can be criticized, it is widely used in the literature. Its validity will be discussed more carefully in Part II of this thesis (in particular, in Chapter 4).

Then, uncertainty surrounding that forecast is measured as the volatility of the forecast error of the past periods. Then, we use these monthly measures of uncertainty to obtain an annual one, to match the data on production and prices that will be used in the analysis that follows.

The first measure is obtained using Autoregressive Conditional Heteroscedasticity models (ARCH). In essence, the squared residuals of the series of the REER changes after being purged of its systematic component (the squared forecast errors) are assumed to be heteroscedastic. The structure of the heteroscedasticity (an autoregressive, and a moving average component) is estimated, and thus, a measure of the conditional variance of the series is obtained. This is taken to be the measure of REER uncertainty (Volat-ARCH). The relevant past volatility that determines the agents perception of uncertainty today is determined by the data.[12]

A simpler structure for expectation formation may be more appealing if there are costs of processing information. Although our second measure (Volat-RollVar) also assumes that agents forecast using an autoregressive rule, and that the forecast errors are heteroscedastic, now uncertainty with respect to REER changes is calculated as the rolling variance of the last twelve forecast errors. The difference with the first measure is twofold. First, with Volat-RollVar, we impose the lag structure that matters in determining today's uncertainty. With Volat-ARCH the choice is based on the best-fit of the model. Second, with Volat-RollVar we impose equal weights for each of the twelve months of the lag structure. With Volat-ARCH those weights are estimated by the model.

The third measure (Variance REER) assumes a naive agent with static expectations about the changes in the REER. The agent predicts no movement whatsover. As in the previous cases, REER uncertainty will be determined by the variance of the past forecast errors, but this variance will now be equal to the variance of the series of REER changes itself. Here as well, we impose a window of twelve months. Notice that if part of the REER changes are predictable, then this measure will be overestimating the forecast error, and thus, the amount of uncertainty perceived.

Given that the series of REER changes is found to be non-normal, higher moments

[12]The best-fit model for Argentina was an ARCH(2), for Brazil an ARCH(4) and for Uruguay an ARCH(4). These suggest a memory of 2 months in the conditional variance series for Argentina and of 4 months in the series for Brazil and for Uruguay.

need to be considered when characterizing the degree of uncertainty it generates, so we also include a measure of their skewness and kurtosis.[13] These measures are computed as twelve-month rolling skewness and kurtosis of the residuals of the best-fit ARIMA on the series of the REER growth, and are common for the three aforementioned measures of uncertainty.

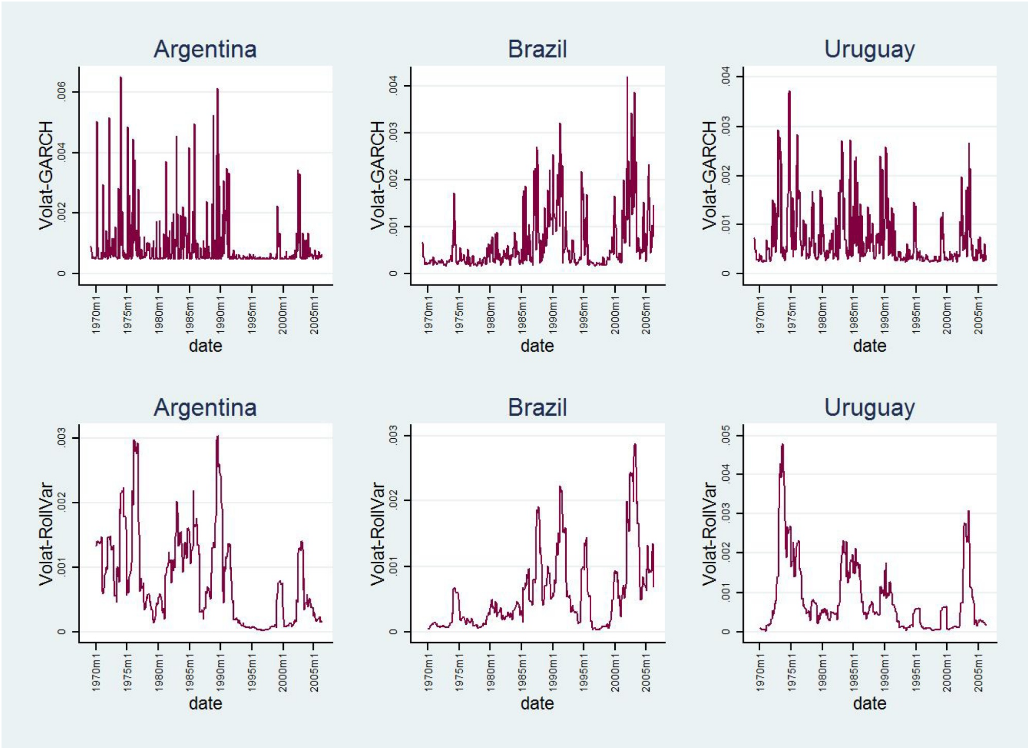

Figure 2.2: Conditional Variance of the REER growth

Figure 2.2 displays the evolution of the first two measures of uncertainty with respect to REER changes, constructed using monthly data, using the method described above, for each of the three countries considered, over the period 1969.01 to 2006.04.[14]

Averaging over the whole period, our measure of uncertainty for Argentina (the volatility of the forecast error) suggests a standard deviation from the mean equal to 3% or 2.8%, depending on whether we look at the Volat-ARCH (top) or Volat-RollVar (bottom)

[13] Gravelle and Rees (1992) show that when probability distributions cannot be fully characterized by parameters of location and scale, then, uncertainty generated by these variables can be understood by looking at all moments of the distribution and not only the first two.

[14] The conditional variance series plotted here are the author's calculations on the basis of data on REER obtained from ECLAC.

measure respectively. For Brazil, the standard deviation is 2.58% or 2.34% respectively and for Uruguay 2.67% or 2.93%. Given that the average of the absolute monthly changes in REER is around 4.8%, 2.25% and 2.5% for Argentina, Brazil and Uruguay respectively, the measures of uncertainty seem large, as they imply that on average, the size of the forecast error, relatively to the actual change in the REER is close to 60% for Argentina, and well above 100% for Brazil and Uruguay.[15] Even if large, these numbers are in sharp contrast with the third measure considered. The standard deviation of the growth rate of the REER, as reported in Table B.2, equals, for Argentina 14.2%, for Brazil 3% and for Uruguay 6.3%. However, as argued before, it is likely that "Variance REER" is overestimating actual uncertainty.

The difference in the degree of inertia that can be observed in Figure 2.2 when comparing Volat-ARCH and Volat-RollVar is explained by the difference in the methodology of construction. For Volat-ARCH, the estimated memory of the first measure is at most, of four months for the cases of Brazil and Uruguay, and two months for the case of Argentina, while the memory imposed on the Volat-RollVar measure is of twelve months. It is not surprising, then, that shocks to volatility appear to have a relatively shorter life when looking at the Volat-ARCH series than when looking at the Volat-RollVar series.

We have argued that REER uncertainty has been particularly high in the Southern Cone economies of interest in this analysis during the period 1970-2002. To investigate this matter, we ask the following question. How do Southern Cone economies fare in terms of REER uncertainty *vis-a-vis* other South American economies?

To answer the question, we calculate the same measures of uncertainty with respect to REER changes, but now for other South American countries, and perform a cross-country comparison across countries using difference-in-means tests, and comparing the

[15]These calculations are, of course, valid, under the assumption of agents forecasting using the autoregressive model described above. Descriptive statistics of the series of REER changes for the three countries are reported in Table B.2 in the Appendix B.

magnitudes of the measures for Argentina, Brazil and Uruguay, versus that of the other countries. Table 2.1 shows the ratios of Volat-ARCH for country 'i' and country 'j'.[16] The intersection of the first row and first column shows the ratio in mean REER uncertainty between Argentina and Brazil ($Argentina's/Brazil's : 1.39$). In this case, the difference is statistically significant at a 1% significance level. The ratio being larger than one informs us that uncertainty in Argentina has been significantly larger than in Brazil, on average, during the period of analysis. The size of the ratio and the results of the tests also suggest that the mean of Argentina's uncertainty over the whole period is significantly higher than that of any of the rest of the countries in the analysis, including the other Mercosur members. Brazilian REER growth volatility is also significantly higher than that of most of South American countries, except Argentina, Peru and Uruguay. Finally, Uruguayan REER growth volatility is significantly higher than that of all the rest of South American countries.[17] These results give empirical support to our statement, Argentina, Brazil and Uruguay have experienced a more uncertain environment with respect to REER.

Table 2.1: Ratios of Means of Volat-ARCH across Countries

Col Mean/ Row Mean	Argentina	Brazil	Uruguay
Argentina			
Brazil	1.390***		
Uruguay	1.262***	0.909	
Bolivia	2.512***	1.805***	1.988***
Chile	1.845***	1.326***	1.459***
Colombia	3.731***	2.688***	2.958***
Ecuador	2.114***	1.519***	1.672***
Peru	1.577***	1.134	1.248***
Venezuela	4.219***	3.030***	3.333***

Notes: '***' indicates differences are significant at 1%, '**' significant differences at 5% and '*' significant diff. at 10%

We now turn our attention to the evolution over time of uncertainty with respect to REER in Argentina, Brazil and Uruguay. Our measures suggest that uncertainty was

[16] The purpose of these tests is to be able to compare these figures in a robust way. We are not trying to test whether REER realizations of, say, Uruguay, come from the same parent population as REER realizations of Brazil. The same applies when the comparisons are made for a given country over time.

[17] The same conclusions emerge if we compare the uncertainty records using Volat-RollVar.

larger during the 1970s and 1980s than during the 1990s and of 2000s, and the differences are significant at a 5%. No difference was found between the levels of the 1990s and 2000s. There are a number of episodes (currency crises and hyperinflation episodes) that can explain these differences by decade, the most notorious taking place in 1974, 1982 and 1989. The 1990s, by contrast, was a decade of relative stability due to the implementation of a price stabilisation plan with an exchange rate anchor which lasted until December 2001. The collapse of this last stabilisation plan did not come with extremely high records of inflation, as had happened during the 1970s and 1980s. That explains the relatively low records of uncertainty during the early years of 2000.

The top and bottom central panels of Figure 2.2 show the evolution of the Brazilian uncertainty, which appears to increase during the period. The period of the 1970s displayed the lowest REER volatility, exhibiting a peak around 1975. The 1980s and 1990s, which experienced two currency crises that respectively led to the implementation of the "Plan Cruzado" and the "Plan Real", and the 2000s, which experienced the shock of the Argentinean crisis, were significantly more volatile in terms of the REER than the 1970s. In turn, the first decade of the 2000 was significantly more volatile than the 1980s. The null of equal mean volatility across the 1980s and 1990s was upheld by the data.

In the case of Uruguay, the 1970s also experienced a peak of uncertainty around 1975 - this peak is the highest for the whole period, and it should be noted that unlike the Brazilian case, this peak was preceded and followed by relatively high levels of uncertainty, whereas the 1980s were hit by a number of high uncertainty episodes, some of domestic origin and some "imported": the currency crisis that affected a number of Latin American countries in 1982 and the hyperinflation episodes of the neighbour countries in 1986 and 1989. This can be observed in the top and bottom right-hand side panels of Figure 2.2, and it is also reflected in the statistical tests. The 1970s and 1980s were significantly more uncertain than the 1990s and 2000s in terms of the REER. The relative calmness of the 1990s is probably a consequence of a long-lasting price stabilisation plan based in a nominal exchange rate anchor, that was only abandoned in 2002 after the Argentinean collapse hit the Uruguayan economy severely, both on the trade and financial fronts. Differences between the 1970s and 1980s and between the 1990s and 2000s were not found to be statistically significant.[18]

Measures of Conditional Skewness and Kurtosis. The measures of conditional skewness and kurtosis of the residuals of the best-fit ARIMA on the series of the REER growth are calculated using a window of 12 months, and are common for the three measures of uncertainty. They are reported graphically in Figure 2.3. Symmetry in the distribution of Brazilian REER growth cannot be rejected while for Argentina and Uruguay the series are right-skewed, with a longer tail on the 'depreciation' side. The kurtosis indicator suggests non-normality of the series of REER growth.[19] Peaks in kurtosis are inevitably associated with episodes of exchange rate jumps or hyperinflation (1974, 1980, 2001 for Argentina; 1985, 1994 for Brazil; 2002 for Uruguay). The measure of kurtosis is significantly higher for Argentina and Uruguay than for Brazil, which suggests that more of the variation in the REER is due to extreme adjustments for Argentina and Uruguay than it is the case for Brazil.

2.4 Research Questions & Methodology

2.4.1 Research Questions

Given the two documented phenomena: that Mercosur countries have experienced an increase in integration over time, and that they exhibit a particularly high record of REER uncertainty, in what follows, the chapter attempts to answer these research questions:

[18] Table B.3 in the Appendix B shows the ratios of the volatility of decade 'i' and decade 'j' for each Mercosur country.

[19] The null of normality is rejected at 99% significance.

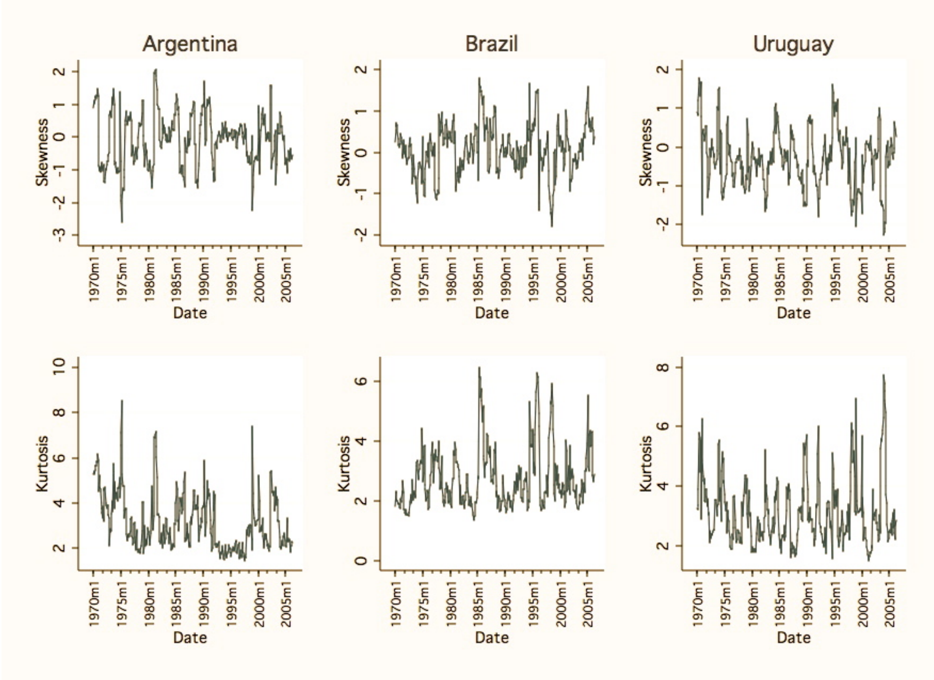

Figure 2.3: Conditional Skewness and Kurtosis of the REER

(1) What has been the impact of REER uncertainty on manufacturing output in Southern Cone countries over the period 1970-2002?

(2) Has this impact been heterogeneous across countries?

(3) Is the effect of REER uncertainty on output stable across different levels of uncertainty, or are there thresholds above which the effects change significantly?

(4) Are there sectoral heterogeneities in the effect of REER uncertainty on output? Can the heterogeneity be accounted for differences in trade integration, and in particular, for differences in the export exposure to Mercosur?

2.4.2 Baseline Model

To answer the research questions above, we specify a supply function and estimate it using the data described in Section 2.2 with yearly periodicity. Our baseline model, fully motivated below, and attempting to shed light on the first of the questions above, relates real sectoral output supplied to real relative sectoral prices, real effective exchange rates, alternative measures of real exchange rate uncertainty (as described above), a measure of misalignment of the real exchange rate, an indicator of crises, dummies controlling for different exchange rate regimes, sector-country fixed effects and year dummies, as presented in equation (2.2):

$$\begin{aligned} q_{tij} &= \alpha_{ij} + \alpha_t + \beta_1 p_{tij} + \beta_2 reer_{tj} + \beta_3 reerUncert_{tj} + \\ &\quad + \beta_4 reerSkew_{tj} + \beta_5 reerKurt_{tj} + \beta_6 reerMisal_{tj} + \\ &\quad \beta_7 BCDI_{tj} + \beta_8 Floating_{tj} + \beta_9 Interm_{tj} + u_{tij} \end{aligned} \tag{2.2}$$

where q_{tij} is the value in constant domestic currency units (base year is 1985) of output produced at time t by sector i and country j, α_{ij} are country-sector fixed effects, α_t are time dummies, p_{tij} is a relative price index at time t for sector i, in country j, $reer_{tj}$ is the real effective exchange rate of country j at time t, $reerUncert_{tj}$ is our measure of REER uncertainty of country j at time t, $reerSkew_{tj}$ is a measure of REER skewness and $reerKurt_{tj}$ is a measure of REER kurtosis of country j at time t, $reerMisal_{tj}$ is a measure of REER misalignment, $BCDI_{tj}$ is the Reinhart and Rogoff (2009) indicator of crises that goes from zero to four, and considers banking, currency, default and inflation crises.[20] $Floating_{tj}$ and $Interm_{tj}$ are dummies constructed on the basis of the exchange rate regime classification of Levy-Yeyati and Sturzenegger (2005) into floating, intermediate and fixed regimes (baseline is a fixed exchange rate regime).

Our dependent variable, q_{tij} is the sectoral level of output. Much of the research that examines the effects of REER uncertainty on productive decisions focuses on investment — stressing its condition of irreversibility, or on international trade flows.[21] We look at

[20] $BCDI = 0$ if at a given period, in a given country, there are no banking, currency, default or inflation crises. $BCDI = 4$ if at a given point in time the country experiences the four types of crisis.

[21] The literature on uncertainty and investment was reviewed in Chapter 1. Some of the most influential

the output effects because the output decision is also characterized, to a certain extent, by irreversibility, because of regulations in the labour markets, and because firms have to pay for inputs before output is sold. In addition, and because the dollarized condition of the economies under consideration, the potential effects of REER uncertainty is not limited to those that engage in international trade, or not even to those producing tradable goods.

Both sectoral prices and the real effective exchange rate are included. While these are correlated, each attempts to capture different effects. The indicator of sectoral prices will capture competitive effects in a broader way than real exchange rates. For example it will capture the effect of changes in international prices of the relevant goods. Therefore, we expect $\beta_1 > 0$. On the other hand, given that sectoral prices are averaged across different economic activities that fall together in a three-digit 'sector', as classified by the international standard industrial classification (ISIC), the indicator may contain more noise than signal, so the with the inclusion of the real exchange rate — which is a variable of reference to manufacturers in these economies, we may be capturing some competitive effects. In addition to this, there are other potential effects associated with the REER. In the context of economies in which dollar-debt is substantial, movements in the real exchange rate may affect output supplied by affecting the net wealth of the firms, and then, their ability to obtain credit, as suggested by Bernanke and Gertler (1989) and Cespedes et al. (2004). For these reasons the expected sign of β_2 is ambiguous.

The inclusion of the BCDI indicator attempts to capture the fact that banking, currency, default and inflation crises have substantial effects on the payment system of the economy, severely affecting the availability of credit. Notice that we control for REER movements, and this variable also captures something similar: currency crises. With respect to this type of crisis, what we expect this indicator to capture is the effect of large

papers on uncertainty and trade flows are those of Ethier (1973), Hooper and Kohlhagen (1978), McKenzie (1999), and Byrne et al. (2008).

movements, picking up non-linearities. Given that REER uncertainty tends to be high during crises, the proper identification of the crises effect is key to be able to isolate a pure uncertainty effect. For this variable, we expect a negative coefficient.

Dummies for different exchange rate regimes, as classified by Levy-Yeyati and Sturzenegger (2005), attempt to capture output effects that these may have, independently of the other covariates. Their inclusion is important, as different regimes may affect both uncertainty and output. The measure of misalignment attempts to capture the effect that large downward departures from a 'perceived' equilibrium (an appreciated REER), may delay output expansions, as agents may expect a realignment. β_6 is expected to be positive.

The country-sector fixed effects, α_{ij}, attempt to capture the effects of omitted regressors that are country-sector specific, but time-invariant, such as factor intensities, institutional arrangements, special regulatory treatments, et cetera. The time dummies, α_t attempt to capture the effects of omitted regressors that are country-sector invariant, but time-specific, such as global trends in energy prices, productivity shocks in the manufacturing sector, generalised increases in trade, et cetera.

To these determinants, we add measures of uncertainty described above. We report empirical experiments in which the three alternative measures are considered. These measures of uncertainty are constructed using a macro indicator of the real effective exchange rate. One concern that arises is that, if some sectors trade predominantly with a subset of countries with which bilateral real exchange rates are particularly volatile, while others trade predominantly with other subset with which bilateral real exchange rates are particularly stable, the using a macro measure of uncertainty may be a crude approximation. Two possible solutions were considered. First, we could have constructed sectoral measures of uncertainty on the basis of the sectoral price indicators. We discarded this possibility because our sectoral price indicators are likely to contain significant noise, for the reasons outlined above. Moreover, the use of sectoral real exchange rates to construct a measure of uncertainty is problematic in the presence of sectoral policies in the form of non-tariff barriers, quotas, et cetera, that may differ across countries. These will make them poor indicators of competitiveness, and undermine the importance of a measure of uncertainty calculated on their basis. In addition to this, data on sectoral prices have annual periodicity and start in 1970. The identification of an autoregressive forecast equation and the calculation of the variance of the forecast error as a measure of uncertainty would imply losing some years at the beginning of the sample period. For these reasons, we did not pursue this strategy. Second, we could have used aggregate prices, but construct sectoral real effective exchange rates, by giving sector-specific weights for the bilateral real exchange rates, based on the trade destination structure of each sector. This is a more appealing strategy. However, the trade data required to calculate the appropriate weights since 1970, with a three-digit disaggregation were not available. In fact, these data are the basic input for the calculation of the Mercosur export shares discussed in Section 2.3.1, and they are only available at a one-digit level since 1980, and only since 1985 for most sectors at a two-digit level. Therefore, and in order to avoid losing almost half of our sample, we decided to use our macro measure of uncertainty in the analysis that follows. In addition, and to tackle this possible source of misspecification, we use Mercosur export shares to adjust this macro measure for different levels of exposure to uncertainty — the method will be described in Section 2.4.4, and report the results in Section 2.5.3.3.

Finally, we also include a measure of real exchange rate misalignment as a control. This is motivated by the fact that during a pilot survey carried out among Uruguayan manufacturing firms, their managers tended to refer to ‘uncertainty’ and ‘misalignment’ interchangeably. By controlling for misalignment, we attempt to test whether there is a pure uncertainty effect on output.

2.4.3 Threshold Model to Explore Non-Linearities

The specification in equation (2.2) assumes that REER uncertainty and changes in output are linearly related. A reason to cast doubt on the validity of a linear relationship is related to balance-sheet effects associated with future REER changes. In economies in which firms have important currency mismatches in their balance sheets, high and low uncertainty may affect output decisions differently. There may be a threshold above which further increases in uncertainty may increase the bankruptcy risk, and then induce firms to act more cautiously, and postpone their plans to increase output. What is more, in countries in which the Central Banks have frequently committed to fixed exchange rates, uncertainty generated after the collapses of the regimes may trigger additional channels through which output is affected, related for example, to the loss of credibility of the government's announcements.

The existing literature on the existence of threshold effects in the relationship of uncertainty and productive decisions has been explored in the context of investment decisions, where the seminal work of Sarkar (2000) triggered research on the presence of non-linearities or threshold effects of uncertainty on investment. The 'real options' approach to the analysis of investment under uncertainty, pioneered by McDonald and Siegel (1986) states that an increase in uncertainty depresses investment as it increases the critical investment trigger. Sarkar argues that increases in uncertainty also affect the probability of investing, and this effect cannot be unambiguously determined analytically (Sarkar, 2000, p.223). By using numerical results to illustrate the uncertainty-investment relationship, he finds an inverted u-shape. Their main result is that an increase in uncertainty may increase investment. Subsequent empirical work has often found that data supported threshold effects. For example Serven (2003), using aggregate data on investment for 61 developing countries spanning the years 1970 to 1995, finds that it's only 'high' real exchange rate uncertainty that depresses investment, while the effect of low uncertainty is positive although not well determined. Lensink and Murinde (2006) use firm-level data for the UK over the period 1995-1999 and find evidence of an inverted u relationship between investment and uncertainty regarding stock market returns. More recently, and with a focus on six Latin American countries, Clausen (2008) finds threshold effects of uncertainty on investment. While the effect of high uncertainty is unambiguously negative, that of low uncertainty is positive on investment in Chile and Mexico.

To answer research question (3), we test for threshold effects of uncertainty with respect to REER changes, on output changes, and estimate the following models.

$$\begin{aligned} q_{tij} &= \gamma_{i-} * \delta_j + \beta_1 p_{tij} + \beta_2 reer_{tj} + \beta_3 reerUncert_{tj} + \beta_4 reerUncert_{tj}^2 + \\ &+\beta_5 reerSkew._{tj} + \beta_6 reerKurt._{tj} + \beta_7 reermisal._{tj} + \beta_8 BCDI_{tj} \\ &+\beta_9 Floating_{tj} + \beta_{10} Interm_{tj} + u_{tij} \end{aligned} \tag{2.3}$$

$$\begin{aligned} q_{tij} &= \gamma_{i-} * \delta_j + \beta_1 p_{tij} + \beta_2 reer_{tj} + \beta_3 LowUncert_{tj} + \beta_4 HighUncert_{tj} + \\ &+\beta_5 reerSkew._{tj} + \beta_6 reerKurt._{tj} + \beta_7 reerMisal._{tj} + \beta_8 BCDI_{tj} \\ &+\beta_9 Floating_{tj} + \beta_{10} Interm_{tj} + u_{tij} \end{aligned} \tag{2.4}$$

The model of equation (2.3) allows us to test for an inverted-u shape relationship between uncertainty and output, while the model in (2.4) allows us to identify whether two different slopes for "high" and "low" uncertainty may fit the model better than imposing a single one.

2.4.4 Interacted Model to Explore Sectoral Heterogeneity

To disentangle some of factors that are behind the relationship between REER uncertainty and output, and so being able to answer research question (4), we also estimate an interacted model, that takes the generic form of equation (2.5):

$$q_{tij} = \alpha_{ij} + \alpha_t + \mathbf{X}\gamma + \beta_1 reerUncert_{tj} + \beta_2 reerUncert_{tj} * Z_{tij} + \beta_3 Z_{tij} + u_{tij} \quad (2.5)$$

where $\mathbf{X}$ is a matrix containing all the controls of equation (2.2), γ is a vector of the associated coefficients, and Z_{tij} is the hypothesized determinant of the relationship between REER uncertainty and output, which are also allowed to have level effects on the dependent variable. In particular, we consider three variables to interact with the REER uncertainty, and discuss their roles in the estimable equation in what follows. The first two are introduced in the analysis as potential determinants of the output sensitivity to uncertainty, while the last one is introduced as an adjustment for the macro measure of uncertainty considered here.

Trade Orientation We measure trade orientation as the share of sectoral output that is exported, and try to identify whether sectoral differences in this respect, explain differences in the output response to changes in uncertainty with respect to REER changes. The effects are *a priori* ambiguous. Thinking in terms of the standard textbook approach, one would expect that — as long as firms are averse to risk — sectors with a higher exposure to export markets are going to be more sensitive to REER uncertainty than those whose output is mainly oriented to the domestic markets, because REER will influence a larger portion of the price received.

On the other hand, in the context of Southern Cone economies, in which the degree of debt dollarization is significant, REER uncertainty affects output through another mechanism, that operates through the firms' financial structure, as discussed in Chapter 1.

Because firms exhibit mismatches in their balance-sheets, REER movements affect disproportionately their liabilities. Higher uncertainty increases expected bankruptcy costs, and induce, even among risk-neutral firms, output contractions. In this case, a higher exposure to export markets contributes to match the currency of denomination of the firm's assets with that of liabilities, and therefore provides a mechanism to insulate firms' output decisions from REER uncertainty.

Labour Productivity For each sector, we measure labour productivity as the quotient of the total wage bill and the value of output. We also calculate the distance to the 'frontier' of productivity, given by that of the corresponding sector in the United States' economy. Assuming an association between productivity and profitability of the sector, these data would help us test the hypothesis of whether higher profitability helps insulating output from REER uncertainty (we use this proxy in the the absence of data on sectoral profitability). As argued in Chapter 1, in the presence of dollar-debt, the output of those firms with higher liquidity, or current profits, was going to be less sensitive to increases in REER uncertainty than that of firms with lower liquidity balances, since, for the latter type, the increase in uncertainty would increase expected bankruptcy costs by more, meaning that the output response will be correspondingly larger than for the former type. Even without dollar-debt, more profitable firms will face better prospects for adjustment than less profitable ones, in the event of adverse competitiveness shock arising from movements in the REER.

Export Exposure with Mercosur Markets This is measured using the export shares described and reported in Section 2.3.1. There are several reasons why we include the shares in the interacted model.

(1) **Misspecification.** The use of a macro measure of REER uncertainty may introduce

a source of misspecification in the model of equation (2.2). A large portion of the REER uncertainty is generated within Mercosur economies — which, as discussed above, tend to be relatively volatile. For this reason, the use of a common uncertainty measure across sectors, regardless of the intensity with which they trade with the volatile region may be misleading. In an attempt to control for this, we adjust our macro measure of uncertainty by multiplying it to our indicator of export shares to Mercosur markets.

Ceteris paribus, if those sectors trading more intensively within Mercosur are exposed to more uncertainty, the estimated coefficient on the interaction term will be negative.

(2) **Adaptation to High Uncertainty.** It is possible that the export share may not only act as an adjustment factor to the measure of uncertainty, but also as a determinant of the output sensitivity to REER uncertainty. One hypothesis that emerged from the pilot survey we performed on a small number of manufacturers in Uruguay is that firms that trade intensively with the volatile region may adapt their production processes to better cope with uncertainty. Most firms expressed that to cope with uncertainty, they introduced shorter-term labour contracts, incorporate short notice termination clauses in agreements so that long-term commitments are avoided, and maintain relatively higher liquid assets.[22] This might imply that export share decreases the sensitivity of output to uncertainty. However, it could also be argued that if these firms have already adjusted to better cope with uncertainty, and now face further increases in uncertainty, they may find themselves with fewer instruments to use. Instead, those that have not yet adapted their production processes,

[22]It is worth mentioning that although forward contracts would allow hedging nominal exchange rate risk, these have been largely unavailable in the countries considered, over the period of analysis. In the last few years, the markets have developed to some extent. However, firms tend to claim that the costs associated to these instruments are significantly high.

as they predominantly trade with the low-volatility region, may have a wider range of margins to adapt and decrease their vulnerability to REER shocks, in the face of increases in uncertainty. Hence, the effect of export share on the output-uncertainty relationship is ambiguous.

(3) **Lower Ability to Diversify Export Markets.** Even if REER uncertainty was faced homogeneously by all firms, independently of where they exported, it would be plausible to expect that those firms that have a more diversified export market structure — or are more capable of diversifying, will be less vulnerable to uncertainty shocks. Now, it could be argued that if the high export shares with Mercosur are related to trade protection that firms within certain sectors obtain, and if this trade protection is associated with relatively low productivity, then in a context of REER uncertainty, firms producing in protected sectors will find it more difficult to diversify, and so, will be more cautious than the non-protected ones. An example may be illustrative. Firms in the Uruguayan automobile sector export almost exclusively to Mercosur countries under a special regime that incorporates substantial protection. Instead, meatpackers in Uruguay tend to have their export destinations largely diversified, and face international competition. In the event of high REER uncertainty with their main trading partner, it would be reasonable to expect a more cautious behaviour of producers in the automobile sector than that of meatpackers, as the latter are likely to be able to re-orientate a larger portion of their output to a new market, in a faster way than the former. If this is the prevalent mechanism, then a higher export share would increase the sensitivity of output to uncertainty.

Another line of argument to explain the capacity of diversifying the export destination structure is related to the type of goods produced by a firm, irrespective of productivity or protection levels. As argued by Rauch (1999), when trading differentiated products, proximity, common languages, and cultural similarities may be very important in matching international buyers and sellers. This may explain why trading of this type of goods by Mercosur firms is predominantly concentrated within the region. In addition, the author presents evidence suggesting that the search costs associated with trading differentiated goods are higher than those associated with homogeneous goods, which result in the former type of goods being traded mostly where the costly networks are already in place. For goods such as bovine meat, or milled rice, that are rather homogenous and tend to trade in organised exchanges, the re-orientation of export destination is likely to be easier than for goods such as bicycles or cars, for example. A quick inspection of the export shares calculated in Section 2.3.1 shows that these tend to be larger for sectors that produce goods that could be considered as "differentiated", so one could expect that those sectors exhibiting high export shares, may find re-orientation more difficult because of the type of product they produce, and so may be more vulnerable to REER uncertainty. Therefore, if this channel is predominant, one would expect the coefficient on the export shares interaction with REER uncertainty to be negative, to capture this vulnerability effect.[23]

The estimation of both (2.2) and (2.5) presents a number of challenges. These are presented in what follows, along with the strategy pursued here to deal with them.

2.4.5 Dynamics

Given that the time period is relatively long (1970-2002), we tested for non-stationarity of the series of output and prices and found some evidence of non-stationarities. Non-stationarity makes a specification in levels problematic and would call for a panel cointegration analysis. The literature on this subject is still being developed and subject to

[23] Byrne et al. (2008) find some evidence that exchange rate uncertainty affects exports of differentiated goods, but it does not for homogeneous goods, when looking at US trade over the period 1989 to 2001.

controversy. In addition, most of the statistical theory supporting it looks at the case in which $T/N \rightarrow \infty$ (where T is the time dimension, and N is the number of groups), while in our case the number of groups (three countries, twenty-eight sectors) is substantially larger than the number of periods (thirty-three).[24]

For these reasons, we opted for estimating the relationship in growth rates (which are all stationary). Conceptually, is worth stressing that as we estimate all models considering growth rates, the relationship of interest becomes the impact of uncertainty with respect to the rate of growth of the real exchange rate, on the rate of growth of industrial output. Methodologically, by taking growth rates, we are introducing a serially correlated error term in the model. The presence of serial correlation would make standard errors look smaller than they really are, thus rendering inference invalid. To control for this, we re-estimate the models using heteroscedasticity and autocorrelation consistent (HAC) standard errors. The estimator we use for the covariance matrix is the Newey and West (1987) (Bartlett kernel function) specification.[25]

2.4.6 The Estimator

Ordinary Least Squares or Instrumental Variables? If all the right-hand side variables in equation (2.2) were independent of the error term, and the errors were independent and identically distributed, then, the ordinary least-squares estimator (OLS) would provide the best linear unbiased estimator of the vector of parameters $\boldsymbol{\beta}$ (actually, the model in equation (2.2) is a two-way fixed-effect).

However, it is likely that sectoral output is jointly determined with sectoral prices. Then, supply shocks, for example, will affect both equilibrium price and quantity in the market, and both variables will be correlated to the error term by construction. Price

[24] See Baltagi (2008) for a detailed discussion.

[25] It is worth mentioning that this estimator of the covariance matrix needs large samples to perform well.

endogeneity makes the OLS estimator of β, $\hat{\beta}_{OLS}$ inconsistent. Consider, for simplicity of exposition, that the only explanatory variable is p, so that the estimable equation turns into $q_{tij} = \beta p_{tij} + u_{tij}$. Then, $\hat{\beta}_{OLS} = (p'p)^{-1}p'q = \beta + p'u$. Because $p'u \neq 0$, the expected value of estimator equals the true parameter plus a bias, which does not tend to zero as the sample size increases.

The solution to this source of inconsistency lies in finding an "instrument" (Z), that affects sectoral output only through its effect on prices. How good a solution to the problem of endogeneity is provided by the instrument depends on whether the instrument is "valid" (i.e., it is exogenous to the market), and "relevant" (i.e. it matters for the process of production). These two conditions imply that $Z'u = 0$ and $Z'p \neq 0$ respectively.

Two Stage Least Squares or GMM? Two alternative estimators that address the inconsistency problem arising from endogeneity by using instrumental variables are the two-stage least squares (2SLS-IV), and the Generalized Method of Moments (GMM-IV) estimators.

The estimation with instrumental variables (IV) can be seen as the application of least squares in two stages. In the first, each of the right-hand side variables in equation (2.2) are regressed on the instruments, Z, and a matrix of fitted values, $\hat{\mathbf{p}}$, is obtained. In the second stage, the dependent variable, q is regressed on $\hat{\mathbf{p}}$, and a vector of instrumental variables estimates, $\hat{\boldsymbol{\beta}}_{IV}$, is obtained.

Alternatively, IV estimation can be seen as a Generalized Method of Moments optimization problem. Following the exposition of Baum et al. (2007), with exogenous instruments Z (i.e.: $Z'u = 0$), then L instruments give a set of L moments:

$$g_i(\beta) = Z_i' u_i = Z_i'(q_i - p_i \beta) \tag{2.6}$$

where g_i is $L \times 1$. The exogeneity condition means that at the true value of β, the L moment or orthogonality conditions will be satisfied:

$$E(g_i(\beta)) \tag{2.7}$$

There is a sample moment corresponding to each of the L moment equations, so for a given estimator $\hat{\beta}$, these L sample moment can be written as:

$$\bar{g}(\hat{\beta}) = \frac{1}{n}\sum_{i=1}^{n} g_i(\beta) = \frac{1}{n}\sum_{i=1}^{n} Z_i'(q_i - p_i\hat{\beta}) = \frac{1}{n}Z'\hat{u} \tag{2.8}$$

Then, the idea behind GMM is to choose $\hat{\beta}$ that brings $\bar{g}(\hat{\beta})$ as close to zero as possible. If, as in our case, the number of instruments is larger than the number of explanatory variables (i.e.: $L > K$, so the equation is overidentified), there are more equations than unknowns and it will not be possible to find $\hat{\beta}$ that sets all moment conditions to zero.[26] In this case, a weighting matrix W is used to construct a quadratic form in the moment conditions. So, the GMM objective function is now:

$$J(\hat{\beta}) = n\bar{g}(\hat{\beta})'W\bar{g}(\hat{\beta}) \tag{2.9}$$

So, the GMM estimator for β is the $\hat{\beta}$ that minimises $J(\hat{\beta})$:

$$\hat{\beta}_{GMM} = argmin_{\hat{\beta}} J(\hat{\beta}) = n\bar{g}(\hat{\beta})'W\bar{g}(\hat{\beta}) \tag{2.10}$$

Solving the set of first order conditions, the IV-GMM estimator is obtained:

$$\hat{\beta}_{GMM} = (p'ZWZ'p)^{-1}p'ZWZ'q \tag{2.11}$$

[26] The instruments to be used in our context will be presented below.

Hansen (1982) shows that when the weighting matrix, W chosen is equal to S^{-1}, where S is the covariance matrix of the moment conditions, then, the most efficient estimator is obtained ($S = E[Z'uu'Z] = lim_{N\to\infty}[Z'\Omega Z]$). S is then the optimal weighting matrix. If the residuals from 2SLS are used to derived a consistent estimator of S, then, the feasible and efficient IV-GMM estimator is:

$$\hat{\beta}_{FEGMM} = (p'Z\hat{S}^{-1}Z'p)^{-1}p'Z\hat{S}^{-1}Z'q) \tag{2.12}$$

If the errors are independent and identically distributed, then the optimal weighting matrix is proportional to the identity matrix ($\sigma_u^2\mathbf{I}$) and IV-GMM equals the standard $2SLS$ estimator.

As argued by Baum et al. (2007), GMM should be preferred to IV in the presence of heteroscedasticity of unknown form, as in this case, the IV-GMM estimator that uses as a weighting matrix an estimate of the inverse of S, computed from the $2SLS$ residuals, will be more efficient than the 2SLS estimator.[27]

Or back to Ordinary Least Squares? It has been pointed out that though consistent, both the 2SLS and the GMM estimators may perform poorly in small samples, as they are biased, and less precise than OLS. Our decision of preferring an IV estimator is guided by economic theory. In the context of the manufacturing sectors of the three countries analysed here, it is reasonable to think, as argued above, that sectoral output and prices are simultaneously determined. We also use a statistical test to determine whether p should be treated as endogenous. The 'C' test considers if the null hypothesis of exogeneity of p is upheld by the data. In essence, the test compares OLS and IV estimates and explores whether the differences in the estimates are systematic. If they are, the null is rejected,

[27]The author argues that even in the absence of heteroscedasticity, GMM is no worse asymptotically than the IV estimator. However, reasonable estimators of the optimal weighting matrix — key to the efficiency of GMM — are only obtained with very large sample sizes.

suggesting a bias of OLS, and IV should be preferred. We report the C test-statistic after the estimation output of each model considered.

Our Choice In the analysis that follows, we use the GMM-IV estimator, as tests suggested the presence of heteroscedasticity.[28] For the actual estimation we use the Stata package 'xtivreg2' (Schaffer (2005)), which requests the two-step feasible efficient GMM estimator and corresponding variance-covariance matrix. As it will see in what follows, the C-statistics suggest that, as suggested by economic theory, prices are endogenous and instrumental variables are needed in most of the models reported below.

2.4.7 Instruments

We use alternative sets of instruments for the "troublesome" variable, i.e.: sectoral prices, and compare results in order to investigate the credibility of our estimates. The first instrument is given by US sectoral price changes. These are likely to be independent of industrial output of Mercosur countries, while they will have an effect on domestic sectoral price changes, given the tradable nature of the goods produced in the manufacturing sectors we are considering. Second, we use lagged values of sectoral price changes. Given that our periodicity is annual and that the production processes in manufacturing are relatively shorter than in other sectors of the economy, lagged price changes are likely to influence output changes through their effect on current price changes only. In both cases we include the growth rate of population as a shifter of the demand curve. We report two additional diagnostic tests for the GMM-IV estimation, and discuss the results. First, a test of "relevance" of the instruments. This is given by the joint significance of the excluded instruments in the first-stage of the GMM-IV procedure (Kleibergen and Paap statistic (KP)). A "large" value of the KP suggests that the instruments are correlated with

[28] We performed Pagan and Hall (1983) tests. These tests whether there is heteroscedasticity in the estimated regression, related to one or more indicator variables.

the troublesome variable, which implies our instruments are relevant to explain sectoral prices. The rule-of-thumb for "large" being when the F-statistic≥10. Second, a test of the overidentifying restrictions of model, or "validity" of the instruments (Sargan-Hansen test). This consists of regressing the residuals from the GMM-IV regression on all instruments (excluded and included). The null is that all instruments are uncorrelated with the the error term, and its rejection would cast doubt on the validity of these instruments. This is because that rejection would be suggesting that the exclusion restriction may be inappropriate as the instrument exerts a direct effect on the dependent variable, instead of only affecting it via its effect on the troublesome regressor.

2.4.8 Cross-Sectional Dependence

Cross-sectional dependence arises when, in a panel, the errors are correlated across groups: $E(e_{it}e_{jt}) \neq 0$. The consequences may be serious, as explained in Baltagi (2008), since pooling may provide little gain in efficiency over single equation estimation, and estimates can be biased. In our panel, a likely source of cross-sectional dependence arises from the fact that the countries included in our panel are of very different dimensions, and during the period of analysis there has been a reduction in trade protection among them. These changes in trade policy may have contributed to an adjustment in the patterns of production within the bloc, and the adjustment in one sector in a country, may have affected the sector in another country. An example will be illustrative: say that after a reduction in tariffs between Argentina and Brazil, there is a structural change in production following comparative advantage, so that output of food and beverages in Argentina increases (and falls in Brazil), while the output of automobiles increases in Brazil (falling in Argentina). If there is a portion of that adjustment that is not driven by sectoral price changes or by changes in other factors captured in the controls we include in the model, then, inevitably, it will appear in the errors, making them correlated across groups, with the implications on efficiency and bias of the estimator mentioned above.

For these reasons, we first test for cross-section dependence using the Breusch-Pagan test. This is based on the following statistic:

$$CD = T \sum_{i=j}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^2 \tag{2.13}$$

where N is the number of groups, T is the number of periods, $\hat{\rho}$ is the sample estimate of the pairwise correlation coefficient of the residuals, and these are obtained as in:

$$\mathbf{e}_{it} = \mathbf{q}_{it} - \hat{\boldsymbol{\alpha}}_i - \hat{\boldsymbol{\beta}}_i^{'} \mathbf{X}_{it} \tag{2.14}$$

with $\hat{\boldsymbol{\alpha}}_i$ and $\hat{\boldsymbol{\beta}}_i$ is the vector of estimates of the parameters computed using a regression of $\mathbf{q}$ on an intercept and a matrix $\mathbf{X}$ containing all the regressors in the model described in equation (2.2) for each group (country) separately. Under the null hypothesis of no cross sectional dependence, $CD \sim \chi^2_{N(N-1)/2}$. If the null is rejected, we use Seemingly Unrelated Regressions (SUR) techniques.

2.4.9 Country Heterogeneity

If in the true model, the responsiveness of output to uncertainty (β) is country specific, as below:

$$q_{jt} = \alpha_j + \beta_j reerUncert_{jt} + u_{jt} \tag{2.15}$$

but we estimate a common slope:

$$q_{jt} = \alpha_j + \beta reerUncert_{jt} + w_{jt} \tag{2.16}$$

where j is the country, and t is the time period, then, the error term will be: $w_{it} = (\beta_i - \beta)x_{it} + u_{it}$, and $X'w_{it} \neq 0$, rendering the estimator of β inconsistent.

Given that our panel includes three countries of different characteristics and that the time dimension of the data is relatively large, we treat the heterogeneity by running separate regressions and examining parameter stability across countries.

2.4.10 Outliers.

In the empirical analysis that follows, we excluded those observations for which the dependent variable lay more than 5 interquartile ranges away from the median. The outlier threshold is defined in a conservative way, in an attempt to identify those observations whose atypically large deviations from the median are likely to be related to data inputting errors. We define it in terms of interquartile deviations from the median so that the threshold is not itself affected by the extremes (as it is the case when thresholds are defined on the basis of standard deviations away from the mean. The chosen threshold implies discarding nine observations in the analysis (out of 2563).

2.5 Results

Here we report and discuss the results from estimating the models presented in Section 2.4. In Section 2.4.2 we start by estimating the most parsimonious model (described in Section 2.5.1). We test whether the identified uncertainty effect on output growth is robust to the inclusion of a variable that captures changes in REER misalignments with respect to an "equilibrium" value. In addition, we examine how robust results are to the choice of instruments, by using a different set and comparing results. Then, we explore whether there is evidence of country-heterogeneity in the parameters.

In Section 2.5.2 we present the results of estimating the threshold model presented in Section 2.4.3, as in equations (2.3) and (2.4). These models will allow us to understand the non-linearities at work in the output growth-REER uncertainty link.

In Section 2.5.3, we discuss the results of estimating the three interacted models proposed in Section 2.4.4, using export orientation, labour productivity and Mercosur export shares. These three variables enter the estimable equation in levels and interacted with REER uncertainty. In this way, we are able to identify any direct effect they may exert on output growth, plus indirect effects that they may exert by affecting the vulnerability of sectoral output to REER uncertainty. Consider, for example, the export shares. It could turn out, for instance, that the level coefficient was positive, while the interaction coefficient was negative. This would mean that high export shares *in itself* was growth-enhancing, but at the same time it raised the vulnerability of the sector, meaning that a rise in uncertainty would have a particularly larger depressing effect on growth.

Initially, we investigate the effects of augmenting the baseline model by adding the level and interaction of export orientation, labour productivity and Mercosur export shares separately (in Sections 2.5.3.1, 2.5.3.2, and 2.5.3.3, respectively). The reason for examining the effects of each of these variables separately at first, is that labour productivity and export shares are only available for a subset of observations. This means that when including them, we substantially lose degrees of freedom in the estimation. By including one at a time, we can scrutinize the effect of each one, with as many observations as possible.

Finally, we augment the baseline model including together the three aforementioned variables in levels and interacted with uncertainty. This implies losing all observations from 1970 until 1980, and for some sectors, until 1986. We then interpret the results and compare them with those obtained when each was included separately.

2.5.1 The Baseline Model

In this section we test the hypothesis of whether REER uncertainty exerts a negative effect on the growth rate of industrial output, and whether this effect is heterogeneous across countries. Table 2.2, on page 116, presents GMM-IV estimates of equation (2.2) in growth rates using three alternative uncertainty indicators. In all cases, country-sector fixed effects and time dummies are included, as well as dummies controlling for different exchange rate regimes. To control for correlations within groups in the errors, we clustered standard errors at country and 2-digit sector level.

Coefficients for continuous variables are reported in elasticity form, those on the uncertainty measures are semi-elasticities, and those on categorical variables are impact effects. Column (1-3) report results when alternative measures of uncertainty are included. The price coefficient is positive and of a plausible size, suggesting that output supplied is inelastic to prices, but not always well-determined, while the coefficient on growth of the REER is close to unity and very well determined in all cases, suggesting that output supplied is very close to be unit-elastic to real depreciations, on average and *ceteris paribus*.[29] Clearly, sectoral prices and REER are correlated, given the tradable nature of the man-

[29]From a statistical point of view, we reject the null of the coefficient on the growth of REER being equal to one.

ufactured goods produced considered here. However, as already argued, sectoral prices contain information that is more idiosyncratic to the sector than REER. An example is the evolution of world prices of the relevant goods. The fact that output seems to be more responsive to REER than to sectoral price changes is somehow puzzling. A likely explanation for this is that, due to averaging over different economic activities grouped under the same three-digit sector, the price series contain more noise than signal, relative to the REER series, that probably exert a rather homogeneous competitive effect across tradables, and that in the context of Southern Cone economies is considered by manufacturers as the emblematic indicator of competitiveness.

Another interesting element in these results, is that given the positive coefficient on the REER, the effect of competitiveness of REER depreciations seems to dominate over possible balance-sheet, or other negative effects on output that arise from depreciations.[30] This is likely to be related to the fact that these balance-sheet effects are captured in the Reinhart and Rogoff (2009)'s BCDI indicator of crises. In fact, the coefficient on the BCDI is well determined and yields a negative coefficient. *Ceteris paribus*, the outbreak of each of the crises that are captured on the index decreases output growth on average, by about $4-5\%$. This is a sizable and plausible effect. Banking and sovereign default crises are associated with disruptions in the payment system of the economy, with important consequences on the availability of credit. Currency crashes in economies with dollarised liabilities trigger harmful balance-sheet effects, which may further affect credit availability. High inflation is associated with relative price distortions, and may significantly affect real revenue when there are lags between sales and payment. Take as an example, the case of Argentina in 2002, where the index takes value 4. All other things equal, our model

[30] Many explanations have been given for the finding of contractive depreciations, since Diaz Alejandro (1963). Operating through the supply side, these are the mentioned balance-sheet effects arising when liabilities are dollarised, and the increases in production costs arising from difficult-to-substitute imported inputs.

predicts a reduction in industrial output of about 22%.[31]

The point estimate for the effect of REER Uncertainty on output is always negative, irrespective of the measure of uncertainty considered, but it is well-determined only for the Roll-Var measure. A number of conclusions can be reached by looking at these results. First, the effect is better determined when using the Roll-Var measure. This measure differs from the GARCH measure in two respects: (a) it implies that agents forecast in a less sophisticated way, and (b) it implies a longer memory of agents (12 months instead of 3-4 months with GARCH). The reason behind the better performance seems to be the longer horizon it considers, as we tried a modified version of RollVar with a 4 month window, and the effect was similar in size, but only significant at 10%. Second, *ceteris paribus*, when RollVar doubles, output falls, on average, by 2.45%, while if it is the REER variance, output contracts by less than half percent.[32] These differences are reasonable, given that the latter measure probably overestimates "true" uncertainty, as discussed in Section 2.3. Not all of the variance in the REER can be attributed to uncertainty, and thus affect behaviour.[33]

Columns (4-5) report results of estimating equation (2.2) when uncertainty is defined in a broader way, including measures of the third and fourth sample moments. Tests of joint significance on the conditional variance, skewness and kurtosis suggest that their effect on output is different from zero, both when the conditional variance measure is the GARCH or the RollVar one. A closer look, however, casts doubt on the relevance of adding the third and fourth moment of the distribution of the REER in these models. The kurtosis is significant at 5% only when the measure of conditional variance is of short

[31]The effect is calculated as: $e^{-0.05\times 4} - 1$.

[32]The elasticity is calculated as $\hat{\beta} \times Roll\bar{V}ar$. $Roll\bar{V}ar = 7.4E04$.

[33]Diagnostics are reported the bottom of the table. The low values of the Hansen statistic lead to a non-rejection of the null of no correlation of the residuals with the instruments, suggesting instrument validity. The size of the K-P suggest that instruments are relatively weak, and that caution should be put at drawing conclusions. The relatively large values for the C-statistic suggest that IV methods are needed. The low value of the Cross-Sectional Dependence Breusch-Pagan test (CSD) indicates no evidence of cross-country dependence in this data.

memory (GARCH), but only significant at 10% in the specifications that include Roll-Var. Given that the kurtosis is calculated on a window of 12 months, and that it is significantly correlated with the GARCH conditional variance measure ($\rho_{Kurt,GARCH} = 34\%$)), the role being played by the kurtosis may be just capturing the longer horizon that agents consider. That would explain why the kurtosis becomes less well determined when the long-memory RollVar measure is incorporated.[34]

2.5.1.1 REER Uncertainty or Misalignment?

During a pilot survey we conducted in the early stages of this research among manufacturing firms in Uruguay, managers pointed out REER uncertainty as a serious impediment for planning production. However, in our small sample of firms surveyed, managers tended to use the terms 'REER uncertainty' and 'REER misalignment' interchangeably. The reason for the association is likely to be related to the fact that agents find it more difficult to predict future movements of exchange rates, when they perceive them to be misaligned with respect to an "equilibrium value". Under those circumstances, a wider spectrum of exchange rate movements are likely and the confidence in any point estimate will fall. Another interpretation is that agents plainly confuse the terms, and their concern is with misalignments and not with mean preserving changes in uncertainty. Because we are interested in identifying a pure uncertainty effect, we decided to perform a robustness check, by controlling for changes in the degree of misalignment of the REER with respect to a long-run value.

The concept of REER misalignment with respect to an equilibrium value, however,

[34]It could be argued that REER growth is endogenous in this specification. If larger exports lead to growth in output, and to substantial inflows of foreign exchange, then the REER would appreciate, *ceteris paribus*. We argue this is not likely to be the case, as we are working here with sectoral data at 3-digits, which means that each sector explains a small portion of total exports. As a robustness check, we excluded from the estimation sample the observations corresponding to the sector that explains, by far, the largest portion of exports in the three countries: 311. The exclusion of these observations does not alter the results reported here, as can be seen in Table C.6 of Appendix C.

is an elusive one, given that the equilibrium level is unobservable. For the purposes of our robustness check, we use a simple statistical procedure to decompose the REER series into a long-run and a cyclical component that relies on the Hodrick-Prescott (HP) filter, due to Hodrick and Prescott (1997). Strictly, this method does not allow us to determine misalignment with respect to value of the REER that, for example, secures internal and external balances for the economy, or that is consistent with purchasing power parity, or that is aligned with the values of long and medium term fundamentals. It simply allows us to decompose the REER series into a slow-moving long run trend (τ_t) and a transitory deviation or cycle (ζ_t) component, assuming that on average, over the sample of analysis, the variable has been on "equilibrium". The extraction of the trend is performed by minimising the variance of the ζ_t component subject to a given "smoothness" of the trend τt, as in equation (2.17):

$$min_{\tau_t} \sum_{t=1}^{T}(reer_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1} [(\tau_{t+1} - \tau t) - (\tau_t - \tau_{t-1})]^2 \tag{2.17}$$

where λ is the noise-to-signal ratio, and acts as a penalty attached to the volatility of the trend component. We apply the HP filter to our monthly data of the REER, and set $\lambda = 14400$.[35] Then, we construct our measure of misalignment, by extracting τ from the series of REER, and include it in the analysis. A note of caution is in order, when interpreting results. As argued above, this is an 'atheoretical' method, and there is no reason for the long run trend extracted here to be in line with an "equilibrium" REER that emerges from other methodologies that rely on different theoretical models.[36] In addition, our measure does not allow us to identify the sources of the misalignment (e.g: transitory factors, random disturbances or misalignment of the fundamentals). Also, from a purely

[35]This value is commonly used in the literature.
[36]For a review on these methods see MacDonald (2007)

statistical perspective, this filter assumes that agents know the future, since the extraction of τ_t relies on the knowledge of τ_{t+1}. Acknowledging its limitations, and given that the purposes here are to provide a robustness check, we chose this avenue as it is relatively simple to calculate and frequently found in the literature.[37]

Columns (6-7) report results when measures of REER misalignment changes are incorporated as explanatory variables. The coefficients are practically unchanged with the inclusion of the REER misalignment measure, and those on the misalignment measures are statistically insignificant and very small.[38]

2.5.1.2 Are Results Robust to the Choice of Instruments?

In Table 2.3 we try to replicate the results reported in Table 2.2, but using US prices instead of lagged prices, as instruments for sectoral domestic prices.[39] The price effect on output produced is systematically positive and generally statistically significant and with magnitudes in the range (0.35-0.54), suggesting that output is relatively inelastic to price changes. The rest of the estimated coefficients is robust to the choice of the instruments, which enhances the credibility of our results.[40]

2.5.1.3 Country Heterogeneity

The conclusions drawn above rest on the validity of the restriction of identical parameters across countries. Given that the time dimension of our panel is reasonably long, we can

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[37] See for example: Goldfajn and Valdes (1999) or Goldfajn and Werlang (2000)

[38] Cottani et al. (1990) also used a measure of REER misalignment in addition to one for REER instability to explain GDP growth, export growth and investment at a macro level, and find a negative and significant effect on the first two dependent variables. Dollar (1992) combines a measure of misalignment of the REER with one of its variability to construct an index of outward orientation, and find that index to be highly correlated with GDP growth.

[39] The number of observations is now increased, as we have one more year in the sample.

[40] Although all diagnostics point to this set of instruments as the best (Hansen suggests validity, KP are in general above 10, suggesting that these instruments are stronger than the previous set, and C-stats that IV procedures are necessary), a negative estimated coefficient for US prices in the first stage of the IV procedure is puzzling. We find comfort in the large invariance of the estimated coefficients in the reduced form to the set of instruments used, and use lagged prices as instruments in the rest of the paper.

investigate whether the data upholds this restriction. We re-estimate (2.2) separately for each country in the panel and compare the estimated coefficients (Table 2.4). The general picture is largely unchanged, with the exception of the estimated coefficients on the REER and the misalignment of the REER, where substantial country heterogeneity is found. The output elasticity with respect to REER changes seem to be significantly larger in Argentina and Uruguay than in Brazil. This is likely to be explained by the lower degree of openness of the latter economy. Regarding the misalignment, when the REER is below the equilibrium value, one would expect that firms delay increases in output, thus pushing sectoral output changes downwards. This mechanism is supported by the sign of the coefficient in the case of Argentina, but not in the case of Brazil, where the misalignment variable yields a negative coefficient, though of small magnitude.

In terms of our parameters of interest, although the point estimates for the effects of REER Uncertainty on output differ, these differences are not statistically significant. We used these country-specific estimates to plot the estimated effect of REER uncertainty on output over time ($\hat{\beta}_{uncert} \times reerUncert$). This is displayed in Figure 2.4 for each of the countries under analysis. The effects are calculated against a baseline of zero uncertainty, which means that all series in the graph must be negative. Two elements emerge from the visualization of the graph. First, that the effects of uncertainty on output are not negligible. There are several episodes during our sample in which these have induced, on average, a reduction in output of more than 5%. Second, that the effects of uncertainty have been larger in Argentina and Uruguay, which is a direct product of their larger record of uncertainty relative to Brazil, given that the estimated sensitivities are similar.

Table 2.2: Output Response to REER Uncertainty Using Lagged Prices as Instrument

Dep. Var.:	(1)		(2)		(3)		(4)		(5)		(6)		(7)	
Growth Ind Output	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Growth of Rel Prices	0.26*	(0.13)	0.14	(0.12)	0.30**	(0.13)	0.29**	(0.14)	0.17	(0.13)	0.31**	(0.14)	0.19	(0.14)
REER Growth	0.88***	(0.03)	0.89***	(0.03)	0.89***	(0.04)	0.87***	(0.04)	0.88***	(0.03)	0.88***	(0.04)	0.89***	(0.03)
REER Uncert GARCH	-19.17	(17.86)					-4.91	(19.89)			-8.47	(19.42)		
BCDI	-0.05***	(0.01)	-0.04***	(0.01)	-0.05***	(0.01)	-0.05***	(0.01)	-0.04***	(0.01)	-0.06***	(0.01)	-0.05***	(0.01)
Dummy Floating	-0.00	(0.02)	-0.01	(0.02)	0.00	(0.02)	0.00	(0.02)	-0.01	(0.02)	-0.00	(0.02)	-0.01	(0.02)
Dummy Interm	0.00	(0.02)	-0.01	(0.02)	0.00	(0.02)	-0.00	(0.02)	-0.01	(0.02)	-0.01	(0.02)	-0.01	(0.02)
REER Uncert RollVar			-29.55***	(8.35)					-23.61**	(9.50)			-22.91**	(9.91)
Variance REER					-0.25	(0.19)								
REER Skewness							0.03***	(0.01)	0.03**	(0.01)	0.03**	(0.01)	0.02**	(0.01)
REER Kurtosis							-0.02**	(0.01)	-0.01*	(0.01)	-0.01**	(0.01)	-0.01*	(0.01)
REER Misalignment											0.01	(0.01)	0.01	(0.01)
Observations	2563		2563		2563		2563		2563		2563		2563	
Time Dummies	✓		✓		✓		✓		✓		✓		✓	
Sector-Country FE	✓		✓		✓		✓		✓		✓		✓	
Clustered SE	C&S		C&S		C&S		C&S		C&S		C&S		C&S	
Hansen Overid Test	1.201		0.341		1.285		1.392		0.478		1.497		0.612	
K&P Statistic	4.637		6.816		4.230		4.101		5.779		4.216		6.346	
C Statistic	5.576		2.909		5.788		6.375		3.548		6.814		4.019	
CSD B-Pagan	3.650		2.793		4.752		2.958		2.633		3.155		2.752	

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The Hansen Overid and the C tests are distributed χ^2_1, the K&P statistic is distributed χ^2_2.
The Breusch Pagan test of Cross Sectional Dependence (CSD) is distributed χ^2_3. Critical Values at 5% significance for χ^2_1=3.84, for χ^2_2=5.99 and for χ^2_3=7.81.

Table 2.3: Output Response to REER Uncertainty Using US Prices as Instrument

Dep. Var.:	(1)		(2)		(3)		(4)		(5)		(6)		(7)	
Growth Ind Output	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Growth of Rel Prices	0.48**	(0.21)	0.35*	(0.18)	0.51**	(0.21)	0.53**	(0.23)	0.40**	(0.20)	0.54**	(0.24)	0.43**	(0.21)
REER Growth	0.82***	(0.06)	0.84***	(0.05)	0.82***	(0.06)	0.79***	(0.07)	0.82***	(0.06)	0.80***	(0.07)	0.82***	(0.06)
REER Uncert GARCH	-17.30	(19.96)					-1.26	(23.70)			-4.14	(23.07)		
BCDI	-0.04***	(0.01)	-0.03***	(0.01)	-0.04***	(0.01)	-0.05***	(0.01)	-0.04***	(0.01)	-0.05***	(0.01)	-0.04***	(0.01)
Dummy Floating	-0.02	(0.02)	-0.02	(0.02)	-0.02	(0.02)	-0.02	(0.02)	-0.02	(0.02)	-0.02	(0.02)	-0.02	(0.02)
Dummy Interm	-0.01	(0.02)	-0.01	(0.02)	-0.01	(0.02)	-0.02	(0.02)	-0.02	(0.02)	-0.02	(0.02)	-0.02	(0.02)
REER Uncert RollVar			-28.51***	(9.60)					-21.31*	(10.97)			-20.46*	(11.67)
Variance REER					-0.27	(0.26)								
REER Skewness							0.04**	(0.02)	0.03**	(0.02)	0.04**	(0.02)	0.03**	(0.02)
REER Kurtosis							-0.02**	(0.01)	-0.01*	(0.01)	-0.02*	(0.01)	-0.01*	(0.01)
REER Misalignment											0.01	(0.01)	0.01	(0.01)
Observations	2646		2646		2646		2646		2646		2646		2646	
Time Dummies	✓		✓		✓		✓		✓		✓		✓	
Sector-Country FE	✓		✓		✓		✓		✓		✓		✓	
Clustered SE	C&S		C&S		C&S		C&S		C&S		C&S		C&S	
Hansen Overid Test	0.084		0.005		0.140		0.162		0.003		0.194		0.018	
K&P Statistic	10.016		14.719		8.849		8.520		12.095		8.222		10.843	
C Statistic	19.031		11.499		17.275		20.897		13.430		22.059		15.141	

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The Hansen Overid and the C tests are distributed χ^2_1, the K&P statistic is distributed χ^2_2. Critical Values at 5% significance for χ^2_1=3.84 and for χ^2_2=5.99.

Table 2.4: Country-Heterogeneous Response of Output to REER Uncertainty

Dep. Var.:	Argentina		Brazil		Uruguay	
Growth Ind Output	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Growth of Rel Prices	-0.098	(0.092)	-0.026	(0.069)	0.077	(0.268)
REER Growth	1.049***	(0.031)	0.504***	(0.037)	0.967***	(0.197)
REER Uncert RollVar	-20.604*	(10.666)	-21.824**	(8.580)	-26.508**	(12.809)
REER Skewness	0.056***	(0.011)	0.046***	(0.009)	-0.018	(0.022)
REER Kurtosis	-0.007	(0.006)	0.026***	(0.007)	-0.022**	(0.011)
BCDI	-0.064***	(0.010)	-0.059***	(0.006)	-0.017	(0.040)
REER Misalignment	0.047***	(0.014)	-0.004***	(0.001)	-0.015	(0.014)
Observations	923		890		859	
Time Dummies	✗		✗		✗	
Sector FE	✓		✓		✓	
Hansen Overid Test	2.299		4.735		0.009	
K&P Statistic	19.444		21.499		5.777	
C Statistic	0.277		0.034		0.696	

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The Hansen Overid and the C tests are distributed χ^2_1, the K&P statistic: χ^2_2. C.V. at 5% significance for χ^2_1=3.84 and for χ^2_2=5.99.

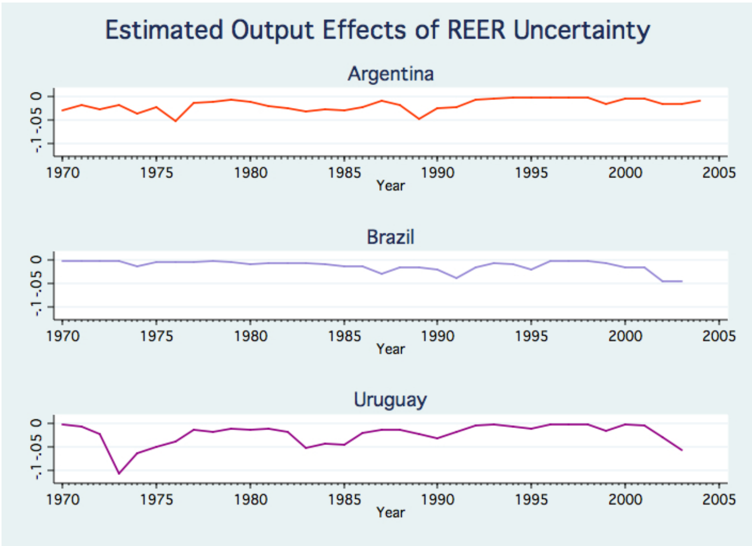

Figure 2.4: Plot of Estimated Effects of REER Uncertainty on Output

2.5.2 Threshold Effects

To test for threshold effects of uncertainty with respect to REER changes, on output changes, we estimate the models described in equations (2.3) and (2.4):

Equation (2.3) allows for the identification of an inverted-U shape relationship with a linear and a quadratic term for uncertainty. Equation (2.4) allows for two different linear relationships between output and uncertainty, depending on whether the latter is 'low' or 'high'. We consider 'high' the episodes that are in the upper quintile of the distribution of REER uncertainty, and examine the sensitivity of the results by allowing the break between low and high uncertainty to take place at 20 different percentiles in the the upper quintile.

Column (1) of Table (2.5) reports the results of estimating equation (2.3). The hypothesis of an inverted-u shape relationship between uncertainty and output is upheld by the data. Uncertainty affects output in a non-linear fashion. The effect is positive for relatively low levels of uncertainty, while it becomes negative for relatively higher levels. The turning point seems to be around the 75-80th percentile of the distribution of uncertainty. On the basis of this result, we determined "high uncertainty" to correspond to the episodes in the upper quintile of the distribution, and investigated the robustness of the results to different breaking points within the 5th quintile. Figure 2.5 depicts the estimated effects of low and high uncertainty, along with their confidence intervals at 95% confidence, for the 20 different breaking points. It is possible to see that the estimated effects of low and high uncertainty are significantly different. While the former are generally positive, the latter are negative. In addition, the effects of high uncertainty seem to be more precisely estimated (a narrower interval) and seem to be quite stable irrespective of the choice of the breaking point. Column (2) reports the results of estimating equation (2.4) when the break for high uncertainty being at the 90th percentile of the distribution. In line with the quadratic specification, we find the effect of REER uncertainty to be different depending on whether we considered 'low' or 'high' uncertainty.[41]

[41] Both the AIC and the BIC favoured these models to that of equation (eqrefeq:quadraticchp2.

Table 2.5: Thresholds

Dep. Var.:	(1)		(2)	
Growth Ind Output	Coeff.	S.E.	Coeff.	S.E.
Growth of Rel Prices	0.26*	(0.14)	0.28**	(0.14)
REER Growth	0.88***	(0.03)	0.87***	(0.03)
REER Uncert RollVar	64.30***	(21.08)		
Sq REER Uncert Roll Var	-27806.21***	(5326.84)		
REER Skewness	0.02**	(0.01)	0.03***	(0.01)
REER Kurtosis	-0.01**	(0.01)	-0.01*	(0.01)
BCDI	-0.04***	(0.01)	-0.05***	(0.01)
REER Misalignment	0.01	(0.01)	0.01	(0.01)
Dumm Floating	-0.02	(0.02)	-0.03*	(0.02)
Dumm Intermed.	-0.03	(0.02)	-0.03	(0.02)
Low Uncert			37.69**	(16.11)
High Uncert			-28.00***	(10.25)
Observations	2563		2563	
Time Dummies	✓		✓	
Sector-Country FE	✓		✓	
Clustered S.E.	C&S		C&S	
Hansen Overid Test	1.471		2.190	
K&P Statistic	5.914		5.123	
C Statistic	4.787		3.946	

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

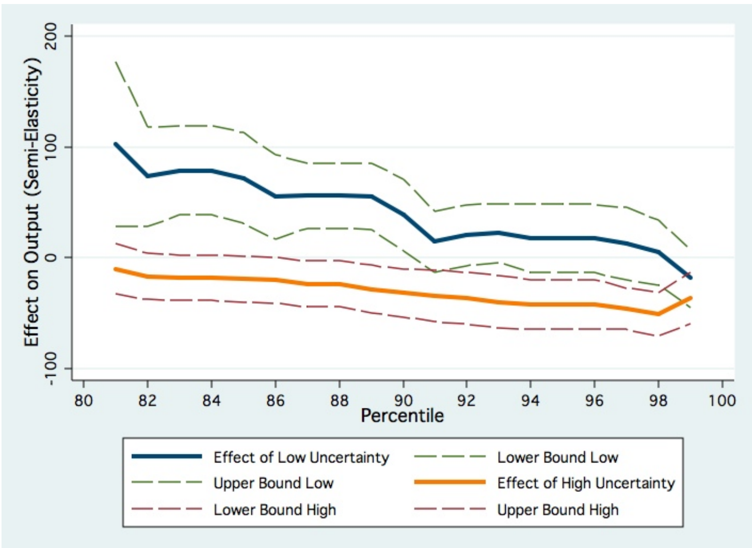

Figure 2.5: Threshold Effects of REER Uncertainty on Output

2.5.3 Sectoral Heterogeneity

The baseline estimation results proposed above pools across industries, imposing a common responsiveness of output to REER uncertainty. As sectors exhibit different characteristics, it is interesting to explore whether differences in characteristics affect the vulnerability of sectoral output changes to REER uncertainty. Here we explore three possible triggers of heterogeneity: trade orientation, productivity and the intensity with which they trade with Mercosur countries. We examine their direct effects on output, and their indirect effects, through the output growth vulnerability to REER uncertainty.

2.5.3.1 Trade Orientation

Differences in trade orientation by sector may explain some of the heterogeneity in the responsiveness of sectoral output to REER uncertainty, although the effects are *a priori* ambiguous. The standard textbook approach would suggest that those sectors that are more exposed to international trade are going to be more sensitive to REER uncertainty than those whose output is mainly oriented to the domestic markets. This is because real exchange rates (and their variations) are going to explain a larger portion of the price received by firms in tradable sectors, and uncertainty about the price to be received will induce an output contraction if firms in those sectors are averse to risk. However, in economies in which firms contract dollar-debt, REER uncertainty affects output through the firms' financial structure — (see Chapter 1 for a full discussion). With dollar-debt, the less the firms export, the larger the currency mismatch in their balance-sheets, and the more sensitive sectoral output will be to REER uncertainty, even if firms are risk-neutral. Given the theoretical ambiguity, we test empirically whether differences in exposure to international trade determine differences in the sensitivity to REER uncertainty, and allowing for a level effect of the measure of exposure to international trade on output changes, by estimating equation (2.5), with Z_{tij} being the ratio of sectoral exports to sectoral output, as in equation (2.18):

$$\begin{aligned} q_{tij} &= \alpha_{ij} + \alpha_t + \mathbf{X}\gamma + \beta_1 reerUncert_{tj} + \beta_2 reerUncert_{tj} * Exp/Output_{t-1,ij} + \\ &\quad + \beta_3 Exp/Output_{t-1,ij} + u_{tij} \end{aligned} \tag{2.18}$$

A specific challenge here is that output appears both on the left and the right hand side of the equation given the way the measure of export exposure is constructed. This means that shocks affecting output due to, say, measurement error, will lead to biased estimates of our coefficients. We address this problem in three alternative ways. First, we use the lagged exports/output measure, and interact this lag with the uncertainty measure. Results are reported in column 1 of Table (2.6). Conditional on the effects of the other covariates, the effect of REER uncertainty on output is heterogeneous across sectors, and depends on the ratio of exports/output. The effect of uncertainty on output changes is found to be negative, but it becomes smaller, the larger the exported proportion of output is. The level effect of the lagged ratio of exports/output is insignificant.

Second, we consider averages of sectoral export/output instead of just the contemporaneous measure, and interact this average with the uncertainty measure. If measurement error is imperfectly correlated over the years, then, by averaging, we reduce its importance. Results of estimating equation (2.18) using this approach (taking 5-year averages) are reported in Column 2. In line with the previous results, we find that those sectors that have been exporting a larger portion of their output are less sensitive to REER uncertainty. In addition, they seem to grow less, on average and *ceteris paribus*. We used 10-year averages, and the results point to the same direction (reported in Column 3). The level effects of export orientation on output changes, when using averages are now negative, suggesting that more open sectors have been less dynamic. The third approach consists of using a discrete measure of exports/output that indicates in which quartile of the distribution of exports/output the sector is. For these purposes we construct quartile dummies. The $i-th$ dummy will take value 1 if the sector is in the $i-th$ quartile and zero otherwise. We interact the dummies with the uncertainty measure. In this way, output does not enter directly on the right-hand side of equation (2.18). In addition to this, we exclude from the estimation those observations that move from one quartile to another in a given year.

Results are reported in Column 4. REER uncertainty seems to decrease output of those sectors that are in the lowest quartile of the distribution of the export/output ratio. For the second and third quartile, the point estimate is negative, but not well-determined. It is worth mentioning that when using this approach, given that we exclude those sectors that change quartile from one year to the next, the sample size is reduced by more than 20%. As in the first approach, the level effects of export orientation on output changes are statistically insignificant, for all the quartiles.

Table 2.6: Trade Orientation

Dep. Var.:	(1)		(2)		(3)		(4)	
Growth Ind Output	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Growth of Rel Prices	0.19	(0.14)	0.27*	(0.15)	0.26*	(0.15)	0.15	(0.18)
REER Growth	0.88***	(0.03)	0.87***	(0.03)	0.87***	(0.03)	0.89***	(0.04)
REER Uncert RollVar	-38.54***	(9.64)	-38.82***	(10.17)	-39.99***	(10.68)	23.62	(23.69)
REER Skewness	0.02**	(0.01)	0.02**	(0.01)	0.02**	(0.01)	0.01	(0.01)
REER Kurtosis	-0.01*	(0.01)	-0.01	(0.01)	-0.01	(0.01)	-0.00	(0.01)
BCDI	-0.04***	(0.01)	-0.05***	(0.01)	-0.05***	(0.01)	-0.04***	(0.01)
REER Misalignment	0.01	(0.01)	0.01	(0.01)	0.01	(0.01)	0.01	(0.01)
Dummy Floating	-0.01	(0.02)	0.00	(0.02)	0.00	(0.02)	-0.01	(0.02)
Dummy Interm	-0.01	(0.02)	0.00	(0.02)	0.00	(0.02)	-0.01	(0.03)
Uncert*Lagged Exp/Out	17.00***	(5.04)						
L.Exp/Out	0.00	(0.01)						
Uncer*5-y Ave Exp/Out			9.05**	(4.51)				
5-y Ave Exp/Out			-0.01***	(0.00)				
Uncer*10-y Ave Exp/Out					9.30**	(4.08)		
10-y Ave Exp/Out					-0.02***	(0.00)		
Uncer*Q1 Exp/Out							-66.74**	(28.56)
Uncer*Q2 Exp/Out							-40.55	(26.84)
Uncer*Q3 Exp/Out							-46.65	(31.08)
Q1 Exp/Out							0.04	(0.04)
Q2 Exp/Out							0.02	(0.03)
Q3 Exp/Out							0.03	(0.03)
Observations	2563		2563		2563		1992	
Time Dummies	✓		✓		✓		✓	
Sector-Country FE	✓		✓		✓		✓	
Clustered S.E.	C&S		C&S		C&S		C&S	
Hansen Overid Test	0.792		1.392		1.240		0.673	
K&P Statistic	6.527		5.911		6.177		6.752	
C Statistic	0.792		4.531		4.724		3.419	

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

2.5.3.2 Productivity

It is plausible to believe that the more profitable a firm is, the less sensitive it will be to REER uncertainty. In Chapter 1, we argued that in a context in which credit was only available in dollars, the output of those firms with higher liquidity, or current profits, was going to be less sensitive to increases in REER uncertainty than that of firms with lower liquidity balances. For the latter type, the increase in uncertainty would increase expected bankruptcy costs by more, which means that the output response will be correspondingly larger than for the former type. But even if credit is not dollarised, more profitable firms will have more chances to adjust to an adverse competitiveness shock that could arise from movements in the REER than less profitable ones. Unfortunately, we do not have data on sectoral profitability. However, we do have data on labour productivity, and on labour productivity of the same sectors in the United States. Assuming an association between productivity and profitability, we test whether there exists a second source of sectoral heterogeneity in the output response to REER uncertainty, related to the level of sectoral labour productivity.

To test this proposition, we include a measure of labour productivity (the quotient of sectoral output and the wage bill), and an interaction between labour productivity and the measure of REER uncertainty, and estimate equation (2.19):[42]

$$
\begin{aligned}
q_{tij} &= \alpha_{ij} + \alpha_t + \mathbf{X}\gamma + \beta_1 reerUncert_{tj} + \beta_2 reerUncert_{tj} * LabProd_{tij} + \\
&\quad + \beta_3 * LabProd_{tij} + u_{tij}
\end{aligned} \tag{2.19}
$$

Like when exploring the role of trade orientation in determining the heterogeneity of the output response to REER uncertainty, in equation (2.19) output appears both on the left and the right hand side of the equation, given the way the labour productivity measure is constructed. We approach the problem as before.

We use the distance to the productivity frontier (DistFrontier) as an alternative to labour productivity. The frontier is assumed to be labour productivity exhibited by USA

[42]Clearly, labour productivity is an imperfect measure of productivity. The choice is mainly motivated by data constraints.

manufacturing sectors (eq. (2.20)). DistFrontier defined as: $(LP_{i,t,USA} - LP_{i,t,j})/LP_{i,t,USA}$ (where $LP_{i,t,j}$ is the labour productivity of sector 'i', in period 't', in country 'j'). As above, endogeneity is a problem. We deal with it in the same way as before, dividing the distribution of the distance to the frontier in four quartiles and interacting each of the four quartile dummies with the uncertainty measure.

$$\begin{aligned} q_{tij} &= \alpha_{ij} + \alpha_t + \mathbf{X}\gamma + \beta_1 reerUncert_{tj} + \beta_2 reerUncert_{tj} * DistFrontier_{tij} \\ &\quad + \beta_3 DistFrontier_{tij} + u_{tij} \end{aligned} \tag{2.20}$$

Table (2.7) reports the results from estimating equation (2.19) using alternative approaches. Column 1 shows the results of when we include labour productivity in levels and an interaction of labour productivity with the uncertainty measure in the model. Conditional on differences arising due to other covariates, those sectors exhibiting higher labour productivity tend to exhibit higher growth rates, as the level effect of labour productivity is positive and significant. In addition to this level effect, productivity also affects the vulnerability of sectors to REER uncertainty. The more productive the sectors are, the lower the effect of REER uncertainty on output, as the interaction term is very well-determined and positive. The size of the estimated parameters of interest is, however, surprising. Calculated at the average level of productivity, the effects of uncertainty on output are positive ($= -32.49 + 142.28 \times 7.06$). The estimates become plausible once we control for the endogeneity problem using the approaches outlined above. Column 2 shows the results of using 10-year productivity averages instead of the contemporaneous productivity level. Here again, sectoral output changes become less vulnerable to REER uncertainty, the larger the average labour productivity is. Figure 2.6 shows the marginal effect of uncertainty on output growth at different levels of labour productivity. At the average, the marginal effect equals: $-51.12 + 3.85 \times 7.06 = -23.95$. This is slightly more than half the size of the effect faced by low-productivity sectors, in the first decile of the distribution ($-51.12+3.85\times 2.70 = -40.71$). Sectors in the top 30 percent of the distribution of labour productivity seem not to be affected by REER uncertainty, as the marginal effect becomes statistically insignificant. The level effect of average productivity on output changes is not well-determined. Column 3 shows the results when the quartiles of the distribution of labour productivity are interacted with the uncertainty measure. The findings are in line with the previous ones. The effects of REER uncertainty on output are negative for those sectors in the 1st and 2nd quartiles of the distribution, but not significant for those with productivity levels in the upper half of the distribution. Here again, the level effect of productivity on output changes is insignificant.

Columns 4-5 report the results of estimating equation (2.20). Results reported in column 4 are as expected. The estimated marginal effect of REER uncertainty on output at the mean distance to the efficiency frontier equals $-93.88\times 0.66 = -62.27$. In addition, sectors that are further away from the frontier, tend to be less dynamic, as indicated by the negative and significant coefficient on the level of distance to the frontier. *Ceteris paribus*, an increase in the distance to the frontier by 1%, decreases the growth rate by about one-fifth of a percentage point, on average. Column 5 shows the results when quartiles dummies of the distribution of the distance to the frontier are interacted with the uncertainty measure. Although the point estimates suggest that the sectors that are closer to the frontier are less affected by REER uncertainty, the imprecision of the estimates prevent us from drawing conclusions.

Table 2.7: Sectoral Heterogeneity: Labour Productivity

Dep. Var.:	(1)		(2)		(3)		(4)		(5)	
Growth Ind Output	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Growth of Rel Prices	-0.03	(0.13)	0.14	(0.13)	0.39	(0.26)	0.10	(0.13)	0.02	(0.16)
REER Growth	0.98***	(0.03)	0.93***	(0.03)	0.92***	(0.05)	0.94***	(0.03)	0.94***	(0.04)
REER Uncert RollVar	-32.49**	(15.23)	-51.12***	(13.52)	-2.37	(16.10)	40.80	(33.71)	-39.32**	(16.22)
REER Skewness	0.02***	(0.01)	0.01	(0.01)	0.00	(0.01)	0.02	(0.01)	0.01	(0.01)
REER Kurtosis	-0.00	(0.01)	-0.01	(0.01)	0.00	(0.01)	-0.01	(0.01)	-0.01	(0.01)
BCDI	-0.06***	(0.01)	-0.05***	(0.01)	-0.08***	(0.02)	-0.05***	(0.01)	-0.04***	(0.01)
REER Misalignment	0.01	(0.01)	0.00	(0.01)	-0.00	(0.01)	0.00	(0.01)	-0.01	(0.01)
Dummy Floating	-0.01	(0.02)	-0.00	(0.02)	0.04	(0.03)	-0.01	(0.02)	-0.00	(0.02)
Dummy Interm	-0.02	(0.03)	0.01	(0.02)	0.06	(0.04)	-0.00	(0.02)	-0.02	(0.02)
Labour Productivity	0.01**	(0.00)								
Uncert*L.Prod	142.28***	(37.37)								
Average L.Prod.			0.00	(0.00)						
Uncert*AveL.Prod			3.85*	(2.16)						
Qtiles LP					-0.01	(0.01)				
Uncert* 1st Qtile. LP					-53.93*	(31.91)				
Uncert* 2nd Qtile. LP					-46.76*	(23.89)				
Uncert* 3rd Qtile. LP					23.64	(24.35)				
Dist.to Frontier							-0.18***	(0.06)		
Uncert*Dist. to Frontier							-93.88**	(40.17)		
Qtiles Dist Frontier									0.00	(0.01)
Uncert* 1st Qtile. Dist.									29.24	(21.41)
Uncert* 2nd Qtile. Dist.									26.18	(16.48)
Uncert* 3rd Qtile. Dist.									16.68	(14.77)
Observations	2235		2514		1931		2570		2048	
Time Dummies	✓		✓		✓		✓		✓	
Sector-Country FE	✓		✓		✓		✓		✓	
Clustered S.E.	C&S		C&S		C&S		C&S		C&S	
Hansen Overid Test	1.054		0.303		2.787		0.039		1.39	
K&P Statistic	1.709		7.340		6.061		6.807		12.823	
C Statistic	0.248		3.530		4.254		3.150		0.340	

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

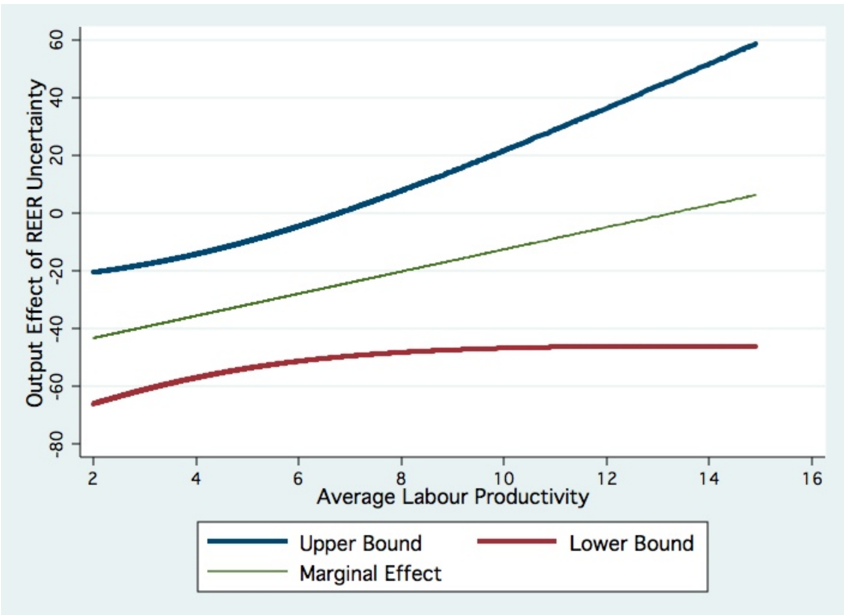

Figure 2.6: Marginal Effect of Uncertainty as a Function of Labour Productivity

2.5.3.3 Orientation to Mercosur Markets

Motivated by the fact that the main sources of REER uncertainty come from Mercosur economies, while we have used a macro-measure of uncertainty that is the same across sectors of a given country, here we try to identify whether results change when we consider sectors that exhibit high exposure and sectors that exhibit low exposure. High and low exposure are defined on the basis of the export shares defined in Section 2.3.1. In addition, and in accordance with the discussion in Section 2.4.4, we adjust our macro measure of uncertainty by multiplying it to our indicator of export intensity to Mercosur markets. This adjusted measure of uncertainty will vary now at a sectoral level, using the 2-digit international standard industrial classification (ISIC).[43] The estimable equation (2.21) is presented below:

$$\begin{aligned} q_{tij} &= \alpha_{ij} + \alpha_t + \mathbf{X}\gamma + \beta_1 reerUncert_{tj} + \beta_2 reerUncert_{tj} * ExpShare_{ti-j} + \\ &\quad + \beta_3 ExpShare_{ti-j} + u_{tij} \end{aligned} \tag{2.21}$$

Columns (1-2) of Table 2.8 report the results of estimating the baseline model separate for sectors that exhibit a low exposure to Mercosur markets (sector exhibiting, on average across the period, an export share below the median, Col.1), and those that exhibit a high exposure (sector exhibiting, on average across the period, an export share above the median, Col.2). Export shares were used to classify sectors into 'high' and 'low' exposure to Mercosur. So, for example, sector 311 will be classified into 'low' exposure for the whole period of analysis 1970-2002, even when the export shares are only available for the period 1980-2002. The validity of this approach relies on sectors not to changing significantly the intensity with which they trade with the neighbour countries over the years. Conditional

[43] This is because the export shares are defined at 2-digit level.

on the effects of the other covariates, REER uncertainty affects negatively the output of those sectors that are mainly oriented to Mercosur, while the effect on those that display a low export intensity is not significantly different from zero. We then estimate equation (2.21) in which the macro measure of uncertainty is adjusted using the sectoral export shares, and in which the export shares also enters in levels. Results are reported Column 3 of Table 2.21. The estimated effect of the uncertainty on output should be read as $\hat{\beta}_1 + \hat{\beta}_2 Exp\bar{S}hare$. Results suggest that, conditional on the effects of the other covariates, this estimated effect is larger for sectors with more exposure to Mercosur, but the effect is poorly determined. On the other hand, the level effect of export shares on output changes is also not well determined, suggesting no specific growth pattern associated to those sectors that trade predominantly with Mercosur, conditional on the other covariates. As argued in Section 2.4.4, there are a number of channels through which export shares may exert significant effects in this model. In an attempt to better understand which channels are at work, we first investigated whether there is an association between the intensity with which sectors trade intensively within Mercosur, and their productivity. We found that this is the case, as the correlation of the export shares with the distance to the US frontier is 13.94%, and statistically significant at 1%. We then modified equation (2.21) in the following way: we created a "high exposure to Mercosur" dummy on the basis of the above classification of sectors (the dummy takes value one for sectors with an above the median exposure), and interacted the dummy with the uncertainty measure. In addition, we incorporated the distance to the US frontier in levels, and interacted with uncertainty in order to control for the fact that the effect of the export shares may be concealing a productivity effect. The new estimable equation is (2.22):

$$
\begin{aligned}
q_{tij} &= \alpha_{ij} + \alpha_t + \mathbf{X}\gamma + \beta_1 reerUncert_{tj} + \beta_2 reerUncert_{tj} * HighExposure_{ti-j} + \beta_3 ExpShare_{ti-j} \\
&\quad + \beta_4 reerUncert_{tj} * DistFrontier_{tij} + \beta_5 DistFrontier_{tij} + u_{tij} \qquad (2.22)
\end{aligned}
$$

Results are reported in Column 4 of Table 2.8. The estimated effects of distance to the US, and its interaction with uncertainty are similar to those found in Section 2.5.3.2. Displaying higher-than-average distance to the productivity frontier has an indirect effect on output growth, increasing the vulnerability of the sector to REER uncertainty. The fact that when including distance to the frontier in the model, the effect of export shares remains significant suggests that the adjustment to the macro uncertainty measure with the sectoral export shares may be necessary to reflect different degrees in exposure to uncertainty.

Table 2.8: Export Exposure to Mercosur

Dep. Var.:	(1)		(2)		(3)		(4)		(5)	
Growth Ind Output	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Growth of Rel Prices	-0.12	(0.27)	0.20	(0.14)	0.06	(0.16)	0.05	(0.15)	0.06	(0.16)
REER Growth	0.94***	(0.07)	0.89***	(0.04)	0.65***	(0.04)	0.65***	(0.04)	0.62***	(0.04)
REER Uncert RollVar	-23.93	(14.72)	-30.13***	(11.53)	10.25	(24.71)	160.70***	(61.08)	155.80**	(64.79)
REER Skewness	0.02	(0.02)	0.03**	(0.01)	0.00	(0.01)	0.01	(0.01)	-0.01	(0.02)
REER Kurtosis	0.00	(0.01)	-0.02*	(0.01)	0.04***	(0.01)	0.04***	(0.01)	0.03**	(0.01)
BCDI	-0.02*	(0.01)	-0.06***	(0.01)	-0.07***	(0.02)	-0.07***	(0.02)	-0.06***	(0.02)
REER Misalignment	0.00	(0.01)	0.01	(0.01)	0.00	(0.01)	0.00	(0.01)	-0.00	(0.01)
Dummy Floating	-0.04	(0.02)	0.01	(0.02)	-0.08**	(0.04)	-0.07*	(0.04)	-0.02	(0.04)
Dummy Interm	-0.06***	(0.02)	0.02	(0.02)	-0.06*	(0.04)	-0.04	(0.04)	-0.02	(0.04)
Uncer*ExpShare					-34.66**	(35.43)				
Merco ExpShare					0.02	(0.02)	0.00	(0.01)	0.01	(0.01)
Uncert*HighExposure							-52.87*	(28.71)	-14.15	23.72
Uncert*Dist to Frontier							-162.91**	(76.31)	-211.84***	(76.53)
Dist to Frontier							-0.31***	(0.12)	-0.30***	(0.11)
Uncert*Lagged Exp/Out									10.12*	(5.8)
L.Exp/Out									0.01	(0.01)
Observations	1006		1557		1530		1530		1530	
Time Dummies	✓		✓		✓		✓		✓	
Sector-Country FE	✓		✓		✓		✓		✓	
Clustered S.E.	C&S		C&S		C&S		C&S		C&S	
Hansen Overid Test	0.138		3.15		4.664		4.912		7.826	
K&P Statistic	6.782		3.234		0.429		0.431		0.436	
C Statistic	0.632		1.218		1.407		2.464		3.108	

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Finally, we estimate our model including the lagged export/ouput ratio, the distance to the frontier, and the Mercosur export shares together, both in levels and interacted with the measure of REER uncertainty, as in equation (2.23):

$$
\begin{aligned}
q_{tij} \quad = \quad & \alpha_{ij} + \alpha_t + \mathbf{X}\gamma + \beta_1 reerUncert_{tj} + \beta_2 reerUncert_{tj} * HighExposure_{ti-j} + \beta_3 ExpShare_{ti-j} \\
& + \beta_4 reerUncert_{tj} * DistFrontier_{tij} + \beta_5 DistFrontier_{tij} \\
& + \beta_6 reerUncert_{tj} * Exp/Output_{t-1,ij} + \beta_7 Exp/Output_{t-1,ij} + u_{tij} \qquad (2.23)
\end{aligned}
$$

Results are reported in Column 5 of Table 2.8. Results are largely unchanged with respect to those obtained when each of the interactions was scrutinized in isolation, when looking at sign and size of the effects. While trade orientation and export shares exert no significant direct effect on output growth, distance to the frontier significantly decreases output growth. Further to this, the indirect effects on output growth that operate through the vulnerability of the sector to REER uncertainty are also in line with those previously found. It is worth mentioning that the point estimate of the interaction of REER uncertainty and export shares decreases as we sequentially add the other covariates, although the confidence intervals for that interaction term in the models reported in Column 3, 4 and 5 overlap. The interaction of the uncertainty measure with the "high exposure" dummy is now not well determined.

It is worth mentioning that the estimated effects reported in this section should be interpreted cautiously, because the diagnostic tests suggests that instruments are weak and not valid for these specifications. This may be related to the fact that because the export shares are only available for two thirds of the sample period considered, we substantially lose degrees of freedom in the estimation of these models.

2.6 Conclusions

This chapter adds to the empirical literature on the effects of uncertainty on productive decisions. The existing literature has generally focused on the relationship between uncertainty and investment, while scant attention has been put on the effects on output. Given that production takes time, the payment for inputs occurs before output is sold, which makes output decisions, in effect, risky investment decisions.

The chapter draws on the case of Southern Cone countries over the period 1970-2002 and focuses on REER uncertainty. Southern Cone countries have exhibited a particularly high record of REER uncertainty over the period, and in addition, they have become more interlinked from a trade perspective. This latter phenomenon has further increased their exposure to uncertainty. The focus on the REER is particularly relevant in the context of these economies where the expected value of the REER and the uncertainty surrounding that expectation are key factors that are constantly in the lobbying agenda of manufacturers, and in the speeches of policymakers. This is because of the effect the REER has on the price of tradable goods sold by manufacturers, because during much of the 1980s and 1990s a large portion of firms contracted dollar-debt to finance their production plans, and because hedging instruments to cover against exchange rate risk have been largely unavailable.

In this chapter, we explored the impact of REER uncertainty on output by estimating a supply function in which the output-price simultaneity was tackled using two alternative sets of instruments. We identified an average non-negligible negative effect of REER uncertainty on output changes, when considering the pooled sample of 28 manufacturing sectors for the 3 countries, after controlling for other determinants of output supply. This finding was robust to our choice of instruments, and relatively homogeneous across countries.

The average effect masks, however, a number of specificities. We found evidence of non-linearities in the uncertainty-output relationship. There is a threshold above which uncertainty affects output negatively, but below which the effect may even be positive. Furthermore, we found that differences in sectoral characteristics explain differences in the sensitivity of output to REER uncertainty. Output in those sectors that are more export oriented seem to be less affected by REER uncertainty. However, those sectors that export more intensively to other Mercosur countries seem to be more affected by REER. This finding is likely to be explained by the fact that exposure to uncertainty is larger in these sectors, and not necessarily because they are more sensitive to uncertainty. In addition, we found that higher labour productivity decreases the negative impact of REER uncertainty on output.

Last but not least, we found that output is not only responsive to the first two moments of the distribution of the REER, but also to higher ones, such as skewness and kurtosis. Given that the series of REER changes are non-normal, then a measure of its uncertainty should not only look at mean and variance, but also at higher moments.

Two policy implications emerge from this analysis. Firstly, given the finding of threshold effects, suggesting that it is high REER uncertainty that exerts a negative effect on output changes, it seems that the strategy of adopting fixed exchange rate regimes, or some sort of hard pegs to the dollar in an attempt to reduce uncertainty may be counterproductive. This is because experience has shown that these regimes tend to come to an end collapsing, and generate extremely high uncertainty. Instead, it is possible that the REER uncertainty associated with a freely floating nominal exchange rate regime may be within the benign range. In addition, if a portion of the effects of REER uncertainty on output are explained by the high degree of dollarization of the economies under analysis, then more flexible exchange rate arrangements may induce firms to internalise the risk of borrowing in foreign currency, and contribute to a reversal of dollarization, which may in turn reduce the vulnerability of output growth to REER uncertainty.

Secondly, if REER uncertainty affects manufacturing sectors' output growth negatively, and if those sectors trading predominantly with other Mercosur countries are particularly affected, because of their substantially higher volatility records, then policies that contribute to the diversification of export markets are likely to be beneficial. One example is to promote negotiations of free trade agreements with other trading blocs or countries. Another, is to strengthen the international networks that each country has already established in the form of their foreign service offices. Given that in the context of trade in differentiated manufactures, the connections between sellers and buyers are made through search processes that are costly, and that these costs tend to increase, the further away the potential buyer is from the seller, the role that foreign service offices have in partnering with the private sector to contribute to the diversification of export markets may be substantial.

Happily, some of the policies implemented since 2003, by the countries under analysis, have been in line with the recommendations that emerge from this study. Since 2003, the three countries have moved —although to different extents of intervention — to relatively freely floating exchange rate regimes.[44] In addition to this, there have been several policy initiatives for the diversification of export destinations. Examples of these are the increase in free trade agreements (or negotiations to that end) that the bloc has implemented with other countries or regions, and the increasing role played by the Secretariats of Foreign Affairs in these countries in promoting exports of goods and services.[45]

A few caveats are in order, which point to directions of future research. First, our measure of uncertainty is restrictive, as it imposes a backward-looking expectation formation mechanism. Although we argue that it is sensible to assume backward-looking expectations

[44] In Argentina, the Central Bank significantly intervenes in the foreign exchange market, but it does not make public announcements or commits to a particular future value.

[45] Of a total of twenty agreements aiming at liberalizing trade, subscribed by Mercosur member countries with other regions, seven have been subscribed before 2003, while thirteen have been subscribed since then (source: Mercosur Secretatat).

for the period under analysis, ideally one would like to construct a measure of uncertainty that does not impose a particular structure on expectation formation, and compare the results. Data for an 'assumption-free' measure of real exchange rate uncertainty would require, for example, the availability of data on forecasts for nominal exchange rates and relevant prices, with which to calculate the variance of a forecast error on the basis of a true mechanism — whichever it is — for forecasting, instead of an assumed one. These data are hard to find, and were not available for the three countries over the period of analysis. Second, in this chapter we cannot identify whether the average negative effect of uncertainty is related to risk-aversion, or to some other factors, such as agents contracting dollar-debt and facing bankruptcy costs. We have no measure of risk-aversion, or data on balance-sheet currency mismatches. We try to control for the latter with the trade orientation of the sector, but this is clearly an imperfect indicator. Finally, the instruments used to deal with the output-price simultaneity problem are in some cases weak, which means that results should be interpreted cautiously.

Part II

Uncertainty and Expectations

Chapter 3

Measuring Real Exchange Rate Uncertainty: A Discussion

3.1 Introduction

In the preceding chapter we measured REER uncertainty by calculating the variance, skewness and kurtosis of a forecast error from an autoregressive model estimated for the REER. Economic literature abounds in similar or alternative measures of uncertainty associated with a number of variables — typically focusing on the second moment (the variance).

In this chapter we review the literature on uncertainty measures and classify them in two groups: those that impose assumptions on the agents' expectation formation mechanisms (like that of Chapter 2), and those that do not impose assumptions on these mechanisms. Among the measures in the former group, typically, the assumptions imposed imply an autoregressive forecast model for the representative agent. Among the latter, the measures are sometimes constructed on the basis of direct, observable data on expectations (e.g.: survey data) or, more frequently, extracted indirectly. For example, provided perfect capital mobility, information about depreciation expectations can be extracted from interest rate differentials. Note that although assumptions are still needed in this case (perfect capital mobility), these assumptions do not refer to the expectation formation mechanism. The choice of which measure to use tends to be driven by data availability and, generally, lacks conceptual justification.

In this thesis, where the focus is on the impact of REER uncertainty on behaviour, we use a measure of uncertainty that imposes a backward looking expectation formation mechanism in which the representative agent uses an autoregressive forecast model. Uncertainty is then measured as the rolling variance (and skewness, and kurtosis) of the forecast error. Our choice is motivated by data constraints.

Ideally, in order to understand how much uncertainty is attached to REER expectations, it would be necessary to have, firstly, a model of how the expectations themselves are being formed to be able to have forecasts, and secondly, an understanding of whether these expectations — however they were formed — have been accurate predictors of actual REER changes, that is, an understanding of the size of the forecast errors. Understanding the former allows us to assess the validity of imposing a particular forecast model on the representative agent. Understanding the latter would give us a better idea of the amount of uncertainty attached to expectations, one that would be less contaminated by assumptions. So, for example, if agents' expectations formation mechanism is clever enough to foresee a sharp depreciation in some given case, there is no surprise when it happens (the forecast errors will be small), and so, an estimated amount of uncertainty based on the history of the forecast error will be correspondingly smaller than if the sharp depreciation had not been foreseen. Measures of uncertainty constructed as the variance of the forecast error of a autoregressive forecast model will thus give misleading information if agents do not attach much weight to the past behaviour of the variable to predict the future realizations of that same variable.

Unfortunately, as argued in the preceding chapter, data for an 'assumption-free' measure of real exchange rate uncertainty are not available. A way of bypassing these data constraints is to shift focus from the real exchange rate to the nominal exchange rate, where expectation proxies or direct expectational data are more readily available, and explore how expectations are formed, and how well they are aligned with actual outcomes. Surely, there is no guarantee that agents use the same mechanisms to forecast nominal and real exchange rates. However, it seems likely that some lessons could be learned.

For the aforementioned reasons, the remainder of this chapter reviews the literature on uncertainty measures in the way described above. Then, the chapters that follow exploit data containing expectation information for nominal exchange rates, for the case of Uruguay and investigate expectation formation mechanisms, unbiasedness and accuracy of expectations. In Chapter 4 we do so by examining a proxy for expectations: nominal interest rate differentials between deposits in domestic and foreign currency, over twenty years that cover several exchange rate regimes. In Chapter 5 we use new survey data on nominal exchange rate expectations over a period of relatively freely floating exchange rates (2005-2010).

This chapter acts as a link between the previous analysis of the impact of uncertainty on economic activity, and the analysis of Chapter 4 and Chapter 5.

3.2 The Literature

There is no consensus on what constitutes the "right way" to empirically capture the concept of uncertainty. In this section we review and discuss the alternative empirical measures of uncertainty that can be found in the literature.[1] Beyond data requirements and the technical complexity embedded in the calculation of each of the measures, their most significant discriminant factor is whether they are constructed on the basis of assumptions placed on the agents' expectation formation mechanism (type one) or whether these assumptions have not been placed, which implies that measures are constructed on the basis of direct, observable data on expectations, or extracted from some other measure that, under certain conditions, reflect expectations about a given variable (type two):

- **Type One: Measures that impose an expectation formation mechanism**: These are probably the most widely used in the literature. Typically, the assumption is that agents use an autoregressive forecast model, and then uncertainty is calculated as the variance of the forecast error. The argument here, in the context of REER, is that uncertainty with regards to the future realisation of the REER is influenced by past REER volatility, and is independent of expectations of changes in policy or other environmental factors.[2] Forecast models imposed are not restricted to an autoregressive one. Think of an economy with a long lasting fixed exchange rate regime, but with an alarming record of interventions of the Central Bank in the foreign exchange market and a sharply declining stock of foreign exchange reserves. In this scenario, the autoregressive forecast model would misleadingly suggest an environment of low uncertainty. A rational agent may be looking at the evolution of reserves or some other relevant variable. So, the forecast model imposed does not

[1] We look at measures of uncertainty of nominal and real exchange rates, inflation, etc..

[2] This seems to be conventional wisdom, mentioned by (Baldwin et al., 2005, p. 25)

need to be restricted to be an autoregressive one, but could also take into account the behaviour of other variables that, on the basis of some preconceptions (theoretically grounded, or based on heuristics, et cetera) are considered to be relevant in the determination of the variable to be forecasted.

- **Type Two: Measures that do not impose assumptions on expectation formation mechanisms**: These measures are appealing, as they do not place restrictions on the mechanism behind expectation formation. Taking the previous example of an economy with a fixed exchange rate regime, and a dramatically declining stock of foreign exchange reserves, both the imposition of an autoregressive forecaster or one with rational expectations that forecasts with the 'true' model in mind may be a poor reflection of the actual mechanism driving expectations. Direct, observable measures of expectations are often survey-based. Expectational information can also be extracted from the evolution of other variables. For example, in the context of expectations about exchange rate movements, and assuming perfect capital mobility, interest rate differentials between domestic and foreign currency denominated bonds reflect depreciation expectations.

3.2.1 Type One Measures

It is not uncommon to find literature in which all variation in a variable is taken as indicative of uncertainty with respect to its future value. One example is the proxy of uncertainty used by Baldwin et al. (2005). These authors use two measures of uncertainty with respect to nominal exchange rates, to assess its impact on trade flows. The first measure is defined as the annual variance of the weekly nominal exchange rate changes. The whole of the variation in the series, over a period of time of 't' years is assumed here to reflect uncertainty. The authors assume a representative agent with forecast model that predicts zero change in the exchange rate, hence all the variability corresponds to forecast error. These authors find, empirically, that it is the previous 5-year variation that influence uncertainty for the outcome of the variable in year 't'. Another example that can be found in Driver and Moreton (1991) uses the unconditional variances of output and inflation variables as a proxy for uncertainty with respect to these variables.

These measures are simple in terms of data requirements and computation. However, they treat volatility and uncertainty as synonymous. These would be appropriate if volatility was fully unpredictable. When that is not the case, a portion of the variability is not uncertain. Therefore considering the former as an estimator of the latter would lead to an upward bias. Take for example a series with some degree of inertia in the data generation process. Then, it would be reasonable for the representative agent to expect a higher realisation of the variable if it has been increasing in the recent past, or a lower realisation if it has been decreasing. If this is the case, then uncertainty will actually be lower than it would be considered to be with no predictable component in the variable's generation process. Therefore, these measures may overstate "true" uncertainty. This leads us to discuss what we can call a not-so-naive approach — which corresponds to the approach followed in Chapter 2 to define our measure of REER uncertainty. Now, the representative agent, whose perception of uncertainty with respect to a particular variable is the object of our interest, is able to identify patterns in the data generation process. In this approach, the key issue has to do with distinguishing between predictable (or systematic) and unpredictable (or unsystematic) components of a series. The variance of the unsystematic portion is a more appealing way of thinking about uncertainty.

The prediction could be viewed as the result of a univariate or multivariate modelling exercise. In the former exercise, we can think of two cases. The first one, in the context of a bounded rationality world in which the representative agent is able to identify simple patterns in the data generation process. One example of this is that of an agent who observes, as already mentioned, some inertia, and predicts X_t to be equal to X_{t-1}. If this agent forms expectations on the value of X with an $AR(1)$ in mind, then we could model uncertainty as the variance of the innovations of the forecast specification of this agent (an $AR(1)$) over the series of interest. This type of approach is quite common in the literature. (See, for instance: Goldberg (1993) —although this author talks about 'volatility' and not 'uncertainty', Ghosal and Loungani (2000), Campa and Goldberg (2005)).

The second case, within the univariate modelling exercise, considers a representative agent, who has gone through an introductory course of Time Series Analysis, understands the autorregressive and moving average components of the series and has a computational package that allows her to identify the process. The appropriate measure of uncertainty here would be again related to the variance of the unpredictable component of the series. In this case, it would be the variance of the innovations on the $ARIMA(p, d, q)$ specification over the series of interest (where 'p' is the order of the autorregressive component, 'd' is the order of integration of the series and 'q' is the order of the moving average component).

The predictable components of a series are not necessarily limited to its past behaviour (i.e.: the forecast model does not necessarily have to be an autoregressive one). There may be other variables that are correlated with the series of interest, X, whose realizations may add information to the forecast of X. Here again, the agents can forecast on the grounds of either simple rules of thumb or models with sophisticated specifications. In any case, the uncertainty proxy will be related to the variance of the innovations of that forecast equation, regardless of its degree of complexity. Examples of this multivariate approach to control for the systematic component of the series can be find in the literature, see, for example, Ramey and Ramey (1995) and Aizenman and Marion (1999).

In any of these two cases mentioned above, the authors calculate rolling sample variances over a number 'k' of periods of time. The assumption is that it is the movement (variance) of the unsystematic component of the series (the residual of the ARIMA specification) over the last 'k' periods that influences perceived uncertainty in period 't'. But the preference of the researchers for the calculation of rolling sample variances suggests heteroscedasticity, that is to say, that the expected value of all error terms, when squared, is not the same at any given point in time (Engle (2001)). Otherwise there would be no point in calculating the variances over different subsamples in order to estimate uncertainty at a given point in time. Instead, the unconditional variance over the whole period would be the best estimate of uncertainty. When the series is heteroscedastic, exploring and modelling the structure of that heteroscedasticity turns into an relevant issue for a number of reasons, but mainly because a) heteroscedasticity affects the efficiency of the OLS estimates of the relevant parameters found for the ARIMA process, and b) understanding the structure may add information on the portion of the volatility of the series that can actually be considered uncertainty (the truly unsystematic component). If there is volatility clustering (Engle (2001)), then, the representative agent expects high variability in the series if it has been already high in the recent past, or low when it has been low. This means that there may be a systematic component in the series of squared residuals themselves. This is why calculating the unconditional variance would overstate actual uncertainty in periods of low volatility (and conversely in periods of high volatility), if the representative agent is sophisticated enough to identify the pattern in the behaviour of the residuals.

The literature has widely used Autorregressive Conditional Heteroscedasticity (ARCH) models and its generalized version (GARCH) — also in this thesis we use this type of approach to construct an alternative measure of REER uncertainty, as it was described in Chapter 2 —, which, to put it simply, model simultaneously the best-fit ARIMA on the levels of the variable and the structure of the heteroscedasticity (by fitting an ARIMA on the squared residuals). The number of lags that are relevant for the estimation of future volatility, and the importance given to these lags, i.e.: the weights, are parameters to be estimated by the data, instead of being imposed by the researcher. The measure of uncertainty consists of the variance of the residuals of this specification — the unsystematic component, which varies along time. Its users claim that it is the conditional variance of a series that gives an accurate measure of uncertainty. As put by Huizinga "This measure seems to best account for the idea that for series whose deviations from the unconditional mean can be reliably predicted, it is not fluctuations around an average value that are of concern (that is, the unconditional variance) but rather fluctuations about a predicted future path" (Huizinga, 1993, p. 528). Then, Serven, for example, emphasizes that "To measure real-exchange rate *uncertainty* (rather than just sample variability)" he uses a GARCH(1,1) specification (Serven, 2003, p. 213). A problem of this measure of uncertainty lies on its computational complexity. It would be difficult to argue that firm managers' perception of uncertainty is constructed by fitting ARIMA processes to REER series and its squared residuals. However, the intuition behind a GARCH(1,1) measure is appealing, as it allows volatility to depend on last period's record but also on the history of volatility. To consider a case of this way of thinking, we could bring the example of Argentina during the 1990s. Volatility of the REER had been significantly lower during the 1990s than it had been during the previous decade.[3] In consequence, during that period, agents perceived lower uncertainty than in the 1980s. Still, when compared with another economy, with a decade of stability, but also with a *history* of stability, uncertainty in Argentina was probably higher. This is because most probably, agents had in mind the turmoils of 1975, 1982, 1986 and 1989, and even a decade of extremely low REER variance would not be enough to fully eliminate those turbulent experiences. A GARCH(1,1) represents the structure of the heteroscedasticity that underlies this way of thinking. Here, uncertainty in 't'' is modeled as a function of volatility in '$t-1'$', but also as a weighted average of past squared residuals, with declining weights that never

[3]See Chapter 2 for the results of the tests.

go completely to zero. From a conceptual point of view, the GARCH(1,1) is appealing, though it implies a significant degree of sophistication in the way agents form expectations. From an estimation point of view, as put by Engle, "it gives parsimonious models that are easy to estimate", and is successful in predicting conditional variances (Engle, 2001, p.159).

3.2.2 Type Two Measures

The relevance of considering measures of uncertainty that make use of data on expectations that does not impose assumptions on the formation mechanism can be illustrated by returning to an Argentinean example. Consider the representative agent standing in Argentina in November 2001. Argentina had had, up to that time and since 1991 a currency board that fixed the nominal exchange rate in a one dollar-one peso relation. That currency board had also successfully helped to bring price inflation down to negligible levels. This means that during most of the nineties, REER volatility had been low (as already pointed out). And therefore, uncertainty for the prediction for REER in December 2001 (one month ahead of the crisis) as suggested by a 'type one' measure discussed above that imposes an autoregressive forecast model, would be quite low. It would be naive to neglect the impact on expectations of a number of events taking place at that moment, *inter alia*: the denial of the International Monetary Fund to renew the credit line with Argentina, the systematic and rapid increase in the fiscal deficit, and the dramatic increase in the risk premium on the Argentinean government debt (a byproduct of the previous two things). It would be reasonable to expect that this representative agent will stop looking at the past behaviour of the exchange rate, and will start widening the range of possible values in her subjective distribution of the exchange rate. A measure of uncertainty will then be given by the range that contains all possible realisations, expected by the representative agent for the exchange rate in December 2001. That uncertainty is affected by events expected to happen in the future, and not necessarily by those that happened in the past. Of course, rational expectations could be assumed for the representative agent. The forecast model imposed would be such that agent's expectations matched the mathematical expectation from the 'true' model that determines exchange rate. It seems, however, that such an approach would give the wrong answers. It is likely that the 'true' model is unknown — to the researcher, and to everybody else. In addition, agents are likely neither to pay attention solely to the past behaviour of the variable to be forecasted, nor to display rational expectations.[4]

The use of direct information on expectations allows for any expectation formation mechanism, not requiring the awkward assumption of a particular type of forecast model being used. An example is that of Guiso and Parigi (1999)'s work. Their paper investigates the effects of uncertainty on the investment decisions of a sample of Italian manufacturing firms. They consider uncertainty with respect to future demand for firms' product and their measure of uncertainty is obtained by using information on the subjective probability distribution of future demand changes. Firms were asked to assign weights to a set of intervals for the growth rate of demand over a given period of time, on the assumption that the relative price of its product was kept constant. Then, the authors derived a measure of idiosyncratic uncertainty related to demand, by using the calculated conditional variance of the expected growth rate of demand, and the initial (known) demand level — the authors find that uncertainty weakens the investment response to demand, and find evidence supporting the hypothesis that the more irreversible the investment decision is, the larger the investment response to uncertainty. These types of measures are very appealing as they are based on actual perceptions of managers, instead of on the researcher's preconceptions. In addition, it allows to have cross-sectional variation in uncertainty, as it is a

[4]This is a conjecture. We will test this assertion in the Chapters that follow. Of course, if the 'true' model was known, agents would then use it.

firm-specific variable. (In the case of Guiso and Parigi (1999), variation comes only from the cross-sectional dimension).

The results support the view that uncertainty weakens the response of investment to demand thus slowing down capital accumulation. Consistent with the predictions of the theory, there is considerable heterogeneity in the effect of uncertainty on investment: it is stronger for firms that cannot easily reverse investment decisions and for those with substantial market power.

Another example is that one of Ferderer (1993) that analyses the impact of macroeconomic uncertainty on aggregate investment in the U.S.. In this case the authors do not use observable data on expectations to construct a measure of risk, but extract it from the term structure of interest rates, which gives a measure of the implicit risk premium on long-term bonds. The author claims there is evidence that the risk premium rises in response to increased uncertainty about interest rates and other macroeconomic variables.[5]

One of the few papers using a type-two measure of uncertainty in the context of exchange rates is Baldwin et al. (2005). The authors extract information on expectations from forward rates — assuming perfect capital mobility — and define it as "the annual average of the weekly growth rate of bilateral forward premium/discount rates in absolute values"(Baldwin et al., 2005, p.25).[6] The authors, who analyze the impact of nominal exchange rate uncertainty on trade, claim that their measure has "the advantage that it reflects the expectations on the exchange rate developments between the period when the contract for exports is concluded and the period when the exports have to be paid"(Baldwin et al., 2005, p.25). With respect to this measure, it could be argued that, as with their type-one measure, Baldwin et al. (2005) consider a world of naive agents.

[5]The author also mentions evidence of "a positive relationship between backward-looking ARCH measures of interest rate uncertainty and the risk premium embedded in the term structure for U.S. Treasury bills" found in previous studies (p. 32).

[6]These authors use two measures, one of type one (described above), and the one described here. It is worth mentioning that in a world in which all agents can trade forward, uncertainty vanishes.

Not all of the forward premium corresponds to uncertainty if agents are rational. Part of it responds to a predictable evolution of the variable of interest. A 'fundamentals-adjusted' forward premium could be more in line with agents' rationality. The naive nature vanishes if the exchange rate could be assumed to follow a random walk, but the authors don't make this explicit.[7]

Finally, Bomberger (1996) investigates how a type one measure of uncertainty compares with a type two measure of uncertainty for inflation. The type one measure used is generated by an ARCH model, while the type two measure, a measure of "disagreement" based on survey data, is calculated as the sample variance across forecasters responding to a specific survey (Livingston). The author finds that the disagreement is proportional to the ARCH measure. The author claims that one of the benefits of the disagreement measures is that, unlike those constructed on the basis of ARCH models, these are model-free, and involve no retrospective procedure. He argues that given the dramatic differences that are commonly found in survey results, it is hard to assume that one single model is used to forecast, as conditional variance measures of uncertainty would assume. Instead, uncertainty regarding the model may explain a large portion of overall uncertainty. (Bomberger, 1996, p.383)

Summary and a Note on the Use of the Term Forward-Looking. The predominance in the literature of uncertainty measures of type one is explained by data constraints. Type two measures seem more appealing as they do not rely on assumptions about the expectation formation process. However, measures with imposed backward-looking (or other) expectation mechanisms use information that is often easily available, whereas primary data on expectations tends to be scarce. Usually these data are obtained from

[7] In page 17 they say that "At all moments, firms take the exchange rate's stochastic process as given. In particular, changes in the process's volatility, including a shift to a common currency, are unanticipated". This doesn't imply a random walk nature of the exchange rate.

derivative markets, e.g.: forward rates for the exchange rate, which have only existed for a relatively limited number of years and countries.

Regarding all measures, a salient pattern in the literature is that the uncertainty associated with the relevant variable, is captured by calculating the (conditional) variance of the forecast error (whatever the forecast model is — assumed, or otherwise). As we have argued in Chapter 1, the validity of this strategy is restricted to cases in which the probability distributions have specific characteristics, or preferences of the decision-maker are quadratic. Both of these restrictions are problematic when considering real exchange rates.[8]

It is worth mentioning that the use of a type-two measure of uncertainty is not equivalent to a forward-looking measure of uncertainty. This will only be the case if agents actually **are** forward-looking to form expectations, internalising expected changes in policy and other environmental factors. This is worth mentioning as it is not uncommon to see the term "forward-looking" associated to these type of uncertainty measures (see for example, Carruth et al. (2000), and Leahy and Whited (1996) commenting on Ferderer (1993)'s measure of uncertainty). This association should not be automatic, as the mechanisms behind the expectation formation are, in general, unknown to the researcher.

[8]Motivated by this, in Chapter 2 we calculated variance, skewness and kurtosis of the forecast error in order to measure REER uncertainty.

3.3 Conclusions

In this chapter we turned our attention to the empirical measurement of uncertainty. The measures found in the literature can be classified into those that impose assumptions on expectation-formation mechanisms, and those that use observable data on expectations. In general, the choice of the measure is driven by data availability, without a clear conceptual justification.

Given that in Chapter 2 we used a backward-looking measure of RER uncertainty, that assumes an autoregressive forecast model for the representative agent, the next two chapters focus on expectations and explore, firstly, expectation formation mechanisms, and secondly, unbiasedness and accuracy of forecasts.

Chapter 4

The Extrapolative Component in Exchange Rate Expectations and the Not-So-Puzzling Performance of the UIP: The Case of Uruguay

4.1 Introduction

The uncovered interest rate parity condition (UIP) implies the domestic currency is expected to depreciate when domestic nominal interest rates exceed foreign interest rates. However, empirical evidence since the seminal work of Fama (1984) has often found the opposite: the currency of the country with the relatively higher interest rate tends to appreciate. This is commonly known in the literature as the 'forward premium puzzle'. This puzzle has triggered significant research on the mechanisms underlying expectations formation, with the seminal contribution of Frankel and Froot (1987).

Two regularities in the extant literature motivate this chapter. First, that most of the tests done on the deviations from the interest parity and on expectations formation mechanisms have been applied to major currencies and developed economies.[1] Second, that most of the tests done on expectations generating mechanisms implicitly assume time stability. An exception in the literature is the work done by Prat and Uctum (2007), who use a switching-regression framework with stochastic choice of regime for a set of European currencies to find that expectation processes change gradually and smoothly over time.

The scant interest in the case of emerging economies, and in the evolution of expectation generating mechanisms is surprising. Exploring determinants of expectations formation and testing for UIP in the context of emerging economies is particularly interesting for these economies which typically display two distinctive features: they evolve from high inflation to low inflation levels, and they undergo changes in exchange rate policies.

Our contribution in this chapter is twofold. First, we test and identify a time-variant exchange rate expectations formation mechanism in the context of Uruguay over the period 1980-2010, and second, we test the UIP across different exchange rate regimes. Uruguay provides an interesting and representative case, since it is a small, open and highly dollarized economy in which agents are familiar with the use of financial instruments denominated in both domestic and foreign currency. During this period it went from high to low inflation levels, as well as different exchange rate regimes: a period of short-lived and non-credible stabilization plans with the exchange rate as a nominal anchor (Pre-TZ), a period of credible target zones for the exchange rate (TZ), and a subsequent period in which the Central Bank had no target for the exchange rate, and this was largely determined by market forces (Post-TZ).

We present new evidence suggesting the extrapolative component in expectations formation mechanisms has been substantial on average, and it has changed over time. By "extrapolative component" we mean the portion of yesterday's depreciation that is expec-

[1] The few exceptions that compare the size of the deviations from the parity for developed and developing countries are Bansal and Dahlquist (2000), and Frankel and Poonawala (2010), while Gilmore and Hayashi (2008) focuses on emerging economies only.

ted to occur today. Furthermore, we find that apart from an extrapolative component, agents display also adaptive and regressive components in expectation formation, and also internalise the potential effects of policy announcements on the path of exchange rates. In addition, we present evidence of deviations from the UIP, although these are relatively small compared to those typically reported in the literature. The size of the deviations from the UIP is larger when looking at sub-periods than when looking at the whole period, which points to the importance of the 'peso problem' in our data. Across sub-periods, the largest deviations are found during the last period of freely floating exchange rates, in which the economy experienced low inflation.

The remainder of the chapter is structured as follows. Section 4.2 describes the links between depreciation expectations and interest rate differentials. Section 4.3 introduces the research questions, and defines a number of key concepts to be used in this chapter. Section 4.4 presents the analysis of the determinants of exchange rate expectations. Section 4.5 explores the tests on the uncovered interest parity. Finally, Section 4.6 concludes.

4.2 Depreciation Expectations and Interest Rate Differentials

To explore the exchange rate expectation generating mechanism one should ideally use forecast data gathered in surveys of participants in the foreign exchange market. Unfortunately, these data are not available for Uruguay for the period under consideration. Inevitably, we have to use an indirect measure of expectations equal to the interest rate differentials obtained from the uncovered interest parity hypothesis.[2]

The hypothesis of uncovered interest parity states that as long as portfolio investors are risk-neutral and have the choice of holding bonds denominated in domestic (pesos) or foreign currency (dollars), with same default risk and no differences in transaction costs, then the following condition is verified:

$$(1 + i^k_{t,dc}) = (1 + i^k_{t,fc}) \times (\frac{s^e_{t+k}}{s_t}) \tag{4.1}$$

where $i^k_{t,dc}$ is the interest on a peso-bond at time t of maturity k-months, i^k_{fc} is the interest on a comparable dollar asset, s is the nominal exchange rate expressed as pesos per dollar, s^e_{t+k} is the expected exchange rate for period $t + k$, t is the time period in months. Then, the expected depreciation rate for the domestic currency will be equal to $(1 + i_{dc})/(1 + i_{fc}) - 1$. If agents are risk-averse, a risk premium is added to the right hand side of equation (4.1). For the same expected return, the holder of the risky asset will require an extra compensation.

During the period of analysis (1980-2010) agents in Uruguay have been allowed to buy or sell assets denominated in foreign currencies without any restrictions. Moreover,

[2] A survey on exchange rate expectations has only been carried out since 2006 by the Central Bank of Uruguay. Also, given the absence of forward markets in Uruguay for most of the period of analysis, we cannot use data on the forward premium.

the banking system faced symmetric regulation for their peso and dollar borrowing. In fact, all banks in the market offered deposits both in pesos and in dollars, which meant that when the agent faced the decision of choosing between the two assets, there were no differences in transaction costs or risk of default. Masoller (1997) argues that the use of interest rate differentials as a proxy for depreciation expectations at the beginning of the 1980s may be problematic due to frictions in the banking system (mainly related to a small number of players). However, we argue that the size of the domestic banking system should not necessarily be taken as suggestive of a lack of competition, since the capital account was fully liberalized in 1978, and restrictions to capital mobility were eliminated. Thus, in the current chapter we use the interest rate differential as an indicator of expected depreciation of the peso against the dollar.

4.3 Some Definitions & Research Questions

Given the aforementioned, in what follows, the chapter uses interest rate differentials for Uruguay over $1980m2 - 2010m3$ and attempts to answer a number of research questions listed below. For the sake of precision, before outlining the research questions, we make explicit the way in which some key terms will be understood in the analysis that follows.

Backward-looking or Extrapolative expectations An agent forming expectations in a "backward-looking" or "extrapolative" manner will be understood, here, as one that uses an autoregressive forecast model for exchange rate depreciations. "Backward-looking expectations" and "extrapolative expectations" will be used interchangeably.[3]

[3]Of course, strictly, the term "backward-looking", when referring to expectations, only suggests that agents look to the past in order to form expectations about the future. But they may look at the evolution of any variable.

Backward-looking or extrapolative component in expectations: This will be understood as the portion of the past depreciation that is extrapolated into the future. That is, the portion of the depreciation that took place in period $t-1$, that agents expect to occur again in period t. "Backward-looking component" and "degree of extrapolation" will be used interchangeably.

Intelligent expectations We will say that agents form "intelligent expectations" when their expectations about the relevant variable (depreciation) are not only shaped by its past behaviour, but by the evolution of relevant indicators that are bound to affect depreciation. This may imply, for instance, the internalization of policy announcement, or the effects of shocks to the exchange rate market.

The research questions to be addressed in this chapter are the following:

(RQ1) To what extent do agents extrapolate past trends when forming expectations about nominal depreciations of the exchange rate?

(RQ2) To what extent agents behave differently in tranquil and crisis periods?

(RQ3) To what extent are they "intelligent" in forming expectations, that is, internalizing policy or environmental changes?

(RQ4) Has the extrapolative component changed over time?

(RQ5) Has the interest rate differential been a good predictor of exchange rate movements?

4.4 Expectation Generating Mechanisms: How much do we extrapolate?

In this section we address Research Questions 1, 2, 3 and 4. We test whether agents have formed expectations by extrapolating past trends in Uruguay over the period 1980-2010, and how the degree of extrapolation changed over time. It is argued that agents in currency markets adopt extrapolative or bandwagon forecasting methods, by simply extrapolating the changes in previous periods into future changes in the same direction. Looking at low-inflation, developed economies, the existing literature finds evidence on extrapolative expectations for short horizons only (up to 1 month), while there is a twist in the mechanism when looking at longer horizons, and agents seem to expect a reversion of the previous exchange rate movement (see, for example, Frankel and Froot (1987), MacDonald and Torrance (1988), Cavaglia et al. (1993) and Chinn and Frankel (1994)).

The focus on Uruguay offers an interesting and representative case study of an emerging economy. During the period of analysis the Uruguayan economy experienced periods of high and low inflation. Consumer Price Inflation reached a maximum of 110% in 1990, then decreased to single digits after 1998. In addition, the economy had different exchange rate regimes. From 1980 until 1992 (Pre-TZ), a number of short-lived regimes were in place. In March 1991, the Central Bank introduced a price stabilization plan with the exchange rate as a nominal anchor. The most visible element of this plan was a target zone (TZ) for the nominal exchange rate à la Krugman (1991). It was not until June 1992 that the amplitude and the slope of the TZ was publicly announced. The regime was abandoned in June 2002, in the middle of a deep recession, a banking crisis and after the drastic depreciations in Brazil (1999) and Argentina (2002). In our analysis, we define the TZ regime as starting in 1993 to allow six months of 'learning' after the public announcement of the width and slope of the bands within which the Central Bank was targeting the exchange rate to fluctuate.[4] A third regime (Post-TZ) started after the abandonment of the target zones in 2002. Since 2003, the Central Bank has not had any explicit target for the exchange rate. It would be wrong, however, to define this regime as a freely floating one, since it is possible to identify Central Bank interventions during this period. However, these have not been systematic, and it was argued by the authorities that their rationale was to decrease the volatility, rather than to affect the level of the exchange rate. These changes in the economic environment are likely to have impacted the way agents formed expectations.

To assist clarity, Figure 4.1 displays a timeline in which the three sub-periods are located as well as the major external events and different policy announcements that may have affected expectations. Figure 4.2 plots the time pattern of depreciation and interest rate differentials, as a proxy for expected depreciation, and shows the depreciation threshold that will be used for the definition of 'tranquil' periods and 'turbulent' periods. Turbulent periods will be considered to be those immediately after a 'jump' in the exchange rate has happened. This presents *prima facie* evidence of some degree of an extrapolative component in expectations, as these seem to lag depreciation.

Firstly, we test the contribution of an extrapolative component in expectations as well as the importance of a number of exogenous environmental variables. For these purposes, we estimate a modified version of Frankel and Froot (1987), in which investors' expected depreciation rate for the following six months is a function of the depreciation over the last six months, of extreme movements in the exchange rate, and of policy and other changes

[4]The TZ regime has been considered as credible during most of its duration. The credibility of the TZ regime at an early stage has been argued first by Bergara and Licandro (1994), and later by Polgar (2002). Masoller (1997) compares the credibility of a stabilization plan in the early 1980s with the TZ regime and concludes that the latter was substantially more credible than the former.

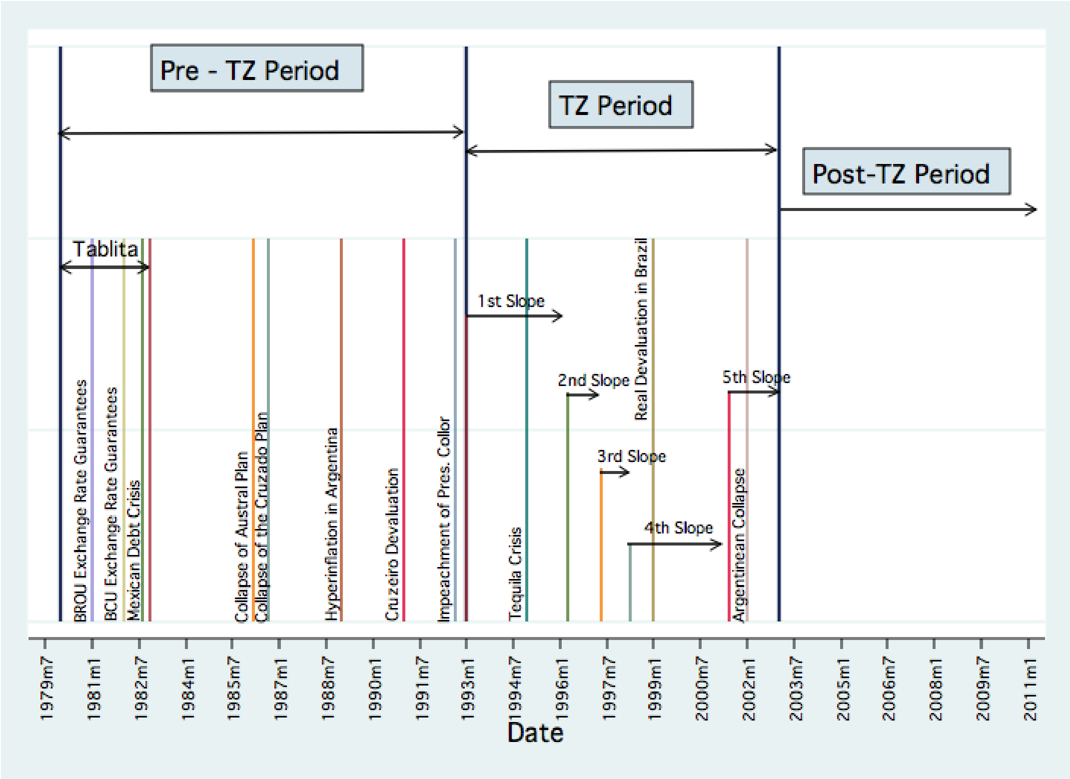

Figure 4.1: Regimes and Major External Events hitting the Uruguayan Economy

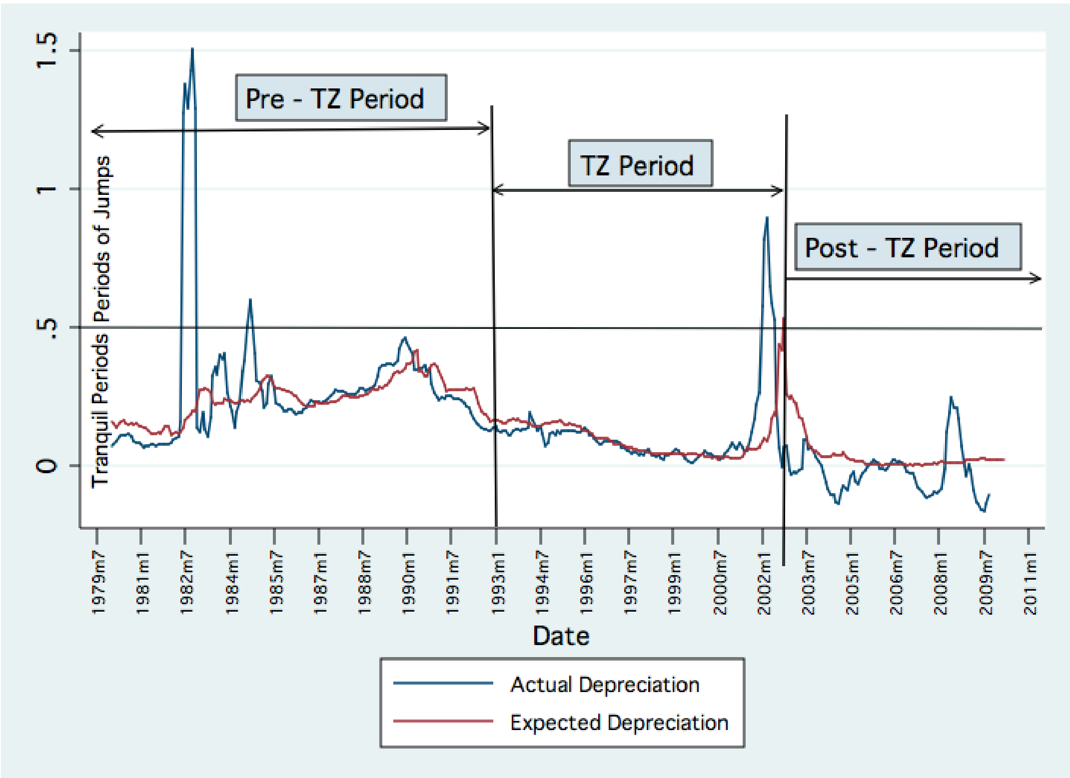

Figure 4.2: Actual and Expected Exchange Rate Depreciation

in the economic environment as in equation (4.2).

$$\Delta s^e_{t+6} = \beta_0 + \beta_1 \Delta s_t + \beta_2 Jump_t + \beta_3 Jump_t * \Delta s_t + \mathbf{X_t'} \beta_\mathbf{4} + \epsilon_{t+6} \tag{4.2}$$

where:

$$Jump_t = \begin{cases} 0 & \text{if } \Delta s_t \leq 50\%, \\ 1 & \text{if } \Delta s_t > 50\%. \end{cases} \tag{4.3}$$

Δs^e_{t+6} is what agents expect at time t the exchange to depreciate in the following six months and Δs_t is the observed depreciation at time t over the past six months.[5] 'Jump' is included to allow for extreme events to have a direct effect on expectations (through β_2). The interaction of 'Jump' and Δs is included to allow for a differential effect of Δs on expectations after an extreme event has taken place (through β_3).[6] **X** is a matrix of variables capturing events affecting the economic environment, including government announcements and international and domestic events that may have an impact on depreciation expectations: a trend during the period of the 'Tablita' stabilization plan (which collapsed in December 1982) to allow for agents internalizing the devaluation announcements during that period ('Trend Tablita'), level-dummies controlling for the effects of the sales of foreign exchange guarantees by the "Banco de la Republica" (BROU, $1981m1 - 1981m10$) and those sold by the Central Bank (BCU, $1982m1 - 1982m3$), the collapse of the Argentinean 'Tablita' stabilization plan ('Tablita Argentina', $1982m11 - 1983m6$), the collapse of the Argentinean 'Austral' plan ('Austral Collapse', $1986m3 - 1986m6$), the collapse of the Brazilian Cruzado plan ('Cruzado Collapse', $1986m9 - 1987m1$), the hyperinfla-

[5] We use depreciation and devaluation interchangeably.

[6] During the period, there have been 15 episodes of depreciations of at least 50% in a 6-month period. The 'extreme' event was arbitrarily defined as a depreciation above 50% in a 6-month period. The threshold was chosen by identifying the atypical episodes in a graph plotting depreciation over time (see Figure 4.2). For sensitivity purposes, different thresholds were chosen and the results were robust to this choice. A alternative method used to capture possible differential effects of Δs_t on Δs^e_{t+6}, for different levels of Δs_t was a linear spline of Δs_t. The results were very similar to those reported here, but the goodness of fit indicators favoured the model specified in equation (4.2).

tion and banking crisis in Argentina ('Hyper', $1989m1 - 1989m12$), the different announced slopes of the target zones ('$i - th$ Slope'), the depreciation of the Brazilian Real (Real, $1999m1 - 2002m6$), the collapse of the Argentinean currency board (Argentina, $2002m1 - 2002m6$); impulse dummies controlling for the effects of the Mexican debt crisis ('Mexican Debt Crisis', $1982m8$), the depreciation of the Brazilian Cruzeiro ('Cruzeiro Depreciation', $1991m1$), the Brazilian institutional crisis due to the impeachment of President Collor (Collor, $1992m9$), the Tequila crisis in Mexico (Tequila, $1994m12$), and the rate of change of the foreign exchange reserves of the Central Bank.

Secondly, we explore whether a mixed expectation model fits the data better, by incorporating variables that would capture adaptive and regressive mechanisms. The rationale for testing a mixed model from an economic point of view, is that forecasters may use several models, or there are heterogeneity of forecasters, with different models. Given that we use a proxy for average expectations, we cannot identify which explanation drives a finding for a mixed model as the two hypotheses are observationally equivalent.[7]

To test for a mixed model, we then estimate equation (4.4):

$$\begin{aligned}\Delta s^e_{t+6} \quad = \quad & \beta_0 + \beta_1 \Delta s_t + \beta_2 Jump_t + \beta_3 Jump_t * \Delta s_t + \beta_4 ForeError_t + \beta_5 (s^*_t - s_t)/s_t + \\ & \beta_6 \Delta CPI_t + \mathbf{X_t'} \beta_\mathbf{4} + \epsilon_{t+6} \end{aligned} \quad (4.4)$$

where:

(1) $ForeError_t$ is the lagged forecast error, given by $(s^e_t - s_t)/s_t$. This would allow for an "adaptive" component in expectations. Here, expectations about the future spot rate, s^e_{t+1}, are formed by placing a weight $(1 - \beta_4)$ on the current spot rate, and (β_4)

[7]Most of the literature tends to estimate different models separately. An exception is Prat and Uctum (1996), who find evidence supporting a mixed model, using average expectation data. Another is the work of Benassy-Quere et al. (2003). These authors exploit a panel with disaggregate expectations data and find evidence supporting the hypothesis that forecasters are heterogeneous in the models they use.

on the past expected spot (s^e_t). [8] β_4 is usually hypothesized to be between 0 and 1 for expectations to be inelastic. We will refer to this added variable as reflecting the "adaptive" component in expectations.

(2) $(s^*_t - s_t)/s_t$ is a measure of exchange rate disequilibrium. If agents perceive that the exchange rate will eventually adjust to ensure a stable real exchange rate, their depreciation expectations will be influenced by how far that s^*_t that would ensure that real exchange rate stability is from the spot rate s_t. Operationally, we defined that "equilibrium" nominal exchange rate s^*, as s such that $RER = R\bar{E}R$.[9] β_5 is the speed at which the spot rate is expected to regress to the "equilibrium" value, and is hypothesized to be positive. In that case, agents adjust depreciation expectations upwards when the nominal exchange rate is below the perceived equilibrium value, s^* (and vice versa).[10] We will refer to this added variable as reflecting the "regressive" component on expectations. This notion of "equilibrium" is consistent with purchasing power parity (PPP) in its absolute version. However, deviations from absolute PPP are observed to have been large. For this reason, and given that here we are considering a long period of about 30 years, in principle it would have been possible to treat the equilibrium real exchange rate for Uruguay as a trend, on Balassa-Samuelson grounds. With hindsight, however, over the period the evidence in the data for such a trend is weak. It seems reasonable to neglect the possibility of agents anticipating such a trend.[11]

(3) ΔCPI_t is CPI inflation over the last six months, pre-determined at period t. Agents

[8] It is possible to see that rearranging, $\Delta s^e = \beta_4 ForeError_t$.

[9] $R\bar{E}R$, the average real exchange rate is calculated over the whole period of analysis, 1980-2010.

[10] This follows the logic of Dornbusch (1976) in which variables such as good prices converge to their long-run values over time. Frankel and Froot (1987) use a similar measure of disequilibrium to test for regressive expectations.

[11] The best-fit trend that emerges from regressing the real exchange rate on a time trend is inconsistent with the prediction of Balassa-Samuelson, and rather small. The estimated trend implies an annual rate of growth of -0.4%.

may form expectations about real exchange rates, but not be sophisticated enough to respond to the disequilibrium as calculated above. If they face computational costs, they may just look at past inflation and expect that its effects on the RER are partially neutralized by a nominal depreciation. $\beta_6 > 0$ would suggest that agents revise expectations upwards after an increase in inflation.

Thirdly, given our interest in understanding if the expectation generating mechanism changed over time, we run separate models for each of the three sub-periods mentioned, and examine how heterogeneous coefficients are across periods. Given that there are a number of extreme exchange rate movements, and that these may affect the estimates, we have chosen the beginning and end dates of the three sub-periods such that the extreme episodes are excluded. This means that when we estimate (4.4) for the period Pre-TZ, we exclude the turbulent first two years. For TZ, we consider the period 1993m1-2002m5, excluding the collapse of the TZ regime, while for Post TZ we estimate over the period $2003m1 - 2010m3$, thus excluding the turbulent second half of 2002.

Data are obtained from the Central Bank of Uruguay. The series used are 7536 for peso deposits and 7538 for dollar deposits. Exchange rate data correspond to the monthly average of bid prices. Data on foreign exchange reserves is obtained from the IMF IFS database. Some descriptive statistics are presented in Table D.1 in the Appendix.

4.4.1 A Note on the Methodology

Here we discuss the methodological problems arising in the estimation of equation (4.2), along with the strategy pursued in this chapter in an attempt to overcome them.

4.4.1.1 Overlapping Observations: Serially Correlated Errors

Because the forecast horizon corresponding to the interest rate differential is longer than the observational frequency (monthly), a problem of overlapping observations arises, which implies that the forecast error ϵ_{t+k} follows a non-invertible moving average process of order $k-1$.[12]

This can be showed as follows. Imagine a non-overlapping model, in which, say the interest differentials, denoted below as Δs_t^e are those for one-month time deposits, so they capture the expected depreciation over one month only. We specify the following model:

$$\Delta s_t^e = \alpha + \beta \Delta s_{t-k} + u_t \tag{4.5}$$

where u_t is assumed to be serially uncorrelated, homoscedastic, $E(u_t) = 0$, $V(u_t) = \sigma^2$.

Now, if we look at interest rate differentials of k-month time deposits, then the differential will contain the sum of the depreciation expectations for each of the k periods. Denoting the sums in capital letters, then aggregating we have:

$$\begin{aligned} \Delta S_t^e &= \sum_{j=t}^{t+k-1} \Delta s_j^e \\ \Delta S_t &= \sum_{j=t}^{t+k-1} \Delta S_j \\ e_t &= \sum_{j=t}^{t+k-1} u_j \end{aligned} \tag{4.6}$$

Which means that, even if the u's are independent and identically distributed, the e's will not be, displaying instead a moving average component of order $k-1$:

$$\begin{aligned} E[e_t] &= E[\sum_{j=0}^{k-1} u_{t+j}] = \sum_{j=0}^{k-1} E[u_{t+j}] = 0 \\ V[e_t] &= k\sigma_u^2 \\ Cov[e_t, e_{t+s}] &= (k-s)\sigma_u^2, \forall k-s > 0 \end{aligned} \tag{4.7}$$

[12]This was first shown by Hansen and Hodrick (1980).

While OLS estimates of the parameters remain consistent with serial correlation, the standard errors are biased downwards. The standard approach in the literature is to use a version of GMM introduced by Hansen (1982) to correct the standard errors. The GMM estimator of the variance-covariance matrix of the OLS estimates of the regression coefficients is:

$$\hat{\Sigma} = (X'X)^{-1}X'\hat{\Omega}X(X'X)^{-1} \tag{4.8}$$

where $\hat{\Omega}$ is the variance-covariance matrix of the residuals. The element ijth of that matrix is given by:

$$\hat{\lambda}(i,j) = \begin{cases} \hat{u}_i\hat{u}_j & \text{if } |i-j| \leq (k-1), \\ 0 & \text{if} |i-j| > (k-1). \end{cases} \tag{4.9}$$

where $\hat{\lambda}$ is the estimated autocovariance. It has been shown that the estimates of $\hat{\Omega}$ need not be positive definite when samples are small. A solution to this problem has been suggested by Newey and West (1987), and it has been usually adopted in the literature. This solution consists in weighting $\hat{\lambda_{i,j}}$ in equation(4.9) as follows:

$$\hat{\lambda}(i,j) = \begin{cases} \hat{u}_i\hat{u}_j\omega_{i,j} & \text{if } |i-j| \leq (k-1), \\ 0 & \text{if} |i-j| > (k-1). \end{cases} \tag{4.10}$$

where the choice of $\omega_{i,j}$ is given by:

$$\omega_{i,j} = 1 - [|i-j|/(m+1)] \tag{4.11}$$

where m is chosen so that positive definiteness is ensured. Here we follow the authors' suggestion, and set $m = k = 6$.

4.4.1.2 Autoregressive Conditional Heteroscedasticity

An additional problem associated to the error term arises if disturbances are conditionally heteroscedastic. This has been frequently found in monthly financial data (and it is almost a regularity in higher frequency data). For example, if large and small errors occur in clusters, then the recent past may provide useful information about the conditional variance of the errors. While OLS are still unbiased in the presence of conditionally heteroscedastic errors, efficiency gains are possible by explicitly modeling the pattern of that heteroscedasticity. Following Engle (1982) and taking our estimable equation (4.2), that would imply estimating simultaneously a mean and a variance equation, in which the latter has a constant, as well as an autoregressive component as specified below:

$$\begin{aligned} \Delta s_t^e &= \beta_0 + \beta_1 \Delta s_t + \beta_2 Jump_t + \beta_3 Jump_t * \Delta s_t + \mathbf{X_t}' \beta_{\mathbf{4}} + \epsilon_t \\ \sigma_t^2 &= \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + ... + \alpha_q \epsilon_{t-q}^2 \end{aligned} \tag{4.12}$$

The variance equation specified as above implies that recent disturbances influence the variance of the current error. In equation (4.12), the pattern is described as an Autoregressive Conditional Heteroscedasticity (ARCH) process of order p, where p is the number of lags that affect the current variance of the error. The parameters in this model are estimated using Maximum Likelihood techniques (ML).

In order to test whether ARCH effects are present, we use a Lagrange Multiplier test (ARCH LM) that consists in estimating equation (4.2) using OLS, extract the estimated errors, and regress their squared values on lags as below:

$$\hat{e}_t^2 = \hat{\alpha_0} + \hat{\alpha_1} \hat{e}_{t-1}^2 + ... + \hat{\alpha_p} \hat{e}_{t-p}^2 + \nu_t \tag{4.13}$$

and then test the joint significance of $\hat{\alpha_1} ... \hat{\alpha_p}$. We tested for ARCH effects in all the models estimated in this chapter, and given that these suggest unambiguously the presence of conditionally heteroscedastic disturbances (ARCH effects), we used ARCH models.[13]

Unfortunately, the Newey-West procedure does not allow for ARCH effects. Our ad-hoc strategy is to use ARCH models to estimate an augmented version of equation (4.2) in which lags of the first differences of the dependent and independent variables are included up to an order of $k-1$, in an attempt to control for the moving average process.[14]

4.4.1.3 Non-Stationarity & Co-integration

Another consideration involves the time-series properties of the variables under consideration. We performed augmented Dickey-Fuller (ADF) tests of unit roots in both actual depreciation rates and interest rate differentials, and results were mixed, depending on the lag length, and on the periods considered (sample size).[15] The inconclusiveness of these unit root tests is not surprising, as it has been widely acknowledged that they have low power in small samples. For these reasons, and in order to exclude the possibility of interpreting results from spurious regressions, we test for cointegration by checking whether residuals from the estimated long-run relationship contain unit roots. Because in the presence of non-stationary regressors, the usual t statistics have non-standard distributions, we use tabulated critical values to perform the cointegration tests. These are reported after each estimation result.

Although the estimator from the long-run relationship is *superconsistent* (it converges to its true value at a faster rate — T — than it would be the case if the series were stationary), this asymptotic characteristic may be of little use when working with finite samples. Banerjee et al. (1993) show that large finite-sample biases can arise in static

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[13] The results from the ARCH LM tests are reported after each estimation result.

[14] This idea was kindly suggested by Professor Ron Smith. For verification purposes, we estimated the same models using the Newey-West procedure and found that the results are largely unchanged: while standard errors increase, the main coefficients of interest remain highly significant. Newey-West estimation results for the key coefficients are reported in the Appendix.

[15] These are reported in Table D.2 in the Appendix.

OLS estimates of co-integrating parameters. A possible method of reducing finite-sample biases, is estimating a single-equation dynamic regression, in the form of an Autoregressive Distributed Lag model (ADL). For purposes of comparison, we run an ADL in which the lag structure to be modeled is chosen using a set of information criteria indicators (Akaike (AIC), and Bayesian (BIC)), compute the implied long-run relation and compare it with that obtained when estimating the static relationship.

The mean equation of the ADL to be estimated can be expressed as in (4.14):

$$A(L)\Delta s_t^e \quad = \quad \beta_0 + B(L)\Delta s_t + \beta_2 Jump_t + \beta_3 Jump_t * \Delta s_t + \mathbf{X_t'}\beta_\mathbf{4} + \epsilon_t \qquad (4.14)$$

where A(L) and B(L) are lag polynomials, whose order is determined by the information criteria mentioned above (both the AIC and BIC suggest 6 lags for the dependent variable and 2 lags for the explanatory variable). The implied long-run relation is given by:

$$\overline{\Delta s_t^e} \quad = \quad \frac{\beta_0}{A(1)} + \frac{B(1)}{A(1)}\overline{\Delta s_t} + \frac{\beta_2}{A(1)}\overline{Jump_t} + \frac{\beta_3}{A(1)}\overline{Jump_t * \Delta s_t} + \overline{\mathbf{X_t'}}\beta_\mathbf{4}[A(1)]^{-1} \qquad (4.15)$$

where replacing L by 1 in the lag polynomial gives the sum of the coefficients in the polynomial. The cointegration test in the context of an ADL model consists of testing whether A(1) and B(1) are zero. This is performed and reported in the section that follows.[16]

4.4.2 Results

Results from estimating equation (4.2) over the whole period are reported in Column (1) of Table (4.1). Consider tranquil times first, when the Jump variable and the interaction term take a zero value. Our results suggest that agents extrapolate about 70% of the past

[16] See Chapter 8 in Johnston and DiNardo (1997) for a discussion on ADL models.

Table 4.1: Expectation Generating Mechanism Regressions

Dep.Var: $i - i^{*}$	(1) Extrap		(2) Mixed		(3) ADL Extrap	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Lagged Dep	0.705***	(0.003)	0.439***	(0.018)	0.017**	(0.007)
Lagged Jump	0.122***	(0.047)	0.204***	(0.024)	0.063***	(0.013)
Inter Lagged Jump*Dep	-0.483***	(0.047)	-0.484***	(0.039)	-0.039**	(0.016)
Lagged Δ CPI			0.317***	(0.016)		
L. Fore Error			0.125***	(0.026)		
L. Diseq E			-0.057***	(0.008)		
Trend Tablita	0.001***	(0.000)	0.001***	(0.000)	0.001***	(0.000)
Slope TZ to come	-0.005	(0.004)	-0.002	(0.003)	-0.002*	(0.001)
Mexican Debt Crisis	-0.000	(0.029)	0.007	(0.036)	-0.003	(54552.198)
Tablita Argentina	-0.069***	(0.012)	0.132***	(0.025)	-0.012**	(0.006)
Austral Collapse	0.017*	(0.010)	0.017***	(0.003)	-0.005**	(0.002)
Cruzado Collapse	0.024***	(0.002)	-0.004	(0.004)	0.006***	(0.002)
Cruzeiro Depreciation	0.021	(0.881)	0.000	(0.039)	-0.001	(0.036)
Forward Contracts BROU	-0.003	(0.004)	0.017***	(0.005)	-0.008**	(0.003)
Forward Contracts BCU	-0.018***	(0.006)	-0.024***	(0.009)	-0.025***	(0.006)
Hyper in Argentina	0.021***	(0.001)	0.011***	(0.002)	0.010***	(0.001)
Collor	0.004	(46399.193)	0.024	(179326.571)	0.008	(15330.109)
1st SlopeTZ	0.005***	(0.001)	0.002	(0.002)	0.003***	(0.001)
2nd SlopeTZ	-0.045***	(0.002)	-0.004	(0.003)	-0.003*	(0.002)
3rd SlopeTZ	-0.055***	(0.002)	-0.011***	(0.003)	-0.001	(0.001)
4th SlopeTZ	-0.049***	(0.002)	-0.004	(0.002)	-0.000	(0.001)
Tequila	-0.008	(0.060)	0.025	(344.482)	0.006	(0.006)
Real	-0.006***	(0.002)	0.001	(0.003)	0.000	(0.001)
Argentina	-0.003	(0.019)	0.026***	(0.005)	0.008***	(0.002)
Var in Forex Reserves	0.008**	(0.004)	-0.026***	(0.007)	-0.009***	(0.003)
Lagged L.Dep.					0.004	(0.007)
L2.L. Dep					-0.008	(0.007)
L.Expected Depreciation					1.035***	(0.069)
L2.Expected Depreciation					-0.037	(0.098)
L3.Expected Depreciation					-0.015	(0.099)
L4.Expected Depreciation					-0.026	(0.079)
L5.Expected Depreciation					-0.025	(0.073)
L6.Expected Depreciation					0.041	(0.038)
Constant	0.065***	(0.001)	0.030***	(0.002)	0.001	(0.001)
ARCH						
Arch	2.061***	(0.218)	1.199***	(0.162)	0.806***	(0.130)
Garch			0.188***	(0.048)	0.447***	(0.060)
Constant	0.000**	(0.000)	0.000**	(0.000)	0.000*	(0.000)
Observations	351		345		351	
AIC	-1586.258		-1744.099		-2387.480	
BIC	-1451.131		-1594.200		-2240.770	
ADF on Res	-6.352		-7.007		-12.977	
ARCH LM	128.084		103.344		70.835	

Standard errors in parentheses. CV for ADF on Res with 2 non-stationary vars. 3.78 at 1%, 3.25, at 5%, 2.98 at 10%
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

exchange rate movement into the future, on average, and *ceteris paribus*. This coefficient is very well determined and suggests a strong extrapolative component in the expectation formation mechanism.

The behaviour is subtler in 'turbulent' times, after agents observe a jump in the exchange rate. The estimated effect of lagged depreciation on expectations should now be calculated as: $\hat{\beta}_1 + \hat{\beta}_3 * Jump_t = 0.222$.[17] After jumps, agents do not extrapolate the whole of the past exchange rate movement, but only a smaller portion. This portion is still sizable, and statistically significant, as we reject the hypothesis of $\beta_1 = -\beta_3$ with 95% confidence. In addition, after jumps, agents revise their depreciation expectations upwards, on average, by about 13%, *ceteris paribus.* The extrapolative component is less pronounced after crisis periods than after tranquil periods, although it is still present. In fact, it explains why agents under-predict large depreciations, but once these have happened, they tend to over-predict them. To visualize this, look at Figure 4.2. In Table D.1 (in the Appendix) it is possible to appreciate that the sample average of expected depreciation during jumps is 12.7% while the actual equals 92.3%. Instead after the jump has happened, expected depreciation is on average, 30.8%, while the actual is 13.2%.

While our results support the hypothesis of a strong extrapolative component in expectation formation, they also suggest that agents are aware of changes in the economic environment, and internalize their effects on depreciation expectations. The collapses of Argentinean (Austral) and Brazilian (Cruzado) currency stabilization plans induced increases in depreciation expectations in Uruguay by 1.7% and 2.4% respectively while the hyperinflation episode in Argentina induced an increase in depreciation expectations in Uruguay by 2.1%, on average and *ceteris paribus.* The hypothesis of agents internalizing the announcements on the slopes of the TZ is upheld by the data, as the coefficients are jointly significant. The hypothesis of $\beta_{Slopei} = \beta_{Slopej}$, $i, j \in$(1, 4) and $i \neq j$, is rejected for the pairs (1, 2), (1, 3), (1, 4) and (2, 3) with 95% confidence. It is worth noting that the changes in the magnitude of the point estimates reflect the direction of the announced changes in depreciation rates. The sales of cheap forward contracts by the Central Bank exerted a negative and statistically significant effect on expectations, reducing them by

[17] A 95% confidence interval for this effect is given by (0.431, 0.013).

1.8%. On the other hand, the estimated coefficients on Mexican Debt Crisis, the sales of cheap forward contracts by the BROU, the sharp depreciation of the Cruzeiro, the institutional crisis in Brazil in 1991, the Tequila crisis, and more surprisingly, the Argentinean crisis of 2001 are not well-determined.[18]

In Column (3) of Table (4.1) we report the results of estimating an ADL model, as described in equation (4.14). The ADL model was estimated in an attempt to understand whether the results are affected by explicitly modeling the dynamics. The implied long-run relation between lagged depreciation and expectations can be obtained by calculating $B(1)/A(1)$, which yields $0.014/0.027 = 0.52$ — which is in line with the one obtained from the static model (reported in Column 1). We test for $A(1)$ and $B(1) = 0$, and reject the null hypothesis at 1% significance, which gives further evidence of cointegration.[19]

Column (2) of Table (4.1) reports the results of estimating equation (4.4), in which adaptive and regressive expectation formation mechanisms are also allowed. The effect of lagged depreciation on expectations during tranquil times is now reduced by about 35%. After jumps, while the effect of lagged depreciation is not statistically significantly different from zero, agents seem to revise their depreciation expectations upwards, on average, by about 23%, *ceteris paribus*. When looking at the coefficients on the environmental variables, now the collapse of the Argentinean Tablita in 1982, the collapse of the Argentinean currency board in 2001, and the changes in foreign exchange reserves carry the expected signs and are statistically significant (positive, positive and negative respectively).

The sign on the estimated coefficient on the adaptive component is positive, implying that the weight placed on the previous prediction is positive, although much lower than

[18] The coefficients for the depreciation trend during the Tablita stabilization plan, the one on the collapse of the Argentinean 'Tablita', the one on the Real Devaluation, and the one on the rate of change of foreign exchange reserves are well determined but do not yield the expected sign.

[19] The test of $A(1) = 0$ is equivalent to testing the sum of the lagged coefficients on the dependent variable being equal to unity. The prob-value for this test is 0.000. The prob-value for the test $B(1) = 0$ is 0.000. We do not report the transformations for all of the covariates, for the sake of brevity of exposition.

that placed on the current spot rate ($\hat{\beta}_4 = 0.125$). The negative sign of the estimated coefficient on the regressive component is puzzling as it implies that agents actually expect the exchange rate to diverge away from the "equilibrium" value. One could argue that the choice of a 'wrong equilibrium' value may determine this finding, although the strong statistical significance of the (negative) coefficient is discomforting. An alternative explanation is related to the finiteness of the sample size. Agents may expect a convergence to an equilibrium value in the long run, but may have reasons to expect a divergence over shorter time periods. The estimated coefficient on past CPI inflation suggests that agents revise expectations upwards by slightly less than a third of what they observed inflation to be in the previous period, on average and *ceteris paribus*.

The diagnostic tests on these estimated models suggest, firstly, that the mixed model performs better than the extrapolative model, using the AIC and BIC information criteria. Secondly, that the stationarity of the estimated residuals cannot be rejected, which provides evidence of cointegration between the interest rate differentials and the depreciation rates. Thirdly, that there is strong evidence of GARCH effects in the errors. For this reason, the reported estimates were constructed on the basis of GARCH models. Given that GARCH models do not allow for a treatment of the non-invertible moving average process present in the errors due to the overlapping nature of the observations, we re-estimated the models using GMM, with the Newey-West adjustment, as described in Section 4.4.1, and report the results in Table D.3 in Appendix D. Those results are in line with these reported here. [20]

It could be argued that because we rely on the interest rate differential as a measure of depreciation expectations, the observed increase in the interest differential after extreme

[20] The size of the coefficients on the ARCH and GARCH terms suggests non-stationarity in the variance, as they add to more than one. This suggests that the system is not stable in the way it absorbs shocks to volatility, which is problematic. We have tried different lag structures in the variance equation, as well as estimated the model using different distributional assumptions for the error term (normal, gaussian and t), but the high coefficients persisted.

exchange rate movements is not fully explained by changes in depreciation expectations, but also by an increase in the risk-premium required by the holders of the peso asset. But even if it is a combination of expected depreciation and risk that is revised upwards after a drastic depreciation, that behaviour would still be indicative of a backward-looking, extrapolative component in the expectation formation mechanism about the variance and about the mean of the exchange rate.

Our findings of extrapolative expectations over long horizons may be related to a perception of uncertainty with respect to the exchange rate exhibited during much of the 1980s and early 1990s. It has been pointed out by DeGrauwe (1990) that when the environment is uncertain, rules based on an autoregressive model become important. This is, probably, because that is all the forecaster has available. One relevant question is how stable the extent to which agents extrapolate has been over the period considered. This is a relevant question, given that over the period considered, different regimes have been in place and constitutes the focus of attention of next section.

4.4.3 A time-varying extrapolating factor

In this subsection we address RQ4. Firstly, we explore whether the extent to which agents extrapolate changed across the three different periods considered in this chapter: Pre-TZ, TZ and Post-TZ. Secondly, and motivated by the heterogeneity we find in the extrapolative component estimated when looking at the sub periods separately, our contribution consists of identifying a time-pattern in the degree of extrapolation in expectation formation mechanisms.

To proceed, we estimate equation (4.4) for the periods Pre-TZ, TZ and Post-TZ separately. Results are reported in Columns 1-3 of Table 4.2. A number of conclusions can be reached by looking at these results.

First, both the Akaike Information Criterium (AIC) and the Bayesian Information

Criterium (BIC) indicate that estimating the model separately for these three sub-periods fits the data better than pooling.

Second, the estimated effect of the extrapolative component in the expectation formation mechanism is always well determined, and it decreases as we move from the Pre-TZ period to the TZ.

Third, the economic environment variables take the expected sign and are of reasonable magnitudes in most cases, although they tend to be less well-determined, probably due to a smaller sample size used to estimate the models separately for each period. The coefficient on the change in foreign exchange reserves changes sign from the Pre-TZ to the Post-TZ period. This may be related to the fact that during the Pre-TZ, Central Bank intervention in the foreign exchange market was relatively common (not only through actual foreign exchange transactions, but also through announcements). Reductions in reserves could have been perceived as an alert that the Central Bank's ability to prevent the currency from depreciating was affected, hence the negative estimate. Instead, the Post-TZ period in which intervention is much less frequent, unsystematic, and the policymakers' concerns are related to the appreciation of the domestic currency, and not the converse, increases in the stock of foreign exchange reserves could be perceived as a signal that the Central Bank is committed to prevent the the currency from appreciating any further.[21] The puzzling result is related to the coefficient on the Real devaluation, which is statistically insignificant. This variable may be capturing the fact that soon after the devaluation of the Real, the Central Bank (BCU) reduced the amplitude of the TZ in an attempt to show commitment to the regime. This could have convinced agents that the BCU was

[21] For example, on the 10th June 2010, the Ministry of Finance announced that they were going to start intervening in the foreign exchange market to counteract forces towards an appreciation of the currency. The announcement was followed by a the largest daily increase in the exchange rate that had happened in the year. The additions to the stock of foreign reserves of the Central Bank could be seen as a factor that enhances the credibility of the announcement, inducing expectations of further depreciation. This episode is out of our sample, but it is helpful to illustrate our point.

serious about its commitment to the exchange rate regime, which explains the negative coefficient.

When investigating the sign and size of the estimated coefficients on the regressive component of the model, an interesting pattern emerges. While the estimated coefficient is negative for the TZ period, it is positive for the Post-TZ period. It is reasonable to think that only if exchange rates are allowed to some extent to float, one could expect that it converges towards an equilibrium value. If the exchange rate is instead manipulated with other objectives, agents may reasonably expect it to diverge from that equilibrium value. Our results are in line with this interpretation, as the estimated coefficient for the regressive component over the Post-TZ period — when the nominal exchange rate was allowed to float relatively freely — is positive and significant, suggesting that agents expect about 6.5% of the disequilibrium to be corrected per period, on average and *ceteris paribus*.

The estimated coefficient on the adaptive component is not well-determined for the Pre-TZ and Post-TZ periods, although it is statistically significant and negative during the TZ period.

In terms of the diagnostics, the ADF tests on residuals suggest no unit roots are present — although for Pre-TZ the rejection is only at the margin. The tests on ARCH effects on the residuals now suggest no ARCH effects for the periods TZ and Post-TZ. This is reasonable. Over shorter periods, it is more likely that the assumption of a constant variance is upheld by the data. Particularly, given that episode of substantial volatility (the collapse of the target zone regime in 2002) is left out of the sample, for the reasons argued in Section 4.4. We still report the estimates from ARCH models, and replicate the analysis using GMM, reporting the results in Appendix D.[22]

[22]Here again, the estimated coefficients on the ARCH processes in the variance equation are larger than one.

The results reported above suggest that imposing a constant effect of past depreciation on expected depreciation as in equation (4.4) is restrictive. For this case study analysed here, given the number of policy changes, allowing for time variation in the expectation generating mechanism is in order. Surprisingly, the hypothesis of the same expectation generating mechanism prevailing at any time of the sample period has generally been implicit in the literature.[23] Even if there is no explicit change in exchange rate policy, it would be reasonable to think that the true model of exchange rates evolves over time (see, for example, Kaminsky (1993)) and so, one should expect some evolution of the expectation formation mechanisms. To our knowledge, the one exception to be found in the literature is attributable to Prat and Uctum (2007). These authors use a switching-regression framework with stochastic choice of regime, and look at six European currencies, to determine if expectation processes change gradually and smoothly over time. However, little attention seems to be paid to the underlying causes of the switching process.

We allow the degree of extrapolation to vary non-linearly over time by interacting lagged depreciation with a linear, and a quadratic time trend.[24] For these purposes we estimate the following equation:

$$\begin{aligned}\Delta s^e_{t+k} = \quad & \beta_0 + \beta_1 \Delta s_t + \beta_2 Jump_t + \beta_3 Jump_t * \Delta s_t + \beta_4 \Delta s_t * Trend + \beta_5 \Delta s_t * Trend^2 \\ & + \beta_6 ForeError_t + \beta_7 (s^*_t - s_t)/s_t + \mathbf{X_t'}\beta_\mathbf{8} + \epsilon_{t+k} \qquad (4.16)\end{aligned}$$

Then, in order to be able to appreciate the evolution of the extrapolative component without imposing any type of functional form to it, we perform rolling regressions, with a window of 120 observations (10 years), starting at the beginning of our sample period (January 1980). This implies running 247 regressions. We then extract the estimated coef-

[23]See MacDonald (2000) and Jongen et al. (2008) for reviews on the subject.

[24]We also experimented with a cubic time trend, but both the AIC and the BIC suggested that the quadratic performed better.

ficients of interest as well as their standard errors and plot their evolution over time (and their confidence intervals). This will allow us to assess the validity of the approximation with a quadratic functional form for the evolution of the extrapolative component.[25]

Table 4.2: Time-Varying Extrapolating Factor Regressions

Dep.Var: $i - i^*$	(1) Pre TZ		(2) TZ		(3) Post-TZ		(4) Whole Per. TV	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Lagged Dep	0.354***	(0.041)	0.177***	(0.041)	0.077***	(0.015)	-1.496***	(0.119)
Lagged Jump	0.117	(0.100)					0.232***	(0.022)
Inter Lagged Jump*Dep	-0.360**	(0.180)					-0.496***	(0.033)
T.V. Extrapol							0.011***	(0.001)
T.V. Extrapol Sq.							-0.000***	(0.000)
Lagged Δ CPI	0.208***	(0.023)	0.158***	(0.027)	0.313***	(0.024)	0.265***	(0.015)
L. Fore Error	-0.062	(0.051)	-0.132**	(0.062)	0.001	(0.013)	-0.016	(0.018)
L.diseq E	0.017	(0.025)	-0.023***	(0.009)	0.065***	(0.006)	-0.035***	(0.008)
Trend Tablita							0.002***	(0.000)
Mexican Debt Crisis							0.003	(0.041)
Forward Contracts BROU							0.005	(0.005)
Forward Contracts BCU							-0.012	(0.008)
Tablita Argentina	0.029	(0.140)					0.095***	(0.015)
Austral Collapse	0.023***	(0.006)					0.040**	(0.019)
Cruzado Collapse	-0.003	(0.004)					0.013***	(0.003)
Cruzeiro Depreciation	0.011	(0.197)					-0.011	(0.032)
Hyper in Argentina	0.015***	(0.003)					0.001	(0.002)
Collor	0.018**	(0.008)					0.019	(5096.624)
Var in Forex Reserves	-0.032***	(0.007)	-0.002	(0.008)	0.020***	(0.006)	-0.013**	(0.006)
Slope TZ to come	-0.002	(0.005)					0.006**	(0.002)
1st SlopeTZ			0.064***	(0.005)			0.004**	(0.002)
2nd SlopeTZ			0.018***	(0.004)			-0.002	(0.003)
3rd SlopeTZ			0.002	(0.003)			-0.008**	(0.003)
4th SlopeTZ			-0.001	(0.003)			0.002	(0.002)
Tequila			0.002	(0.003)			0.021	(4345.545)
Real			0.002	(0.001)			0.004	(0.002)
Argentina			0.052***	(0.005)			0.036***	(0.004)
Constant	0.102***	(0.011)	0.038***	(0.005)	-0.004***	(0.001)	0.016***	(0.002)
ARCH								
L.arch	1.740***	(0.530)	1.097***	(0.378)	1.883***	(0.521)	1.410***	(0.184)
L.garch			0.310**	(0.140)			0.052	(0.038)
Constant	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)	0.000***	(0.000)
Observations	119		113		81		345	
AIC	-583.628		-799.586		-577.240		-1854.576	
BIC	-508.592		-728.674		-534.140		-1696.990	
ADF on Res	-2.844		-3.550		-6.042		-6.332	
ARCH LM	25.544		6.091		4.495		-116.722	

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Column (4) of Table (4.2) reports the results of estimating equation (4.16) over the whole period. Both the AIC and the BIC reveal substantial improvements in the fit of this model compared to that postulated by equation (4.4). The marginal effect of lagged

[25] Results reported for the rolling regressions correspond to GMM models and not ARCH. This is because convergence could not be achieved for the majority of the 247 regression models run.

depreciation on expectations during periods of tranquility is given by $\beta_1 + \beta_4 * Trend + \beta_5 * Trend^2$. The effect takes an inverted-U shape during this period, starting from 0.5, and tending to zero at the end of the period. The analysis suggest that the maximum is found in the period that goes from $1990m3 - 1993m2$. This is consistent with the beginning of the TZ regime (which started in March 1991 and was publicly announced in June 1992). The point estimate at the midpoint of the period is 0.58. In line with our previous results, our estimates suggest that after extreme exchange rate movements, agents revise expectations upwards by 24%, on average and *ceteris paribus*, while the effect of lagged depreciation gets close to zero.[26] Although not formally explored here, this inverted-U shape pattern in the extrapolative component may be indicative of a U shape pattern in the evolution of Central Bank credibility during the Pre-TZ and TZ periods. The coefficients on the economic environment variables exhibit, generally, the expected signs. The size of the estimated coefficients on the slope announcements during the TZ period are as expected, although now only the 1st and 3rd slope are statistically significant. The estimated coefficient on the regressive component suggests that agents expect the exchange rate to diverge away from the equilibrium value, although very slowly (about 1.3% deviation per period). Instead, past inflation of 1% induce an increase in depreciation expectations of about 0.26%, on average. The estimated coefficient on the adaptive component is not statistically significant.

To examine the validity of the quadratic form for the variation over time of the extrapolative component in expectations, in Figure 4.3 we plot together interval estimate for the time varying effect of lagged depreciation on expectations, together with the evolution of the coefficients on lagged depreciation, obtained from the 247 regressions, when the estimation window of 120 observations was allowed to roll. A number of conclusions can

[26] At the midpoint of the period, the hypothesis of $(\beta_1 + \beta_4 * Trend + \beta_5 * Trend^2) = -\beta_3$ is actually rejected with 95% confidence. While $(\beta_1 + \beta_4 * Trend + \beta_5 * Trend^2) = 0.58$, $\beta_3 = 0.496$

be drawn from this comparison. Firstly, that the interval for the quadratic time varying extrapolative component contains almost all of the relevant coefficients from the rolling regressions, and that the inverted-U shape pattern seems to be common. Secondly, the evolution of the coefficients from the rolling regressions seem to suggest that during the TZ period, the drop in the weight placed on lagged depreciation to form expectations about the future is more pronounced than that estimated when the quadratic functional form is assumed. The reason behind this drop may be related to the fact that the target zone regime became credible soon after it was implemented. The quadratic form does not allow a rapid decrease in that component. Thirdly, the estimated coefficients from the rolling regressions are quite volatile, particularly those calculated from samples that include the turbulent period of 2002. Given the small window considered, the extreme movements in both the dependent and explanatory variables may be very influential in the determination of the estimate. Overall, however, the quadratic time varying factor seems to be a reasonable approximation of how the weight placed on the past depreciation changed over time.

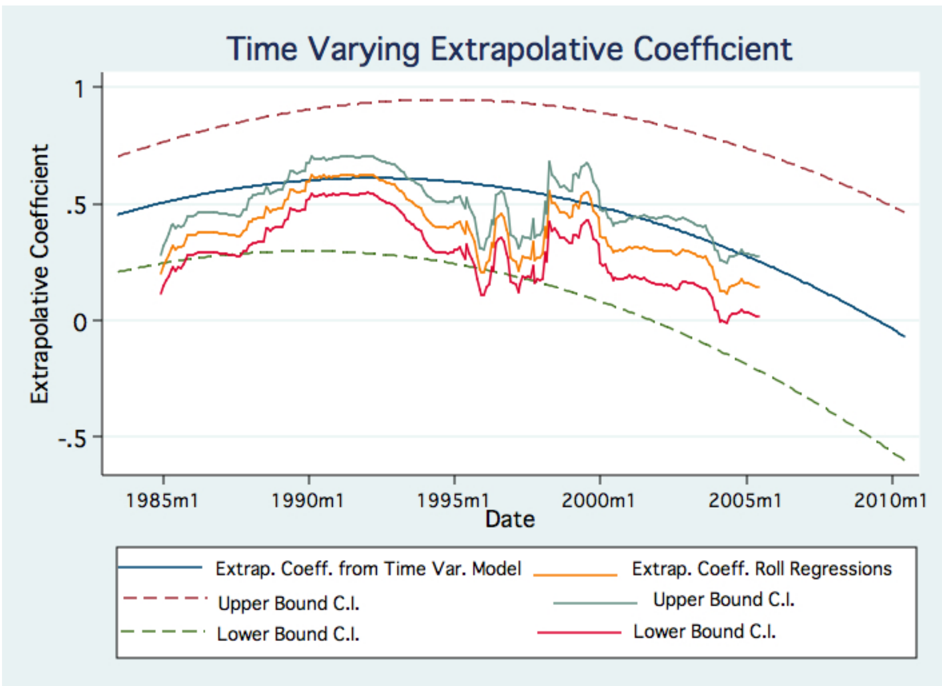

Figure 4.3: Time Varying Extrapolation Factor for All Period

4.5 Predictive Power of the Interest Rate Differentials

Having explored what determines the expectation generating mechanism and its evolution, we now turn our attention to RQ5 and investigate how well the interest rate differential performs as a predictor of the future change in the spot exchange rate.

4.5.1 Estimation Strategy

The 'traditional vehicle' to test unbiasedness of the interest rate differential that is found in the literature is to run some version of the Fama (1984) regression[27], as follows:

$$\Delta s_{t+6} = \gamma_0 + \gamma_1 (i^k_{dc} - i^k_{fc}) + \epsilon_{t+6} \tag{4.17}$$

where Δs_{t+6} is the ex post future depreciation, defined as $(s_{t+6} - s_t)/s_t$ and $(i^6_{dc} - i^k_{fc})$ is the interest rate differential corresponding to a six-month deposit in domestic and foreign currency respectively, actually defined as: $[(1 + i^6_{dc})/(1 + i^6_{fc}) - 1]$. The null hypothesis to be tested is $\gamma_1 = 1$, which implies no systematic time-varying component of the forecast errors: $E(\Delta s_{t+k} - (i^k_{dc} - i^k_{fc})) = \alpha$. This hypothesis is a joint hypothesis of rational expectations plus no time-varying risk premium.[28]

We estimate a model for the period $1980 - 2010$, and then for the sub-periods corresponding to Pre-TZ, TZ and Post-TZ, as done above. The results are presented in Table D.5. The scatter plots for the whole period, and for each of the sub-periods are depicted in Figure 4.4.

[27] This has been widely used in the literature. The most recent example is Frankel and Poonawala (2010), who use the forward premium instead of interest rate differentials.

[28] A second hypothesis that is sometimes tested in the literature jointly with $\gamma_1 = 1$ is $\gamma_0 = 0$, implying no time-invariant bias in the forecast errors. Our focus here is based entirely on γ_1.

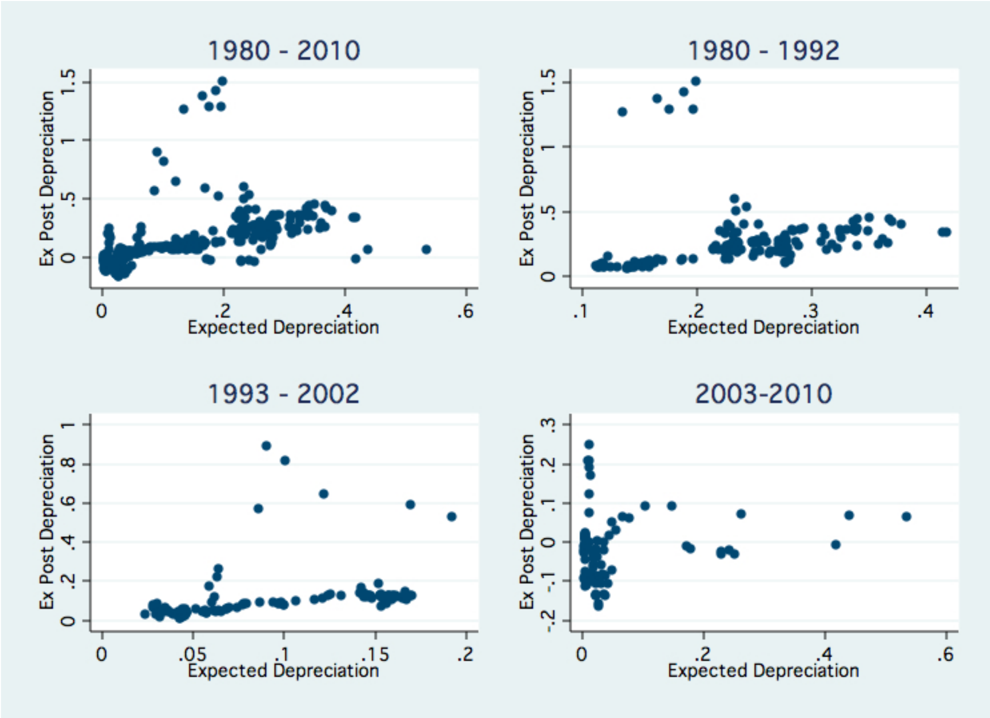

Figure 4.4: Ex-Post Depreciation on Interest Differential Regression Data

4.5.2 A Note on the Methodology

4.5.2.1 Overlapping Observations & ARCH effects

In Section 4.4.1 we discussed how when the forecast horizon associated with the interest rate differentials (six months) is longer than the data periodicity (monthly), a problem of overlapping observations arises. The same considerations apply here, and we deal with the problem in the same way. Given the presence of ARCH effects, in addition to the moving average process of order 5, we estimate ARCH models including lags of the first differences of the dependent and independent variables.

4.5.2.2 Problems with the "Traditional Testing Vehicle"

Moore (1994) argued that the traditional approach used in the literature (and presented in equation (4.17) above) to test for unbiasedness of the forward premium as a predictor of the ex post depreciation (or that of the interest rate differential) is not generally valid. Its validity relies on a number of restrictive assumptions. The author's argument, invoking the Granger Representation Theorem, is as follows. If the spot and forward rate are two non-stationary and cointegrated variables, then their vector autoregressive representation can be expressed as an error-correction mechanism (ECM) — the cointegrating vector being $\boldsymbol{\beta} = (1, -\beta_1, -\beta_0)$, and the error correction adjustment parameter vector being $\boldsymbol{\alpha} = (\alpha_s, \alpha_f)$. Two related equations are involved here, as in:

$$\begin{aligned}
\Delta S_t &= \alpha_s(S_{t-1} - \beta_1 F_{t-1} - \beta_0) + \sum_{i=1}^{k-1} b_{si}\Delta S_{t-i} + \sum_{i=1}^{k-1} c_{si}\Delta F_{t-i} + \epsilon_{st} \\
\Delta F_t &= \alpha_f(S_{t-1} - \beta_1 F_{t-1} - \beta_0) + \sum_{i=1}^{k-1} b_{fi}\Delta S_{t-i} + \sum_{i=1}^{k-1} c_{fi}\Delta F_{t-i} + \epsilon_{ft} \qquad (4.18)
\end{aligned}$$

Long run unbiasedness requires, according to the author, cointegration between the spot and the forward rate, with the cointegrating vector being $\boldsymbol{\beta} = (1, -\beta_1 = -1, -\beta_0 = 0)$. In turn, short run unbiasedness requires long run unbiasedness, an ECM adjustment parameter in the spot equation (first one in (4.18)) equal to -1, and no short run dynamics in the spot equation ($b_{si} = c_{si} = 0$).

Under short run unbiasedness, the forecast error is white noise. This can be seen by imposing the condition of short run unbiasedness on the spot equation of (4.18). This yields:

$$(S_t - F_{t-1}) = \epsilon_{st} \qquad (4.19)$$

Johansen (1992) argues that in the context of a cointegrating system (as the one outlined in (4.18)), the estimation of a single equations (as the one of (4.17)) generates efficiency losses unless there is one variable that is weakly exogenous. That would be implied if only one equation contains an error-correction term. In the case of interest here, where the dependent variable is ΔS_t, then, the forward rate must be weakly exogenous ($\alpha_f = 0$). If that condition holds, efficient estimates are obtained, as shown by Johansen, from:

$$\Delta S_t = b_0 \Delta F_t + \alpha_s (S_{t-1} - \beta_1 F_{t-1} - \beta_0) + \sum_{i=1}^{k-1} b_i \Delta S_{t-i} + \sum_{i=1}^{k-1} c_i \Delta F_{t-i} + \epsilon_t \quad (4.20)$$

The parameters in equation (4.20) are related to those of the spot equation of (4.18) in the following way: $b_0 = \sigma_{sf}\sigma_{ff}^{-1}$, $b_i = b_{si} - \sigma_{sf}\sigma_{ff}^{-1} b_{fi}$, and $c_i = c_{si} - \sigma_{sf}\sigma_{ff}^{-1} c_{fi}$ (where σ_{ij} are the components of the variance covariance matrix of $(\epsilon_{st}, \epsilon_{ft})$. As argued by Moore (1994), if the errors in the two equations in (4.18) are uncorrelated, so that $\sigma_{sf} = 0$, then (4.20) is identical to the spot equation of (4.18).

The author then re-writes (4.20) as in (4.21), to better illustrate the number of restrictions imposed when using the traditional testing vehicle for unbiasedness, presented in equation (4.17):

$$\begin{aligned} \Delta S_t = & -\alpha_s \beta_0 - \alpha_s (F_{t-1} - S_{t-1}) + b_0 \Delta F_t + \alpha_s (1 - \beta_1) F_{t-1} + \\ & + \sum_{i=1}^{k-1} b_i \Delta S_{t-i} + \sum_{i=1}^{k-1} c_i \Delta F_{t-i} + \epsilon_t \end{aligned} \quad (4.21)$$

Only if $b_0 = 0$, $\beta_1 = 1$, $b_i = 0$ and $c_i = 0$, estimating (4.17) would be analogous to estimating (4.21). This leads Moore (1994) to conclude that only if:

(1) spot and forward rates are cointegrated,

(2) the forward rate is weakly exogenous, that is to say, the error correction term in the forward equation is zero, implying that the derivative market is driving the underlying market,

(3) the long run condition of unbiasedness holds (i.e. $\beta_1 = 1$),

(4) the cross-equation covariances are zero and

(5) the lag order of the error correction mechanism is exactly equal to one,

then, the traditional testing method of unbiasedness would be valid.

Because these conditions are of empirical nature, we tested each of them using our dataset for the whole period under consideration, using the Johansen procedure. This allows us to test for long and short run unbiasedness in the foreign exchange market in Uruguay, and to assess the validity of testing unbiasedness using a single equation approach, in the traditional way. Results of this analysis are discussed in Section 4.5.3.

Then, in Section 4.5.4 we discuss the results obtained when using the traditional testing vehicle, and comment on the compatibility of both approaches.

4.5.3 The Validity of the Traditional Testing Vehicle

The validity of the traditional approach relies on five conditions outlined above. We consider each of them in turn, and use a system estimation approach to test for long and short run unbiasedness.

Firstly, we choose the lag structure for the vector autoregression represented by equation (4.18). This choice was motivated on tests of serial correlation on the residuals. The null hypothesis of serially uncorrelated residuals cannot be rejected when a generous structure of 12 lags is chosen. Different information criteria point in the same direction in terms of the lag order (see Tables D.9 and D.8 in the Appendix). This provides the first piece of evidence casting doubt on the validity of the traditional approach to test unbiasedness of expectations in the Uruguayan foreign exchange market.

Secondly, we test for long run unbiasedness. This implies, to begin with, testing for cointegration between the ex-post spot exchange rate and the expected exchange rate. We find evidence of one cointegrating relationship between these two series, and this finding is robust to the choice of the lag structure. In fact, for any lag order between one and twelve, the null hypothesis of the number of cointegrating vectors being no greater than zero is rejected, while the null of the number of cointegrating vectors being no greater than one cannot be rejected (see Table D.7 in the Appendix). Further to this, we examine the estimated cointegrating vector. The second part of the long run unbiasedness hypothesis is that $\beta_1 = 1$ and $\beta_0 = 0$. For any lag-length in the interval $[1, 12]$, the hypothesis is rejected. However, β_1 is, from an economic point of view, very close to unity (see Table D.11 in the Appendix). This suggests a substantial kernel of truth for the uncovered interest parity condition for the case of Uruguay.

Thirdly, we test for weak exogeneity of the expected exchange rate. If the expected exchange rate is weakly exogenous, that would imply that there is no significant rectification of any displacement from long-run equilibrium via changes in the expected exchange rate. We then tested the hypothesis of the error correction adjustment parameter in the equation corresponding to the expected exchange rate, $\alpha_f = 0$. Here again, we test the hypothesis using lag orders in the interval $[1, 12]$ and systematically reject it. In line with previous research done for different currency pairs, such as Moore (1994), and MacDonald and Moore (2001), we cannot reject the null of $\alpha_s = 0$.[29] Conceptually, these results suggest that expectations are not driving the exchange rate movements. Instead, this would be consistent with a world in which agents have some sort of information about what is going to happen with the exchange rate, and form expectations accordingly. For the case of Uruguay over the period considered, this is intuitively appealing, as the market is relatively thin, and the main actor was the Central Bank, whose systematic interventions were largely pre-announced. Methodologically, the rejection of weak exogeneity of the expected exchange rate implies that efficiency losses are incurred when using a single equation approach to test unbiasedness of expectations.[30]

To conclude, evidence suggests, firstly, a strong rejection of short-run unbiasedness — or short run validity of the uncovered interest parity, as defined by Moore (1994).

[29] We can only reject it when the lag order of the VAR is 1, case in which serial correlation is severe.
[30] The condition of the cross-equation uncorrelated errors is also violated.

Secondly, although long-run unbiasedness is also rejected, $\hat{\beta}_1$ is from an economic point of view, quite close to unity. Thirdly, that caution should be placed in the interpretation of results emerging from using the traditional testing vehicle for unbiasedness.

4.5.4 The Traditional Testing Vehicle: Results

The results from the analysis of Section 4.5.3 suggest that equation (4.17) is mis-specified. We found it pertinent, however, to proceed and estimate it given that this approach is so widely used in the literature. Frankel, for example, considers the single equation procedure to be a parsimonious way of testing a simple hypothesis.[31] Of course, caution should be placed when interpreting the results.

When estimating (4.17) we find that during the period $1980m02 - 2010m3$ there has been a statistically significant bias in the expectations contained in the interest rate differentials, as $\hat{\gamma}_1 < 1$ (Column 1 in Table D.5). Given the important extrapolative component in expectations that was found in Section 4.4, this bias is not surprising. What is remarkable is that the bias is lower than the general finding in the literature for developed countries' currencies ($\hat{\gamma}_1 = 0$, and even negative).[32] Our results are in line with the argument of Frankel and Poonawala (2010) that the bias for emerging economies is lower than that for advanced economies, as currencies in the former group have more easily identifiable trends of depreciation than those in the latter group. Also, Gilmore and Hayashi (2008) report $\hat{\gamma}_1$ in the range of $0.5 - 1.5$ for Argentinean, Chilean and Brazilian currency markets, and Bansal and Dahlquist (2000) also find lower forward premium biases for emerging economies and argue that the bias is positively correlated with GDP per capita and negatively with average inflation and inflation volatility.

We then investigated whether these findings are stable across the sub-periods defined

[31] This was expressed by Jeffrey Frankel in a personal communication, dated on Nov. 7th, 2010.
[32] For a survey of the original literature, see Hodrick (1987) and Engel (1996).

in Section 4.4. Column 2 reports results for the Pre-TZ regime ($1980-1992$). Surprisingly, the results imply that expectations move in the opposite direction to actual spot rates. However, a closer look at the scatter plot for this sub-period (top-right panel of Figure 4.4) suggests that the finding is driven by the large depreciation of the peso in 1982. We exclude the extreme event of 1982, and re-estimate equation (4.17) for the Pre-TZ period starting in 1983 (Column 3). The rationale for this adjustment is as follows: our sample period starts with a drastic exchange rate movement. It is likely that the internalization of this drastic event has happened earlier, out of our sample, which induces a small-sample bias. This can be thought of as the other side of the coin of the 'peso problem'. Conceptually, the peso problem refers to a perennial premium on the market interest rate associated with a currency that is pegged to the dollar (or any other). [33] The discount is due to a small probability attached to a big fall in the value of the pegged currency. A bias due to the small-sample used arises if interest rate differentials contain information on this 'small probability of a big change' expectation, while this big change is realized out of sample. Our small sample includes the jump but not the whole of the gradual expectation adjustment that is likely to have taken place before the actual depreciation. After adjusting the sub-period to start in 1983, ($Pre-TZ^*$), we find a strong co-movement of expectations and spot rates, although the bias in the prediction of the interest rate differential is still statistically significant. Results for the TZ period point to the same direction (Column 4). The period Post-TZ, characterized by a floating exchange rate regime, reveals a different pattern: no significant co-movement is found between expectations and spot rates.[34] These results raise a number of issues.

[33]It is claimed to be first observed by Milton Friedman in the context of the Mexican Peso interest rate in the 1970s.

[34]We also estimated equation (4.17) using the Newey-West procedure. Newey-West results are in line with those reported here, and the γ_1 coefficient is always highly significant, with the exception of the one estimated for Post-TZ. It is worth mentioning that because using Newey-West the standard errors are larger, now the 95% confidence interval estimates for γ_1, for the whole period, and the sub-periods Pre-TZ and TZ contain 1. This implies that the null of unbiasedness cannot be rejected.

First, the bias of the interest rate differential as a predictor of exchange rate movements is smaller when looking at the whole sample period, than when looking at a set of sub-periods, separately. This is likely to be related to the 'peso problem'. As argued by Flood and Rose (1996), a sufficiently large sample, with a representative number of actual drastic depreciation will attenuate this bias.[35]

Second, the fact that the bias seems to be larger in the Post-TZ than in the Pre-TZ period offers some evidence that the drivers of these results are not related to unidentified time-varying risk premia, but instead are associated with expectational failures. This is because if the risk premium is associated with exchange rate volatility, then, given the record of exchange rate volatility one would expect the risk premium to have been (a) higher, and (b) more volatile during Pre-TZ than Post-TZ. However, the bias is found to be smaller during Pre-TZ than during Post-TZ.

Third, the poor performance of the interest rate differential over the Post-TZ period could be attributed to the fact that with a regime in which there are no announcements from the Central Bank, and in the context of low inflation, predicting exchange rate movements becomes more difficult than during Pre-TZ and TZ. It is worth mentioning that this period is characterised by non-systematic interventions of the Central Bank in the foreign exchange market, and erratic messages from both its board of directors and the government, in terms of exchange rate policy. This introduces uncertainty with respect to the underlying model determining the exchange rate and makes it more complex to predict. One could argue that, of the three sub-periods considered, this one is the one in which the resemblance to a developed currency market is the highest, and so is the finding: the interest rate differential does not predict depreciation at all. It fits the 'forward premium puzzle'.[36] This is in line with previous findings. For example Flood and

[35]Of course, there is no guarantee that the 15 drastic movements that we have in our sample are enough to make our sample 'large'.

[36]This is further evidence that is in line with Frankel and Poonawala (2010). They argue that the bias

Taylor (1996), Huisman et al. (1998), Lothian and Wu (2005) and Huisman and Mahieu (2006) find that the larger the interest rate differentials are, the better their predictive power. As argued by (MacDonald, 2007, p. 387), in contexts of low inflation, interest rates reflect liquidity effects, while in environments of high inflation, they will reflect Fisher effects. So, the regression of depreciation on interest rate differentials will show a correctly signed association for the high inflation environment, but a wrongly signed one for the low inflation environment.

An additional explanation related to the 'peso problem' can be found through a close examination of the scatter of ex-post depreciation and the expectations contained in the interest rate differential, reported in the bottom-right panel of Figure 4.4. Expectations have been predominantly biased upwards. While the interest rate differentials have been systematically positive, actual depreciation alternated between positive (30 periods) and negative (56 periods). Given the history of exchange rate movements in Uruguay, it seems reasonable to attribute a portion of that bias to a perennial discount in the peso, as agents have the perception of a small probability of a large peso depreciation.[37]

Table 4.3: Ex-Post Depreciation on Interest Rate Differentials Regressions

	(1) All Period		(2) Pre-TZ		(3) Pre-TZ*		(4) TZ		(5) Post-TZ	
D.V. Actual Dep.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Expected Dep.	0.748***	(0.008)	-0.132***	(0.032)	0.723***	(0.032)	0.634***	(0.032)	0.011	(0.285)
Constant	0.004***	(0.001)	0.286***	(0.008)	0.081***	(0.008)	0.019***	(0.003)	-0.026***	(0.010)
ARCH										
L.arch	2.675***	(0.065)	1.892***	(0.168)	1.596***	(0.266)	1.194***	(0.241)	0.713	(0.446)
Constant	0.000***	(0.000)	0.000	(0.000)	0.000	(0.000)	0.000***	(0.000)	0.001***	(0.000)
Observations	357		156		120		120		81	
AIC	-971.122		-292.497		-359.173		-525.847		-213.692	
BIC	-955.611		-280.298		-348.023		-514.697		-204.114	
Arch LM Test	254.2		116.6		65.9		74.9		62.9	
ADF on Residuals	-6.672		-4.504		-4.726		-3.041		-3.601	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, CV for ADF on Res with 2 non-stationary vars. 3.78 at 1%, 3.25, at 5%, 2.98 at 10%
Standard errors in parentheses. C.V. for the Arch LM Test: 3.84.

is larger for developed countries' currencies, and reach this finding by exploiting their panel structure. An analogy can be drawn here. Exploiting the time series structure of our data, we find the bias to be largest when the market most resembles one of a developed economy.

[37]For all periods, the null of no ARCH effects in the residuals is overwhelmingly rejected by the data for all specifications.

4.6 Conclusions

This chapter adds to the literature on exchange rate expectation generating mechanisms and the uncovered interest parity testing. The empirical departures from the uncovered interest parity are well-known in the literature, which has mostly focused on developed economies. These departures, in turn, have brought about research on the drivers of expectation generating mechanisms but tend to have ignored that these mechanisms may change over time.

This chapter draws upon the Uruguayan case over the period 1980-2010. The Uruguayan case is interesting because during the period it exhibited two distinctive features of emerging economies: a movement from high to low inflation levels, and changes in exchange rate policies. Both features are likely to have a direct bearing on exchange rate expectations formation, and on the correlation between exchange rate changes and the interest rate differentials.

First, this chapter explores how much weight agents placed on the past behaviour of exchange rates to form expectations, and what determines that weight. Our contribution is motivated from the conjecture that economic conditions related to exchange rate determination and the degree of inertia in the economy changed significantly during the period. In line with this, we reveal that the extrapolative component associated with expectations changes over time. The identified evolution of the extrapolative component in expectation formation, jointly with our finding that agents internalize in their expectations policy announcements and external events that may affect exchange rate fundamentals, points to some degree of rationality and smooth adaptation to different environments.

We also find, using alternative testing frameworks, that there have been statistically significant departures from the uncovered interest parity over the period. Overall, the prediction bias for the case of Uruguay is significantly lower than that found for developed economies. However, the result is not homogeneous across periods. During Pre-TZ and

TZ periods, the prediction of the interest rate differential performs quite well, during the period characterized by a relatively freely floating exchange rate regime — or at least, lack of announcements about target values for the exchange rate — and low inflation, the interest rate differential has no predictive power over the exchange rate movements.

In light of our findings on the drivers of expectations mechanisms, we can claim that as long as what it takes to predict well is rather simple — i.e. look backwards, follow policy announcements, the interest rate differential performs well. However, once the exchange rate determination model becomes intricate, or at least unfamiliar — regimes in which the Central Bank does not pre-announce a target for the exchange rate have not been frequent in Uruguay— agents fail in their attempt to accurately predict exchange rate depreciations. The 'forward premium puzzle' does not seem so puzzling in this case.

Although the focus of this chapter is on the Uruguayan economy and this might raise some doubts on the external validity of the results, it offers some interesting insights on the process of adaptation of expectation generating mechanisms, and its implications on agents' forecasting ability across different environments.

However, a few caveats are in order. First, we use interest rate differentials as an indirect measure of expectations. Within those differentials there is a risk-premium. We have argued above why these results are not likely to be driven by the risk premium, though strictly, we would need to use survey data on exchange rate expectations, which unfortunately are not available for Uruguay over the period of analysis. Second, we have not found a way of simultaneously treating the ARCH effects and the non-invertible moving average process in the residuals. The ad-hoc approach used attempted to do so, although this has not proved to be entirely satisfactory. On the one hand, we obtain ARCH estimates exceeding unity in some cases, which violates the stationarity condition for the conditional variance. This is suggesting that the processes are not stable in how they absorb shocks to volatility. On the other hand, there is still some evidence of serial correlation, which led us to re-estimate all models using the Newey-West correction procedures. The results found are in line with those obtained using ARCH models (Newey-West estimates of the key coefficients estimated here are reported in the Appendix). Finally, it is worth noting that both ARCH models and Newey-West procedures rely on asymptotic properties, while our sample size is relatively modest. For these reasons, the reported estimates of the standard errors should be interpreted with some caution.

In light of these caveats, and given the availability of survey data on expectations for the period 2005-2010, in the next chapter we investigate the consistency of these results with those obtained using survey data.

Chapter 5

Exchange Rate Expectations in the Southern Cone

"It's tough to make predictions, especially about the future"[1]

5.1 Introduction

The analysis of Chapter 4 used interest rate differentials as a proxy for depreciation expectations to test for expectation formation mechanisms and unbiasedness of the interest rate differentials as a predictor of the ex-post depreciation rates. However, as argued in that chapter, the interest rate differentials not only contain information about depreciation expectations, but also a risk premium required by the holders of the risky asset. This latter confounding factor prevented us from disentangling (in the face of rejections of the unbiasedness hypothesis), the extent to which this is attributable to expectational failures, or to the presence of a risk premium that varies over time.

In this chapter, we use unexploited survey data on foreign exchange rate expectations

[1]This quote is attributed to a baseball-playing philosopher, Yogi Berra. A quick internet search reveals a similar quote "Prediction is very difficult, especially about the future" by Niels Bohr, a Danish physicist.

for the Uruguayan Peso/US dollar rate available for the last five years of the post target zone period (Post TZ), to examine how much of the "puzzle" found in the previous chapter can be explained by expectational failures. Broadly speaking, expectational failures refer to situations in which agents' expectations do not coincide with the mathematical expectation of the variable. Expectational failures could be attributed to irrationality, slow learning processes, or peso problems (defined in the previous chapter). We investigate expectation formation mechanisms, examine whether expectations are unbiased predictors of ex-post exchange rate changes, and measure the accuracy of expectations.

The motivation for this chapter is twofold. Firstly, using interest rate differentials for the Uruguayan case, we have rejected the hypothesis of unbiasedness more strongly when looking at the Post TZ period that goes from 2003 until 2010. This period is atypical since exchange rates were allowed to float relatively freely, and because CPI inflation records were low by historical standards. Probably, looking back at the past fifty years, the period Post TZ is the one in which the foreign exchange market most resembles that of a small open, developed economy. At the same time, survey data on exchange rate expectations for the Uruguayan Peso/Dollar exchange rate have been made available by the Central Bank of Uruguay since June 2005, and, to the best of our knowledge, these data have been unexploited to date. Survey data on expectations are extremely useful, allowing us to understand to what extent our version of the "forward premium puzzle" found above is attributable to expectational failures, in a period in which participants in the foreign exchange market were learning to adapt to the lack of Central Bank announcements or commitments to particular exchange rate values.[2] Secondly, given that the region was undergoing a similar adaption process to a new foreign exchange regime (also the Argentinean Peso and the Brazilian Real were floated, although to different extents, around

[2]In fact, given that we do not use forward premia in Chapter 4, but interest rate differentials — as forward markets were inexistent for much of the period, strictly, what we find is not a "forward premium" but an "interest rate differential" puzzle.

the beginning of the 2000s), and that the three countries have exhibited relatively low levels of inflation since then, we incorporate these markets in the analysis and test for expectational failures in the three markets to see if patterns could be extracted.

The first part of the chapter concentrates on the Uruguayan survey data. Firstly, we test for extrapolative, adaptive and hybrid expectation formation mechanisms, with inconclusive results. Although there is some evidence of extrapolative and adaptive mechanisms when investigated in isolation, this vanishes when a hybrid mechanism is allowed.

Secondly, we test for expectational failures. Unbiasedness of exchange rate forecasts is rejected at the three horizons considered (one, six and twelve months), although forecasts perform well at predicting the direction of the exchange rate movement over a one-month horizon. Error orthogonality is tested and results suggest that at short time-horizons, orthogonality cannot be rejected.

Thirdly, we calculate the root mean squared error of alternative forecast rules to assess their accuracy. We compare the survey expectations, the interest rate differentials, and a simple rule of predicting depreciation rates using the mean depreciation of the period. We find that survey expectations, although biased, are more accurate than other forecast rules.

Finally, we incorporate survey data for the Argentinean Peso/Dollar and the Brazilian Real/Dollar markets into the analysis. We test for expectational failures in the three markets. We find that unbiasedness of expectations cannot be rejected only for the Argentinean Peso/Dollar market, where the Argentinean Central Bank intervention is substantial and rather systematic. One explanation for this result is that systematic central bank interventions make the forecast exercise simpler.

The remainder of the chapter is structured as follows. Section 5.2 presents a decomposition of the forward premium puzzle into a portion explained by expectational failures and a portion explained by a time-varying risk premium. Section 5.3 describes the Uruguayan survey data and presents some descriptive statistics. Section 5.4 tests for extrapolative, adaptive and hybrid expectation formation mechanisms. Sections 5.5 and 5.6 focus on analysing expectational failures. In Section 5.5, the hypothesis of unbiasedness and error orthogonality are tested, while in Section 5.6 a measure of accuracy is calculated for alternative forecasting rules. In Section 5.7 we incorporate survey data for Argentina and Brazil and test for unbiasedness of expectations in the three foreign exchange markets. Section 5.8 concludes.

5.2 A Decomposition of the Puzzle

The forward premium puzzle refers to the generalized finding in the literature that the forward premium is a biased predictor of the change in the future spot exchange rate. This means that in the regression:

$$\Delta S_{t+k} = \beta_0 + \beta_1(f_t - S_t) + v_{t+k} \tag{5.1}$$

the null hypothesis $\beta_1 = 1$, and with non-overlapping data, $E(v_{t+k}) = 0$, is generally rejected. The possible sources of the rejection of this null hypothesis have been extensively discussed in the literature. Here we follow the exposition of MacDonald (2007).

This hypothesis consists of two legs: a non-time varying risk premium (or alternatively, risk-neutral agents) and no expectational failures.[3] Violations of either of the two would imply a rejection of the null. But identifying a reason for the rejection is elusive if one only has data on the forward premium, as it conflates expectations and risk.

Fama (1984) showed how the rejection of that null hypothesis could be explained by the presence of a time-varying premium required by the holder of the risky asset, or some

[3]Often, the null is expressed as the joint hypothesis of $\beta_0 = 0$ and $\beta_1 = 1$. That would imply no risk premium, or risk-neutrality.

sort of expectational failure (such as irrationality, or slow learning processes, or small sample biases), or, of course, a combination of both. We examine these in turn.

5.2.1 Conditional on Rational Expectations

To see how a time-varying risk premium would imply $\beta \neq 1$, consider Fama (1984)'s 'complementary regression', that relates the risk-premium contained in the forward rate, consistent with rational expectations to the forward premium, as described by (5.2):[4]

$$f_t - S_{t+k} = \gamma + \alpha(f_t - s_t) + v_{t+k} \tag{5.2}$$

The forward premium can be expressed as the sum of depreciation expectations and a risk premium required by the holder of the risky asset: $(f_t - S_t) = \Delta S^e_{t+k} + rp_t$. Assume no expectational failures, such that the mathematical expectation of the future spot coincides with the agents' expectation: $E_t S_{t+k} = S^e_{t+k}$, and that the difference between the actual and the expected outcome for the exchange rate is a random term: $S_{t+k} = E_t S_{t+k} + u_{t+k}$.

A careful examination of the probability limit of $\hat{\beta}_1$ helps understanding under which conditions the estimate of $\beta = 1$:

$$plim(\hat{\beta}_1) = \beta_1 = \frac{Cov((f_t - S_t), \Delta S_{t+k})}{Var(f_t - S_t)} \tag{5.3}$$

Substituting f_t for $\lambda + S_{t+k}$ in (5.3), and expanding the denominator yields:

$$plim(\hat{\beta}_1) = \beta_1 = \frac{Cov(\lambda, ES_{t+k} - S_t) + Var(ES_{t+k} - S_t)}{Var(\lambda) + Var(ES_{t+k} - S_t) + 2Cov(\lambda, ES_{t+k} - S_t)} \tag{5.4}$$

[4]The risk premium consistent with agents not making systematic forecast errors (the 'rational expectations risk premium') can be written as $\lambda_t = f_t - S_{t+k}$

In turn, $plim(\alpha)$ can be expressed as:

$$\begin{aligned} plim(\alpha) &= \frac{Cov(\lambda + ES_{t+k} - S_t, \lambda)}{Var(\lambda + ES_{t+k} - S_t)} \\ &= \frac{Var(\lambda) + Cov(ES_{t+k} - S_t, \lambda)}{Var(\lambda) + Var(ES_{t+k} - S_t) + 2Cov(\lambda, ES_{t+k} - S_t)} \end{aligned} \tag{5.5}$$

Notice that $\beta_1 = 1 - \alpha$. Conditional on rational expectations, the forward rate will be an unbiased predictor of the future spot exchange rate as long as $\alpha = 0$. Thus, testing the null of $\beta_1 = 1$ implies, as argued above, testing no expectational failures (so that $ES_{t+k} = S^e_{t+k} = S_{t+k}$) jointly with a constant risk premium (which would imply the numerator of (5.5) to be zero).

5.2.2 Conditional on a Time-Invariant Risk Premium

Alternatively, one could condition on a time-invariant risk premium, and see how expectational failures also imply $\beta_1 \neq 1$.

One case of an expectational failure is what is known as the 'peso problem'. Agents form expectations using the correct distribution of the exchange rate and expect, for instance, a large depreciation of S, but the expected change does not occur in the sample that is analyzed. That would imply, given the finite sample considered, $ES_{t+k} > S_{t+k} - S_t$. Note that in this case agents are still assumed to form expectations rationally.

Then, $\beta_1 = 1 - \alpha - \alpha_{FS}$, where α_{FS} is the finite sample bias, which tends to zero as the sample size tends to infinity (given that we have conditioned on a time-invariant risk premium, $\alpha = 0$). This can be written as:

$$\alpha_{FS} = \frac{Cov(f_t - S_t, \hat{E}S_{t+k} - S_{t+k})}{Var(\hat{f_t} - S_t)} \tag{5.6}$$

If, as in the example above, $ES_{t+k} - S_t > S_{t+k} - S_t$ and correspondingly, $f_t - S_t$ is high, then, α_{FS} will be positive, and $\hat{\beta} < 1$.

Analogously, a bias will be introduced due to irrational expectations— when the market expectations differ from the mathematical expectation, even in large samples — or because of slow learning processes after policy changes.

The availability of survey data on expectations is helpful as it allows us to unravel the forward premium bias, and understand to what extent the bias is due to expectational failures or to the presence of time-varying risk premium. This is what we attempt to do in what follows, using the available survey data on exchange rate expectations for the Uruguayan Peso/Dollar rate.

5.3 The Survey Data

The survey data on expectations were supplied by the Central Bank of Uruguay (BCU). The BCU has compiled systematic monthly series for one-month and twelve-month forecast horizons since June 2005, as well as unsystematic monthly series for different forecast horizons (two, three, six, eighteen months, et cetera). The exchange rate surveyed is the bilateral US dollar exchange rate against the Uruguayan Peso.

The group of surveyed agents has increased over the period, although not all of them actually responded (on average, the number of responses is around seventeen). The BCU aggregates the data, providing mean, median, standard deviation, minimum and maximum indicators. They do not disclose the micro data. To match this data, we use inter-bank spot rates for the last working day of each month (Interest rate differentials are differences in the monthly average rate for a fixed-maturity deposit in pesos and for a fixed-maturity deposit in dollars in the private banking sector).

There are two sources of periodicity mismatch in this analysis. Firstly, even if the forms are sent to the analysts at the beginning of the period, the precise date of the response is not revealed. Therefore, it is not possible to know precisely the true horizon of the forecast. Here we assume that the forecast is made at the beginning of the month. Secondly, because interest rate differentials are calculated from monthly average interest rates and not of those at the end of the month, another source of mismatch is introduced. These are inevitable, given data availability constraints. However, they are likely to affect mainly the analysis for the one-month horizon, and have less impact for longer forecast horizons.

Data availability constrains us to assume that the mean survey response is a valid proxy for a single expectation, homogeneously held by investors.

Figure 5.1 plots the evolution of the spot exchange rate and its forecast (made one month, six months and twelve months before) for the period from June 2005 to July 2010. Visual inspection suggests that while the one-month-ahead prediction moves closely with the actual rate, there are substantial differences between the forecast made six and twelve months ahead the real outcome.

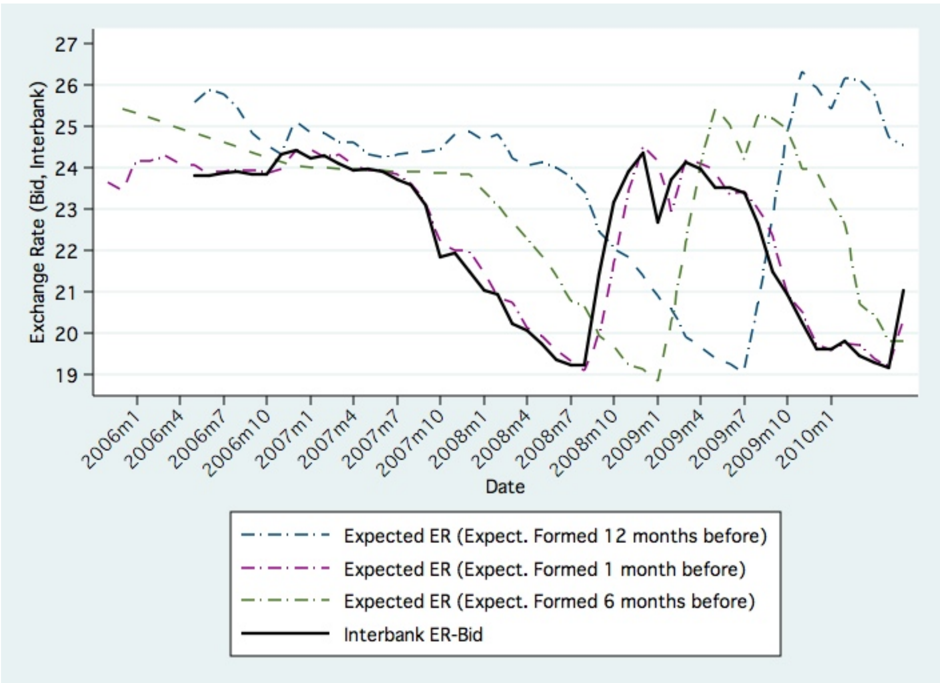

Figure 5.1: Exchange Rate and Expectations

Figure 5.2 displays the distribution of forecast errors, calculated as $(S_t - S_t^{e,t-k})/S_t$, where S_t is the spot exchange rate at period t, and $S_t^{e,t-k}$ is the expectation, formed k

periods before, for the exchange rate at period t. The left panel shows all forecast horizons grouped, the middle panel shows the one-month ahead forecast errors, and the right panel shows the twelve-month ahead forecast errors. Two interesting observations can be made from the graphs. Firstly, and in line with Figure 5.1, these histograms show the forecast error concentrated around zero for the one-month ahead predictions, while these are more evenly distributed for the twelve-month ahead prediction. Secondly, when looking at all forecast horizons, the distribution of the forecast error is negatively skewed. Appreciations seem to take agents by surprise more than depreciations. This is not surprising if one assumes a slow learning process after policy changes. The period considered is relatively atypical from a historical perspective: freely floating exchange rates have been in place, consumer price inflation has been historically low, and nominal appreciations of the peso have been more frequent than depreciations.

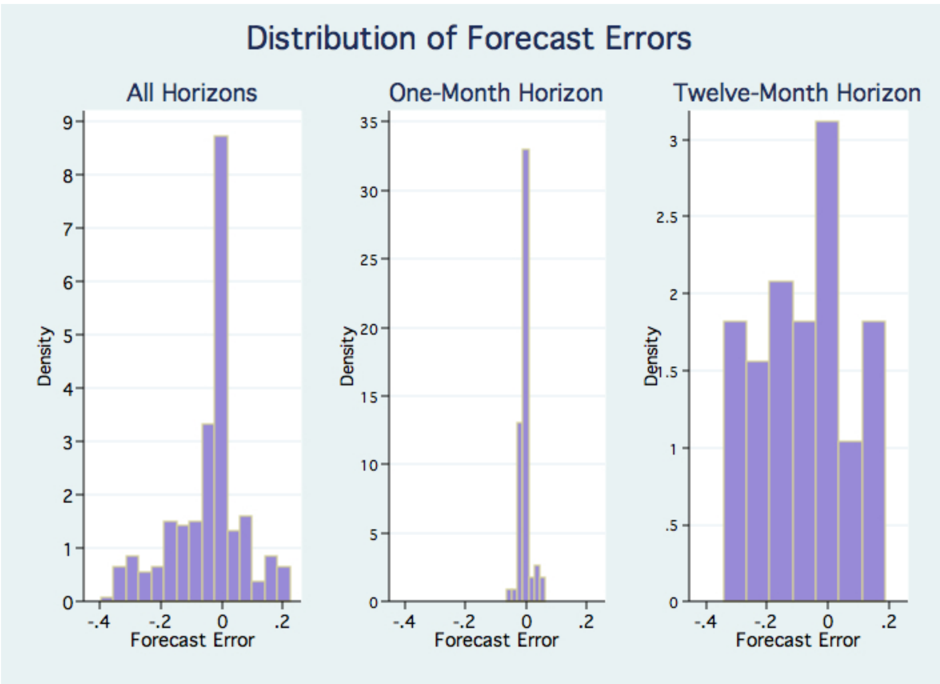

Figure 5.2: Distribution of Forecast Errors

Table 5.1 reports the number of observations on expectations we have for each forecast horizon considered (measured in months), along with some statistics that inform us on the heterogeneity of expectations at every time horizon. As already mentioned, systematic data on expectations is only available for one-month and twelve-month ahead forecasts for the period of analysis (June 2005-July 2010). Other forecast horizons are only occasionally surveyed. At a given horizon, and for a given period, the difference between the mean of expectations formed by different analysts is very small. The spread of distribution of expectations increases as agents have to forecast values for longer horizons. For example, increasing the forecast horizon by one month, increases the standard deviation of the forecasts, measured in pesos, by 0.037, on average (or by 6.8% percent).

Table 5.1: Descriptive Statistics on Expectation Heterogeneity

Horizon	(Med-Mean)/Med	(Max-Min)/Med	Ave Std Dev	Obs.
1	0.000	0.028	0.168	62
2	0.000	0.034	0.210	13
3	0.000	0.042	0.286	12
4	-0.003	0.088	0.506	5
5	-0.002	0.047	0.342	6
6	0.000	0.087	0.504	35
7	-0.004	0.089	0.532	6
8	-0.001	0.080	0.494	5
9	0.003	0.079	0.468	5
10	-0.002	0.106	0.576	5
11	0.003	0.118	0.694	5
12	-0.001	0.101	0.625	62
13	-0.002	0.133	0.743	4
14	0.006	0.129	0.817	3
15	-0.007	0.174	1.030	3
16	0.005	0.165	0.990	3
17	-0.001	0.104	0.677	6
18	0.001	0.132	0.824	46
19	-0.001	0.182	0.990	4
20	0.003	0.173	0.923	4
21	-0.005	0.139	0.835	4
22	0.000	0.169	1.003	4
23	0.003	0.145	0.925	4
24	0.004	0.170	1.058	4

Notes: (Med-Mean)/Med is the difference between the median and the mean as a prop. of the median median. (Max-Min)/Med is the difference between maximum and minimum as a prop. of the median.

5.3.1 Interest rate differentials and survey expectational data on exchange rates.

In the preceding analysis of Chapter 4 we have used the data contained in the interest rate differentials for a six-month horizon as a proxy for depreciation expectations. We now examine the correlation between interest rate differentials and depreciation expectations extracted from the survey data available for the period June 2005 - July 2010. The correlation matrix for three forecast horizons (one-month, six-month, twelve-month) between actual depreciation, expected depreciation and interest rate differentials is reported in Table 5.2. For the six-month horizon considered in the preceding chapter, the correlation between the interest differential and the depreciation expectations for a matching period, constructed from the survey data compiled by the BCU is 0.445, and statistically significant at 5%. The correlation falls below 20% when looking at twelve month time horizons, while there seems to be no association between the information contained in the one-month interest differential and the expectation data.

Table 5.2: Correlations between Interest Differentials and Survey Expectation Data

	Int Differential	**Actual Deprec.**
One-Month Horizon: June 2005-July 2010		
Actual Deprec.	-0.044	
p-value	(0.735)	
Exp Deprec.	-0.015	0.829
p-value	(0.908)	(0.000)
Six-Month Horizon: June 2005-July 2010		
Actual Deprec.	-0.133	
p-value	(0.483)	
Exp Deprec.	0.445	-0.223
p-value	(0.014)	(0.236)
Twelve-Month Horizon: June 2005-July 2010		
Actual Deprec.	-0.015	
p-value	(0.917)	
Exp Deprec.	0.192	0.043
p-value	(0.178)	(0.762)

Note: *p-values* in parentheses

5.4 Expectation Generating Mechanism

Here we use expectational data for the period June 2005-July2010 to test for extrapolative and adaptive expectations at forecast horizons of one, six and twelve months. The literature provides evidence of a twist in the expectation formation mechanism as the forecast horizon lengthens. At short horizons (one month and less), expectations tend to exhibit bandwagon effects, while at longer horizons, expectations tend to be stabilizing. For example, recent depreciations are expected to be followed by appreciations. This type of result is found, for example, in Frankel and Froot (1987), MacDonald and Torrance (1988), Frankel and Froot (1990), Cavaglia et al. (1993) and Chinn and Frankel (1994).

Table E.2 in Appendix E summarizes the main contributions to the literature.

To understand the mechanism used for expectation formation, we estimate the following three equations, (5.7), (5.8), (5.9), to test for extrapolative, adaptive and a combination of extrapolative and adaptive expectations respectively, over horizons of one, six and twelve months.

$$\Delta s^e_{t+k} = \beta_0 + \beta_1 \Delta s_t + \epsilon_{t+k} \tag{5.7}$$

$$\Delta s^e_{t+k} = \gamma_0 + \gamma_1 ForeError_t + \upsilon_{t+k} \tag{5.8}$$

$$\Delta s^e_{t+k} = \alpha_0 + \beta_1^{'} \Delta s_t + \gamma_1^{'} ForeError_t + \eta_{t+k} \tag{5.9}$$

If $\beta_1 \geq 0$, then expectations display "bandwagon" effects, and are destabilizing, while if $\beta_1 < 0$, then they are said to be stabilizing. On the other hand, if $\gamma_1 \geq 0$, agents adjust their expectations upwards after they observe that they have under predicted, and the converse is true for $\gamma_1 \leq 0$.

Results are reported in Table 5.3, for time horizons of one, six and twelve months.[5] The top part of the table displays the results of estimating (5.7). These suggest that, for all horizons, the extrapolative component in expectations (the coefficient β_1 in equation (5.7)) is statistically significant, but relatively small. This is in line with the results reported in Chapter 4, when interest rate differentials were used as a proxy for expectations.

The middle portion of the table displays the results of estimating (5.8). Our results suggest the presence of an adaptive component in expectations. Given that the forecast

[5] The same methodological considerations discussed in Chapter 4 regarding the moving average component and the ARCH effects in the error apply here. We test for serial correlation (using the Breusch-Godfrey test) and ARCH effects (using a Lagrange Multiplier test) and report the statistics and critical values in the table. We reject the null of no serial correlation for the models estimated for the twelve month horizon, so we report results of estimating them with OLS and with GMM, with standard errors corrected using the Newey and West (1987) adjustment. We do not reject the null of no ARCH effects in all models.

error is defined as the difference between the actual and the expected rate (relative to the actual), the positive coefficient suggest destabilizing expectations, in that, for example, an unanticipated appreciation of the currency indicates the expectation of a further appreciation over the next period. Similar findings have been reported by, for example, Frankel and Froot (1987), MacDonald and Torrance (1988), and Cavaglia et al. (1993).[6]

The estimated adaptive component loses statistical significance for the twelve-month horizon, once the adjustment for serial correlation is made to the variance-covariance matrix.

The bottom portion of the table shows the result when a hybrid model is estimated (as in (5.9)), in which expectations are allowed to have both an extrapolative and an adaptive component. In this case, the estimates for β_1' and γ_1' are poorly determined at all horizons. This is likely to be explained by the high collinearity between lagged depreciation and the lagged forecast error (the variables display a correlation coefficient of 0.899) .[7]

5.5 Testing for Expectational Failures

In Chapter 4 we found that the interest rate differentials had no predictive power on the behaviour of exchange rate depreciation during the Post-TZ period. As argued above, the availability of survey data on expectations allows us to identify the extent to which that lack of predictive power is associated with expectational failures. By expectational failure we mean situations in which agents' expectations do not match the mathematical

[6]A reminder on the terminology used in this thesis is in order. Strictly speaking, if agents form expectations adapting to the past forecast error, as described in equation (5.8), their expectations about future depreciations are going to be formed on the basis of past information, and therefore, these agents are "backward-looking". However, here we use "backward-looking" to refer to the situation in which agents use an autoregressive forecast model. That is, they look backwards, but only at the past evolution of the variable to be forecasted.

[7]We have estimated a model allowing for regressive expectations, by including the measure of the distance between the actual exchange rate and the "equilibrium" value needed to preserve a constant real exchange rate, as defined in Chapter 4, but we find no evidence of agents forming regressive expectations, neither when considering that mechanism separately, nor when allowing for a hybrid mechanism. For these reasons, and for brevity of exposition, we did not report the estimation output of these models.

Table 5.3: Expectation Formation

	(1) 1-M OLS		(2) 6-M OLS		(3) 12-M OLS		(4) 12-M GMM	
D.V. ΔS^e.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
			Extrapolative					
Lagged ΔS	0.13**	(0.06)	0.15***	(0.04)	0.11***	(0.04)	0.11*	(0.07)
Constant	0.00	(0.00)	0.02***	(0.00)	0.03***	(0.00)	0.03***	(0.01)
AIC	-344.00		-120.55		-195.77		-195.77	
BIC	-339.78		-117.96		-191.94		-191.94	
ARCH LM Test	0.004		0.172		1.546			
BGodfrey	0.231		0.005		26.397			
ADF on Residuals	-4.269		-2.812		-1.837		-1.837	
			Adaptive					
L.Forecast Error	0.19*	(0.10)	0.17***	(0.04)	0.09**	(0.03)	0.09	(0.07)
Constant	0.00	(0.00)	0.02***	(0.00)	0.03***	(0.01)	0.03***	(0.01)
AIC	-342.93		-123.50		-194.36		-194.36	
BIC	-338.71		-120.91		-190.53		-190.53	
ARCH LM Test	0.031		0.757		1.519			
BGodfrey	0.603		0.135		27.141			
ADF on Residuals	-3.865		-3.32		-1.735		-1.735	
			Hybrid					
Lagged ΔS	0.14	(0.14)	-0.10	(0.15)	0.21	(0.16)	0.21	(0.24)
L.Forecast Error	-0.01	(0.22)	0.27*	(0.15)	-0.08	(0.13)	-0.08	(0.23)
Constant	0.00	(0.00)	0.03***	(0.01)	0.03***	(0.01)	0.03	(0.02)
AIC	-342.00		-122.07		-194.15		-194.15	
BIC	-335.67		-118.18		-188.41		-188.41	
ARCH LM Test	0.006		1.516		2.222			
BGodfrey	1.228		0.125		26.130			
ADF on Residuals	-4.286		-3.464		-1.906		-1.906	
Observations	61		27		50		50	

Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

ARCH LM and BGodfrey $\sim \chi^2_1$. Critical Values at 5% significance for χ^2_1=3.84

expectation of the relevant variable. One reason for expectational failure is due to irrationality. However, expectational failures will also arise if agents display slow learning processes, or, if there are peso-problems as discussed above. We first test for the unbiasedness of the expectational data, and second, test whether analysts efficiently use all available information.

5.5.1 Unbiasedness Tests

Here we use survey data to test for systematic forecast errors for exchange rate depreciation. We estimate equation (5.10) and test for no expectational failures by testing the joint hypothesis of $\alpha = 0$ and $\beta = 1$:

$$\Delta s_{t+k} = \alpha + \beta \Delta s^e_{t+k} + \epsilon_{t+k} \tag{5.10}$$

where Δs_{t+k} is the actual depreciation rate in the period $t, t+k$, Δs^e_{t+k} is the expected depreciation in t, for the period $t, t+k$, and ϵ_{t+k} is an error term, with a moving average component of order $k-1$.

Results are reported in Table 5.4. Equation (5.10) is estimated using ARCH models and GMM as we find evidence of ARCH effects, and for the horizons of six and twelve months, of serial correlation.[8] The message conveyed by Figures 5.1 and 5.2 is confirmed by the estimation results. Only when predicting one-month ahead do agents get the right sign of the exchange rate movement, although they systematically overestimate its size. Regardless of the estimation strategy (ARCH model in Column 1, GMM in Column 2), the null hypothesis of unbiasedness ($\alpha = 0$, $\beta = 1$) is overwhelmingly rejected by the data, suggesting that forecast errors are systematic. For longer horizons (six-month in Columns 3 and 4 for ARCH and GMM respectively, and twelve-month in columns 5 and 6 for ARCH and GMM respectively) the results are suggestive of significant expectational failures, as agents do not even get the sign of the exchange rate movement right, and the models are poorly determined (residuals exhibit unit roots).

This helps explaining the finding of Chapter 4. During the Post-TZ period, when the Central Bank has no target for the exchange rate, and this is largely determined by market forces, six-month-horizon interest rate differentials may not perform well at predicting exchange rate movements due to to expectational failures. It is worth mentioning that the period for which the survey data is available exhibits some swings in the exchange rate that follow an international trend, due to the sharp depreciation of the dollar, followed by a substantial appreciation during 2008. This period, atypical by international standards, may have particularly affected the predictive capacity of agents. Lothian and Wu (2005) argue, for example, that many of the expectational failures reported by the literature for

[8]The null of no serial correlation is upheld only for the one-month horizon model. This is reasonable, as in this case there is no problem of overlapping of observations, as the frequency of the data matches that of the expectation horizon.

the period of the 1980s are related to the atypical behaviour of the dollar in that period, and may then be attributable to a bias due to small samples. Their approach to tackle the small sample bias, is to look at two-hundred years of data, which is, unfortunately, beyond our possibilities due to data constraints. Another reason behind the lack of prediction ability of agents, as argued in Chapter 4, may be related to the erratic messages given by the Central Bank and the government in terms of the "desired" value for the exchange rate over the period of consideration. Even if not systematic, the Central Bank often intervened during the period, although the authorities kept claiming the prevailing was a freely floating regime. This could have generated uncertainty with respect to the model underlying the determination of the exchange rate, thus affecting the agents' prediction ability.

Table 5.4: Unbiasedness

Dep.Var. ΔS	**1-M-ARCH**	**1-M-GMM**	**6-M-ARCH**	**6-M-GMM**	**12-M-ARCH**	**12-M-GMM**
ΔS^e	1.68***	1.68***	0.71	-0.02	-0.65***	-1.42**
	(0.13)	(0.21)	(0.70)	(0.80)	(0.24)	(0.69)
Constant	-0.00**	-0.00	-0.05**	-0.01	0.02	0.01
	(0.00)	(0.00)	(0.02)	(0.05)	(0.01)	(0.05)
ARCH						
L.arch	0.75**		0.64		1.35**	
	(0.30)		(0.43)		(0.63)	
L.garch	0.26*					
	(0.14)					
Constant	0.00**		0.00		0.00	
	(0.00)		(0.00)		(0.00)	
Observations	62	62	30	30	51	51
AIC	-349.94	-328.37	-47.34	-38.04	-108.66	-75.36
BIC	-339.31	-324.12	-41.73	-35.24	-100.93	-71.50
ARCH LM	7.926		11.722		19.346	
BGodfrey	2.871		22.927		38.518	
Wald:$\alpha = 0$, $\beta = 1$	69.38	21.7	6.27	2.53	167.12	53.86
ADF on Res.	-4.812	-4.812	-1.980	-1.750	-1.928	-1.746

Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.ARCH LM and BGodfrey $\sim \chi^2_1$. Critical Values at 5% significance for χ^2_1=3.84. Wald on Unbiasedeness $\sim \chi^2_2$. Critical Values at 5% significance: 5.99

5.5.2 Orthogonality Tests

A second test on expectational failures is concerned with answering if forecasters are efficiently using all available information. If that is the case, any variable containing relevant information regarding the formation of expectations of exchange rate depreciation, regressed against the ex-post forecast error should be orthogonal to that forecast error.

Otherwise, the forecaster could use that information to improve their prediction.

We estimate equations (5.11) and (5.12), using the lagged forecast error and the interest rate differentials as elements of the relevant information set respectively, and test whether α_1 and α_2 are jointly equal to zero (and analogously for $\alpha_1^{'}$ and $\alpha_2^{'}$).

$$(s_{t+k} - s^e_{t+k})/s_{t+k} = \alpha_1 + \alpha_2(s_t - s^e_t)/s_t + \epsilon_{t+k} \tag{5.11}$$

$$(s_{t+k} - s^e_{t+k})/s_{t+k} = \alpha_1^{'} + \alpha_2^{'}(i - i^*)^{t+k}_t + \epsilon_{t+k} \tag{5.12}$$

Table 5.5: Error Orthogonality

	(1) **1M ARCH**	(2) **1M GMM**	(3) **6M ARCH**	(4) **6M GMM**	(5) **12M ARCH**	(6) **12M GMM**
			Using Lagged Forecast Error			
Lagged F.Err	0.27	0.24	-0.20**	-0.20	-1.56***	-1.20***
	(0.19)	(0.23)	(0.08)	(0.13)	(0.06)	(0.18)
Constant	-0.00	-0.00	-0.03**	-0.04	-0.15***	-0.14***
	(0.00)	(0.00)	(0.01)	(0.05)	(0.01)	(0.02)
ARCH						
L.arch	0.21		1.00		1.41*	
	(0.21)		(0.72)		(0.75)	
Constant	0.00***		0.00		0.00	
	(0.00)		(0.00)		(0.00)	
Observations	61	61	22	22	39	39
ARCH LM	6.996		16.399		32.314	
BGodfrey	0.098		25.761		43.681	
Wald: $\alpha_1 = \alpha_2 = 0$	6.09	4.29	20.63	6.34	823.23	48.65
AIC	-312.93	-310.45	-31.54	-24.74	-111.13	-87.79
BIC	-304.49	-306.23	-27.18	-22.56	-104.48	-84.46
			Using Interest Rate Differentials			
$i - i^*$	-2.19***	-0.63	-5.10*	-7.61*	-4.12***	-2.52
	(0.53)	(1.13)	(2.80)	(4.23)	(0.60)	(3.79)
Constant	-0.00**	-0.00	0.02	0.09	0.10***	0.02
	(0.00)	(0.00)	(0.05)	(0.08)	(0.02)	(0.13)
ARCH						
L.arch	1.21***		0.65		1.31**	
	(0.35)		(0.62)		(0.57)	
Constant	0.00***		0.00		0.00	
	(0.00)		(0.00)		(0.00)	
Observations	62	62	30	30	51	51
ARCH LM	9.278		11.893		36.458	
BGodfrey	3.709		19.887		36.458	
Wald: $\alpha_1^{'} = \alpha_2^{'} = 0$	50.34	1.24	17.63	5.41	199.93	3.39
AIC	-323.58	-313.29	-48.35	-44.70	-87.03	-47.99
BIC	-315.07	-309.03	-42.75	-41.89	-79.31	-44.12

Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.ARCH LM and BGodfrey $\sim \chi^2_1$. Critical Values at 5% significance for χ^2_1=3.84. Wald on Orthogonality $\sim \chi^2_2$. Critical Values at 5% significance: 5.99

Results are reported in Table 5.5. When using the lagged forecast error as explanatory variable of the forecast error (top of Table 5.5) , results seem to suggest that at short horizons, the null of orthogonality is upheld by the data, but as the horizon lengthens, we reject it. This suggests that analysts use past forecast error information efficiently for one-month forecast horizons, but not for the longer horizons of six and twelve months.

When using the interest rate differentials as an explanatory variable of the forecast error (bottom of Table 5.5), the results are puzzling. Orthogonality seems to be rejected at all horizons when looking at the estimates obtained using ARCH models. However, results are very different when using GMM. A reason that could explain this puzzle is related to the short sample size.[9]

Nevertheless, the results of estimating (5.11) seem to be in line with the literature. For example, Cavaglia et al. (1993), Cavaglia et al. (1994), Sobiechowski (1996) and Verschoor and Wolff (2001) tend to find that rejection of orthogonality is found as the forecast horizon considered lengthens.

5.6 Accuracy

Results in the previous section suggest that agents correctly predict the direction of exchange rate changes in the context of Uruguay, in the period 2005-2010, only over short time-horizons. In a seminal contribution, Meese and Rogoff (1983) show that most methods of exchange rate determination (standard monetary models, time series models, lagged forward rates, et cetera) cannot perform better than a simple random walk characterization, using data for the dollar/mark, dollar/pound, dollar/yen and trade weighted dollar exchange rates. A question that arises, is whether the survey forecast can do better. Assessing the accuracy of forecast is very important, as these forecasts are generally used to guide economic decisions.

Here, we use a simple statistical measure of accuracy, given by the root mean squared error (RMSE), calculated as in equation (5.13) to compare the accuracy of alternative

[9] In large samples, the point estimates of the coefficients that obtained when using ARCH should not differ from the point estimates when using GMM.

forecasting methods over a one-month horizon, for the period of analysis.[10] These are the interest rate differential, the analyst expectations, and a simple rule that predicts depreciation to be equal to the average over the period. The RMSE is just an average measure of the forecast error, over a certain time period.

$$RMSE = \sqrt{\frac{\sum_{t=1}^{n}(\Delta s_t^{e,t-k} - \Delta s_t)^2}{n}} \tag{5.13}$$

We calculate the RMSE using the expectations data, taking six period rolling windows and plotting it together with the evolution of the spot exchange rate in Figure 5.3. The RMSE peaks right after the swings in the exchange rate caused by the worldwide appreciation of the dollar.

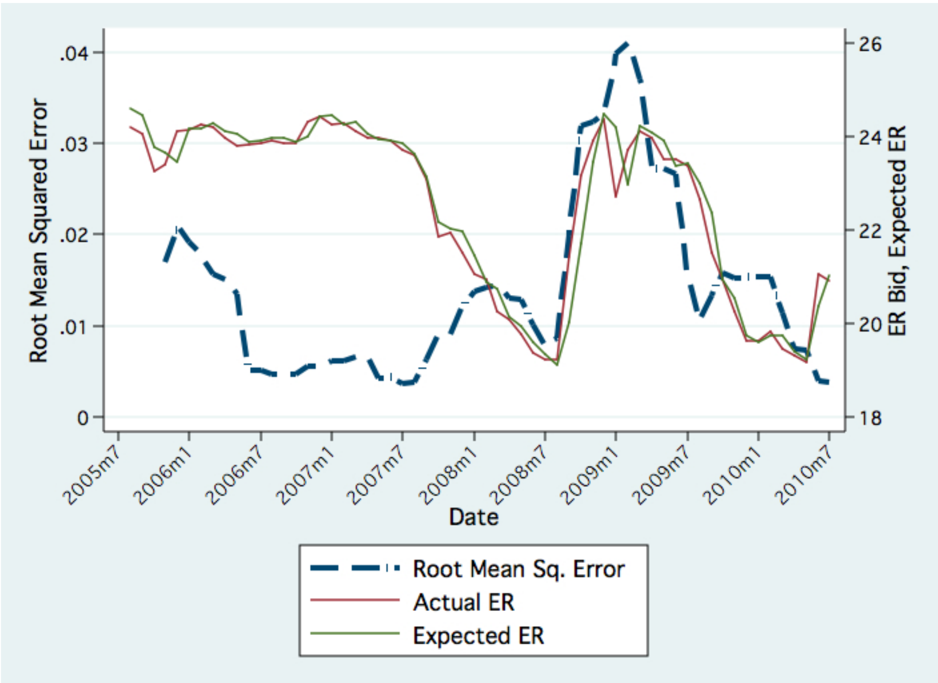

Figure 5.3: Root Mean Squared Error

Then we calculate the RMSE for the other two forecast methods and report the mean

[10] MacDonald and Marsh (1994) and MacDonald and Marsh (1996), using micro data on expectations, determine the RMSE for 30 individual forecasters, the country averages, and total cross-sectional mean, and compare them with the RMSE for the forward rate and forecast based on a random-walk hypothesis. They find that only for two individual forecasters, the RMSE of their prediction is lower than that calculated for the prediction emerging from a random-walk hypothesis.

Table 5.6: Accuracy of Alternative Prediction Methods

	Interest Diff.	Expectation Survey	Mean
RMSE	0.024	0.014	0.024
SD(RMSE)	0.016	0.010	0.017

and standard deviation over the period in Table 5.6. Results show that agents are better off following analysts' expectations than looking at interest rate differentials, or predicting depreciation to be equal to the mean, as the average forecast error of analysts' expectations is about one percentage point below that of the other methods. While analysts err on the depreciation rate, on average, by about 1.4 percentage points, using the alternative methods would imply a 2.4 percentage point error. It should be noted that these conclusions are drawn conditional on the assumption that the mean of the analysts' expectations is, as already argued above, a good proxy for a single, homogeneous expectation held by the representative market participant. If this is not the case, all these results are saying is that using the average of all analysts' predictions is more accurate than using other forecast rules.

5.7 Unbiasedness Tests for the Southern Cone

In a recent contribution, Frankel and Poonawala (2010) present evidence suggesting that expectations in developing countries are less biased than in developed countries. The authors conjecture that as relatively high inflation has been pervasive in this group of economies, exchange rate trends are more easily identifiable, hence the ability to predict is better. Here we exploit available survey data on exchange rate expectations for Argentina and Brazil in addition to Uruguay, and explore the unbiasedness hypothesis for these three Southern Cone countries. Looking at the performance of forecasts for these three foreign exchange markets is interesting as they share some characteristics. Price inflation records in the last decade have been low by historical standards. In fact, for the period 2005-

2009, the annual variation of the CPI has been below 10% in almost all cases, for the three countries (See Table E.1).[11] In addition, it is only recently that the Central Banks (CBs) stopped announcing a target for the future exchange rate value, in a movement towards floating regimes (Argentina in 2002, Brazil in 1999, Uruguay in 2002). *De jure*, freely floating regimes are in place in the three countries. Whether the regimes are freely floating *de facto* is less clear (as already discussed for the case of Uruguay). Probably, the three foreign exchange markets are consistent with managed floating schemes, although the degree of intervention of Central Banks varies substantially across countries.

How much do Central Banks Intervene in these Countries? In an attempt to understand if countries that *de jure* have freely floating exchange rate regimes, would *de facto* fall in the same category, Calvo and Reinhart (2000) construct a number of indicators that allow to measure the degree of CBs' intervention in foreign exchange markets. In essence, what they do is to investigate the frequency distribution of changes in a nominal exchange rate depreciation, rates of change of foreign exchange reserves, rates of change of the monetary base, et cetera. When the regime is actually one in which the CB intervenes to a high extent, the authors expect to find minimal changes in depreciation rates, and substantial changes in the rates of change of foreign exchange reserves and of the monetary base, and the converse, of course, when the regime is a truly freely floating one. Their benchmark for comparison is that of the USA, where, according to the authors, the exchange rate regime is closest to a freely floating one.

Using Calvo and Reinhart (2000)'s indicators, Pires de Souza (2006) concludes, after a systematic study that examines the foreign exchange markets in Argentina, Brazil and Uruguay, over the post-crisis period until 2006, that while in Brazil and Uruguay the

[11]The exception is Argentina in 2006, when CPI inflation was at 10.9%. It is worth mentioning that for the case of Argentina, there seems to be a consensus on the downward bias of the official estimate for inflation. Private analysts have reported own calculations on CPI inflation that are well above those reported by the INDEC (National Statistics Office).

regimes were closer to a freely floating one, the Argentinean one was closer to a peg "in disguise" (p. 207). The author argues that while in the former two countries CBs intervene to avoid "excessive" volatility, in Argentina, intervention has two goals: firstly to reduce the burden of the debt, and secondly, to keep a "competitive exchange rate" (p. 208).

The analysis of Pires de Souza (2006) does not cover much of the period under analysis in this chapter (2005-2010). To gain an understanding of the heterogeneous behaviour of CBs in the different markets under consideration we calculated Calvo and Reinhart (2000) indicators for this period, for each of the three countries. Of course, these measures are imperfect indicators of the degree of CB's intervention. If, for example, the economies are subject to idiosyncratic shocks, exchange rate, reserves and monetary base variability will differ independently of any policy decision of a CB. During the period considered, one of the largest shock that could have affected foreign exchange markets in these economies has been a positive terms of trade shock, arising from systematic increases in world food prices. Given the production structure of the economies, this shock is likely to have been common to the three.[12] For these reasons, we consider this indicators to be an acceptable measure of intervention. However, the interpretation of the indicators reported here should be done with caution, acknowledging its limitations to accurately assess the differences in the degree of CB intervention across countries.

Table 5.7 reports frequency with which depreciation rates, rates of change of foreign exchange reserves of the Central Bank, and rates of change of the monetary base fall outside: (a) a band given by 1 percentage point amplitude, and (b) a band given by 2.5 percentage points amplitude. The striking result in the table corresponds to the substantial differences in terms of the frequency distributions for nominal exchange rate depreciations. While in Argentina only 24% of the monthly changes in the variable fell

[12] Another important, and common shock to the three economies is the swings in the international value of the dollar during the period under consideration.

outside the interval (-1%, +1%) and 8% fell outside the interval (-2.5%, +2.5%), in Brazil and Uruguay monthly depreciation rates larger than 1% in absolute value tended to be the rule rather than the exception. These results are in line with what Pires de Souza (2006) finds for the preceding period (2000-2005). Brazil and Uruguay's variations in depreciation rates are more in line with a freely floating regime, whereas Argentina's variations are more in line with peg "in disguise". The indicators that refer to the frequency distribution of the rates of change of CB's reserves and that of the Monetary Base do not suggest substantial differences. One could conclude, thus, that even though intervention is present in the three markets — hence the substantial variation in reserves for the three cases — in Argentina it is associated with much less exchange rate flexibility.

Table 5.7: Adaptation of Calvo and Reinhart (2000)'s Fear of Floating Indicators

	Argentina		**Brazil**		**Uruguay**	
	1pp Band	*2.5pp Band*	*1pp Band*	*2.5pp Band*	*1pp Band*	*2.5pp Band*
Dep. NER	0.24	0.08	0.77	0.45	0.56	0.21
Change in Reserves	0.76	0.55	0.83	0.53	0.88	0.61
Change in Monetary Base	0.85	0.52	0.73	0.44	0.85	0.71

Source: Own elaboration on the basis of data from IMF IFS. The period considered is Jan 2005-July 2010. Dep. NER stands for Nominal Exchange Rate depreciation. 1pp and 2.5pp stand for 1 and 2.5 percentage points of amplitude bands.

5.7.1 OLS by country or System Estimation?

To test for unbiasedness of expectations for the three countries, we estimate a modified version of equation (5.10), as in (5.14).

$$\Delta s_{i,t+k} = \alpha_i + \beta_i \Delta s^e_{i,t+k} + \epsilon_{i,t+k} \qquad (5.14)$$

where the subindex i indicates the country considered (Argentina, Brazil and Uruguay). One could estimate separate equations for each country using OLS, the best linear unbiased estimator under no serial correlation and homoscedasticity, and under the assumption of errors being orthogonal to expected depreciation.

However, gains in precision due to a larger sample size could be achieved if we stack the data together and estimate a system as in:

$$\begin{bmatrix} \boldsymbol{\Delta} s_1 \\ \boldsymbol{\Delta} s_2 \\ \boldsymbol{\Delta} s_3 \end{bmatrix} = \begin{bmatrix} \boldsymbol{\Delta} s_1^e & 0 & 0 \\ 0 & \boldsymbol{\Delta} s_2^e & 0 \\ 0 & 0 & \boldsymbol{\Delta} s_3^e \end{bmatrix} \begin{bmatrix} \boldsymbol{\beta}_1 \\ \boldsymbol{\beta}_2 \\ \boldsymbol{\beta}_3 \end{bmatrix} + \begin{bmatrix} \boldsymbol{\epsilon}_1 \\ \boldsymbol{\epsilon}_2 \\ \boldsymbol{\epsilon}_3 \end{bmatrix} = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\epsilon} \quad (5.15)$$

where $\boldsymbol{\Delta} s_i$ is an $n \times 1$ vector containing depreciation rates for the i-th country over n periods, $\boldsymbol{\Delta} s_i^e$ is a matrix of dimensions $n \times 2$, containing a first column of ones, and a second column of expected depreciation rates for the i-th country over n periods, and $\boldsymbol{\beta}_i$ is a 2×1 vector of parameters (α, β), and $\boldsymbol{\epsilon}_i$ is an $n \times 1$ vector of errors.

Estimating equation (5.15) using OLS will yield inefficient estimates even under the assumption of $E(\boldsymbol{\epsilon}_i \boldsymbol{\epsilon}_i^{'}) = \sigma^2 \times \mathbf{I}$. That is to say, serially uncorrelated, and homoscedastic errors within the i^{th} equation. The reason is that error contemporaneous correlations across equations are likely to be non-zero, i.e.: $E(\boldsymbol{\epsilon}_i \boldsymbol{\epsilon}_j^{'}) \neq 0$. Since the three exchange rates considered are defined with respect to the US dollar, any unanticipated shock affecting the international value of the dollar, for example, will appear in the error term, thus generating cross sectional dependence. The literature typically deals with this problem by using seemingly unrelated regression techniques (SURE), due to Zellner (1962). The SURE estimator is a generalized least squares (GLS) estimator, in which the weighting matrix, $\boldsymbol{\Omega}$ is defined as the Kronecker product of the error covariance matrix of the system of equation (5.15), $\boldsymbol{\Sigma}$, and an identity matrix, $\mathbf{I}$.[13]

The parameters contained in $\boldsymbol{\Sigma}$ are unknown and need to be estimated using the sample covariances of the estimated residuals, so the estimator to be used is feasible GLS (FGLS). The FGLS is a two-step approach, consisting in estimating each of the three equations separately by OLS, and then using the residuals to estimate the components of $\boldsymbol{\Sigma}$. As a consequence, inferences on the model's estimates are only asymptotically valid.[14]

[13]The GLS estimator of β is given by $\hat{\beta} = [X'\Omega^{-1}X]^{-1}X'\Omega^{-1}y$.

[14]For a detailed exposition of SURE techniques, see (Greene, 2002, Chp. 14).

Notice that if the contemporaneous correlations across equations are actually zero, then the SURE estimator reduces to the application of OLS to each equation separately.

Given the structure of our data, the choice of whether to estimate separate equations for each country or use seemingly unrelated regression techniques and estimate the system as in equation (5.15) is not obvious. This is because the datasets for the three countries only overlap over a period of 30 monthly observations. For Brazil, data are available since January 2002, until July 2010, for Uruguay between June 2005 and July 2010; and for Argentina from November 2004 until July 2010, with several gaps over the period. Using SURE would imply throwing away the information corresponding to the non-overlapping part of the data (almost three years for Brazil). For this reason we estimate the system of seemingly unrelated regressions, as in equation (5.15), and test the unbiasedness hypothesis on the overlapping 30 periods with available data for the three countries. Then, we estimate equation (5.14) separately for each country and test the unbiasedness hypothesis. This allows us to exploit all the information available for Brazil. Given that data used are monthly and expectations are formed over horizons of one month, we assume serially uncorrelated errors.[15]

Scatter plots of the data on actual and expected depreciation for each of the countries considered along with a 45-degree line are displayed in Figures 5.4, 5.5 and 5.6. Results of estimating (5.15) for Uruguay and Brazil only, and then for Uruguay, Brazil and Argentina are reported in Columns 1 & 2 of Table 5.8, along with the unbiasedness tests and some diagnostic statistics. Results of estimating (5.14) separately for every country are reported in Table 5.9.[16] Both estimation strategies provide comparable results. For Brazil and Uruguay, where Central Banks intervene in the foreign exchange market in an

[15] Data on foreign exchange expectations for Argentina were obtained from the Central Bank of Argentina (BCRA). Data for Brazil were obtained from the Central Bank of Brazil. Daily interbank exchange rates both for Argentina and Brazil were obtained from OANDA.

[16] For Uruguay, results were reported above, in Table 5.4.

unsystematic way, and do not commit explicitly or implicitly to any exchange rate value, the unbiasedness hypothesis is rejected by the data at 5% significance (although in the latter country results suggest that agents do get the sign of the exchange rate movement right). For Argentina, where the BCRA intervenes actively and systematically to keep a "competitive" exchange rate, unbiasedness of expectations cannot be rejected, even at 10% significance. A possible explanation for these results is that the systematic intervention of the BCRA and implicit commitment to keep a competitive exchange rate may simplify the forecast process. This explanation is also consistent with our findings of Chapter 4 when looking at the Uruguayan case over 1980-2010. As long as what it takes to predict well is simple, agents perform well. If instead the exchange rate determination model is intricate or unfamiliar, agents fail at predicting.[17]

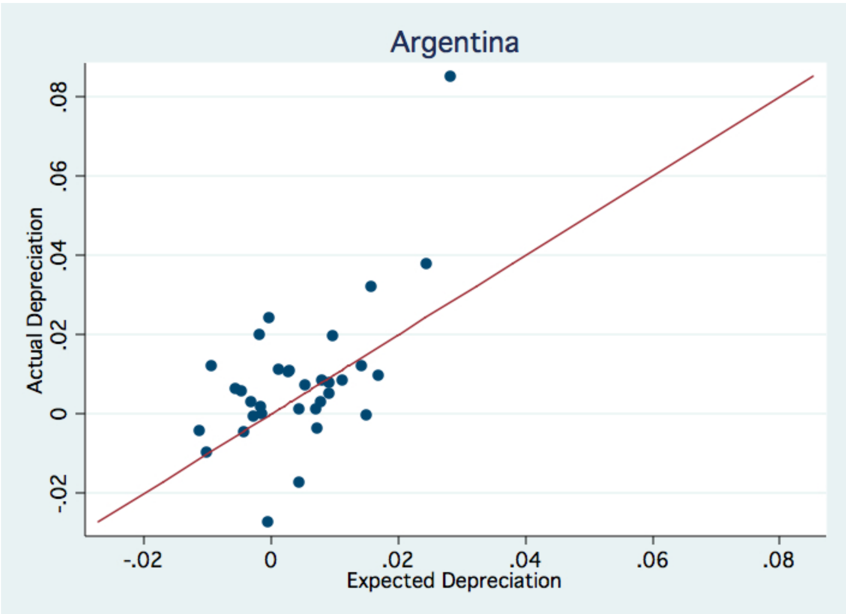

Figure 5.4: Scatter of Expected and Actual Depreciation Rates: Argentina

[17]Both for Argentina and Brazil, the hypothesis of no ARCH effects in the error terms is upheld by the data. The null of independence of errors across equations, tested using the Breusch-Pagan test of cross sectional independence (B-P Indep.) is clearly rejected, confirming that SURE techniques were necessary to treat the cross sectional dependence.

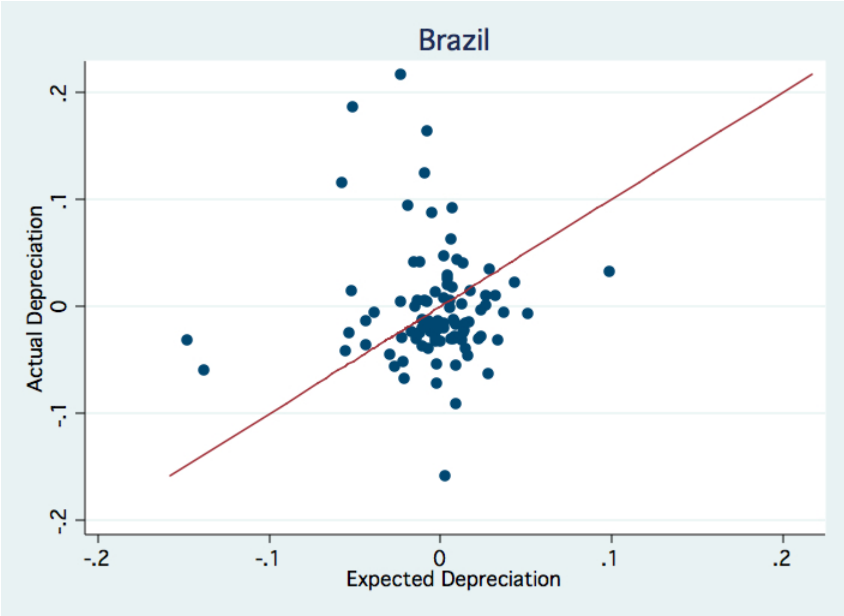

Figure 5.5: Scatter of Expected and Actual Depreciation Rates: Brazil

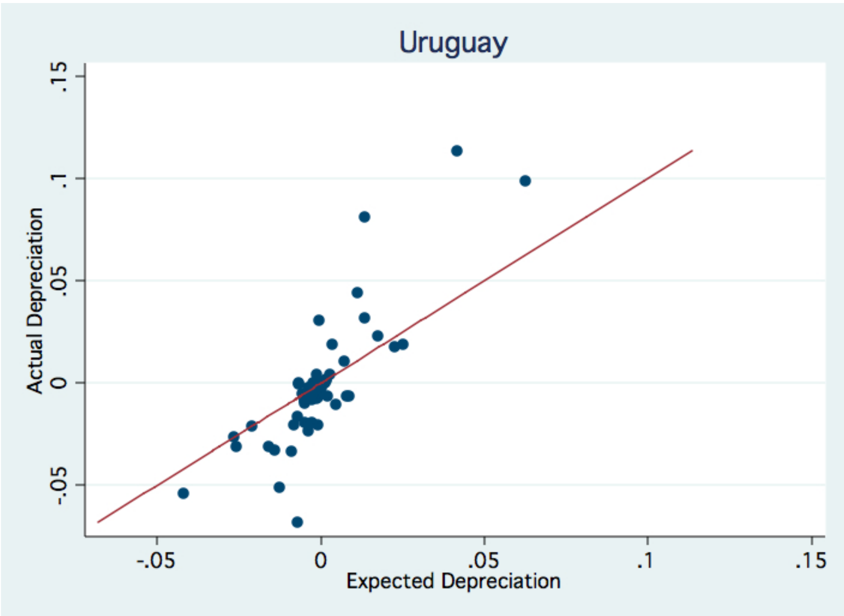

Figure 5.6: Scatter of Expected and Actual Depreciation Rates: Uruguay

5.8 Conclusions

This chapter has used unexploited survey data on expectations for the Uruguayan Peso/US Dollar exchange rate over the period June 2005-July 2010 to investigate expectation formation mechanisms, unbiasedness and accuracy of survey expectations as predictors of ex-post exchange rate movements. It then incorporated survey data for the Argentinean and

Table 5.8: Unbiasedness Tests For Mercosur Countries - SURE

	(1) 1-M Uru-Bra			(2) 1-M Uru-Bra-Arg		
Dep.Var. ΔS.	Coef.	S.E.	Diag.	Coef.	S.E.	Diag.
Uruguay						
ΔS^e	1.55***	(0.14)	RMSE: 0.017	1.57***	(0.18)	RMSE: 0.022
Constant	-0.00	(0.00)	R^2= 0.7038	-0.00	(0.00)	F Unbias= 5.24
Brazil						
ΔS^e	0.09	(0.29)	RMSE: 0.048	-0.16	(0.44)	RMSE: 0.055
Constant	-0.00	(0.01)	R^2=-0.0036	-0.01	(0.01)	F Unbias= 3.46
Argentina						
ΔS^e				1.26***	(0.24)	RMSE: 0.015
Constant				0.00	(0.00)	F Unbias.= 1.37
Observations	54			30		
AIC	-474.05			-423.75		
BIC	-466.09			-415.34		
B-P Indep	9.999			21.999		

Standard errors in parentheses, $*(p < 0.10)$, $**(p < 0.05)$, $***(p < 0.01)$, B-P Indep is the Breusch Pagan test of cross-sectional independence. $B - P \sim \chi^2_J$ (j=number of countries). CV at 5% for$\chi^2_2 = 5.99$, for$\chi^2_3 = 7.81$
F Unbiased. is an F test for $\alpha = 0 \& \beta = 1$, F $\sim$ F(2, 84). CV at 5% = 3.1, at 10% = 2.34.

Table 5.9: Unbiasedness Tests For Mercosur Countries - OLS

	Brazil		Argentina	
Dep.Var. ΔS.	Coef.	S.E.	Coef.	S.E.
ΔS^e	-0.03	(0.18)	1.20***	(0.28)
Constant	-0.00	(0.01)	0.00	(0.00)
Observations	93		33	
ARCH LM	2.930		0.097	
F Unbias.	16.10		1.5	
AIC	-273.73		-181.52	
BIC	-268.67		-178.53	

Std. errors in parentheses, $*(p < 0.10)$, $**(p < 0.05)$, $***(p < 0.01)$.
ARCH LM $\sim \chi^2_1$. CV at 5% = 3.84. F Unbias is a test on $\alpha = 0$ & $\beta = 1$.
CV for Brazil $F(2, 91) = 3.09$. For Arg. $F(2, 31) = 3.3$

Brazilian foreign exchange rate markets and tested for unbiasedness of expectations in the three markets.

The first part of the chapter focuses on the Uruguayan market. Firstly, we tested for extrapolative, adaptive and hybrid expectation formation mechanisms, with inconclusive results. Although some evidence of extrapolative and adaptive mechanisms was found when investigated in isolation, this vanished when a hybrid mechanism was allowed.

Secondly, we tested for expectational failures. Unbiasedness of exchange rate forecasts was rejected at all forecast horizons considered, although short-horizon forecasts perform better, as at least, they predict the direction of the exchange rate movement correctly. In line with previous results reported in the literature, when error orthogonality was tested results suggest that non-rejections only happen at short forecast horizons.

The evidence presented here on significant expectational failures does not necessarily imply irrationality, but instead may reflect slow learning processes or peso problems. This is because the period under consideration is both atypical in terms of the prevalent exchange rate regime in Uruguay (relatively freely floating) and in terms of the evolution of the international value of the US Dollar, which has exhibited important swings.

Thirdly, we calculated the root mean squared error of three forecast rules to assess their accuracy: we compared survey expectations, interest rate differentials, and a simple rule consisting in predicting depreciation rates using the mean depreciation of the period. We found that survey expectations, although biased, were more accurate than other forecast rules.

In the second part of this chapter, we incorporated survey data for the Argentinean Peso/Dollar and the Brazilian Real/Dollar markets into the analysis. Given that the Uruguayan Peso, the Argentinean Peso and the Brazilian real were floated (although to different extents), around the beginning of the 2000s, and that the three countries have exhibited relatively low levels of inflation since then, it seemed interesting to test for expectational failures in the three markets and see if some pattern could be extracted. For the Argentinean Peso/Dollar market, where the Argentinean Central Bank intervention is substantial and rather systematic, we found that unbiasedness of expectations cannot be rejected. Instead, unbiasedness is clearly rejected for the Brazilian market. The pattern that emerged from these results hinted that systematic central bank intervention, even if it does not involve a public announcement or a commitment to a particular exchange rate value, may simplify the forecast exercise for the participants in the foreign exchange market. This seems to be in line with our finding in the previous chapter. As long as what it takes to predict well is rather simple, agents perform well, but once the exchange rate determination model becomes intricate or unfamiliar, agents fail to predict.

Lastly, one implication of these results is that the systematic forecast errors observed in Brazil and Uruguay suggest a substantial level of uncertainty with respect to exchange rate movements.

Future research in this area could systematically explore the extent to which central bank interventions in foreign exchange markets imply lower deviations from the unbiasedness hypothesis.

Conclusions

Fundamentally, this thesis is about exchange rate uncertainty and its impact on manufacturing output in Southern Cone economies. It begins with the premise that production takes time, and so, every output decision can be seen as a risky investment decision.

In this thesis we analytically show that the output response to exchange rate uncertainty depends on a number of firm characteristics, including risk preferences, trade orientation, currency mismatches in balance sheets, profitability, and perceptions about soft budget constraints. Furthermore, we argue that it also depends on characteristics of uncertainty itself. High uncertainty levels, typically perceived in these economies immediately before or after the collapses of fixed exchange rate regimes, tend to affect firm behaviour disproportionately more than low uncertainty levels.

Given the analytical ambiguities, we use a panel spanning 28 manufacturing sectors in Argentina, Brazil and Uruguay over the years 1970-2002 and empirically investigate the impact of REER uncertainty on output by estimating a supply function in which the output-price simultaneity was tackled using alternative sets of instruments. The on average negative effect of uncertainty on output that we identified when controlling for relevant supply determinants masks a number of specificities. We find non-linearities in the uncertainty-output relationship. There is a threshold above which uncertainty affects output negatively, but below which the effect may even be positive. Furthermore, we find that output in those sectors that are more export oriented seem to be less vulnerable to

REER uncertainty. This is in line with the prediction of our model. It is possible that the more exposed to international trade a sector is, the more its assets are linked to exchange rate variations, and so, the lower the currency mismatch that firms in that sector face. However, those sectors that display a higher export exposure to other Mercosur countries seem to be more affected by REER. This finding is likely to be explained by the fact that exposure to uncertainty is larger in these sectors, and not necessarily because they are more sensitive to uncertainty. An alternative — or perhaps a complementary — explanation for this result is related to differences in the types of goods that are traded within Mercosur and with the Rest of the World. Differentiated goods are predominantly traded within the bloc. This is because for these types of flows, proximity, historical and cultural links are key. These characteristics make it relatively more difficult to reorientate trade flows of differentiated goods. It is thus likely that those producers trading these type of good, that happen to trade them mainly within the bloc, will be more cautious during episodes of exchange rate uncertainty. In addition, we find that higher labour productivity decreases the negative impact of REER uncertainty on output. Labour productivity is likely to be associated with profitability. Higher profitability grants firms with a "buffer stock" of liquidity that may make firms immune to more depreciated exchange rate outcomes. Hence, sectors in which firms are more profitable may be less vulnerable to uncertainty.

The aforementioned effects are identified using different measures of REER uncertainty that are based on the history of errors of three alternative autoregressive forecast models, that differ in their degree of sophistication. The autoregressive nature of the models was a choice driven by data constraints. Data for an 'assumption-free' measure of real exchange rate uncertainty would require, for example, the availability of data on forecasts for nominal exchange rates and relevant prices, with which to calculate the variance of a forecast error on the basis of a true mechanism — whichever it is — for forecasting, instead of an assumed one. These data were unavailable for the three countries over the period of analysis.

This constraint motivates the second part of the thesis, in which we carefully examine the behaviour of exchange rate expectations. Our hypothesis is that an autoregressive forecast model is a reasonable approximation of the true model in the context of firms operating in Southern Cone economies during the period of analysis, implying that agents attach a substantial importance to recent exchange rate trends to form expectations about future outcomes. The empirical analysis on expectations focuses on nominal exchange rates. The shift from the real to nominal exchange rates is motivated, here again, by data constraints. Expectation proxies or direct expectational data are available for the latter variable but not for the former, and although there is no guarantee that agents use the same mechanisms to forecast nominal and real exchange rates it seems likely that some lessons could be learned.

The fourth chapter of this thesis uses data contained in interest rate differentials as a proxy for exchange rate depreciation expectations, and looks at the period 1980-2010 for Uruguay. It examines the econometric evidence for the presence of an extrapolative component in expectations, and allows for the internalization of changes in the economic environment, and other expectation formation mechanisms. The evidence suggests that although the extrapolative component in expectations has evolved (in an inverted-U shape pattern) over time, it has been significant both from an economic, and from a statistical point of view. This provides to some extent comforting evidence that an autoregressive forecast model is a reasonable approximation. Nevertheless, our results suggest that the expectation formation mechanism is actually more complex, as agents tend to internalize Central Bank announcements and changes in the economic environment, and display also adaptive, and regressive expectation mechanisms. In addition to this, using alternative testing frameworks we find that the prediction bias for the case of Uruguay is significantly lower than that found for developed economies. However, the result is not homogeneous across periods. During Pre-TZ and TZ periods, the prediction of the interest rate differential performs quite well. Instead, during the period characterized by a freely floating exchange rate regime and low inflation, the interest rate differential has no predictive power over the exchange rate movements. Although the focus of this chapter is on the Uruguayan economy and this might raise some doubts on the external validity of the results, it offers some interesting insights on the process of adaptation of expectation generating mechanisms, and its implications on agents' forecasting ability across different environments.

The fifth chapter uses unexploited survey expectational data on exchange rate changes for Uruguay, Argentina and Brazil. Given that the Uruguayan Peso, the Argentinean Peso and the Brazilian real were floated (although to different extents), around the beginning of the 2000s, and that the three countries have exhibited relatively low levels of inflation since then, we test for expectational failures in the three markets and investigate if patterns can be extracted. For the Argentinean Peso/Dollar market, where the Argentinean Central Bank intervention is substantial and rather systematic, we find that unbiasedness of expectations cannot be rejected. Instead, unbiasedness is clearly rejected for the Brazilian market, and although less strongly, it is also rejected for the Uruguayan market. The pattern that emerges from these results hints that systematic Central Bank intervention, even if it does not involve a public announcement or a commitment to a particular exchange rate value, may simplify the forecast exercise for the participants in the foreign exchange market. The results from the last two chapters seem to suggest that as long as what it takes to predict well is rather simple, agents perform well, but once the exchange rate determination model becomes intricate or unfamiliar, agents fail to predict.

Two policy implications emerge from this analysis. Firstly, given the finding of threshold effects, suggesting that it is high REER uncertainty that exerts a negative effect on output changes, it seems that the strategy of adopting fixed exchange rate regimes, or some sort of hard pegs to the dollar in an attempt to reduce uncertainty may be counterproductive. This is because experience has shown that these regimes tend to come to an end collapsing, and generate extremely high uncertainty. This is confirmed when one examines the performance of expectations. Even if agents display intelligent expectations, and to some extent internalize changes in the economic environment that may affect fundamentals, they have been systematically "surprised" by large exchange rate movements triggered by the collapses of fixed regimes that can be identified in our sample, for the case of Uruguay. Because agents also extrapolate recent trends when forming expectations, they under-predict large exchange rate movements, but once they have occurred they tend to over-predict them. The large forecast errors during these periods introduce high uncertainty.

Instead, it is possible that the REER uncertainty associated with regimes that allow more flexibility of nominal exchange rates may be within the benign range that we identify in this thesis. In addition, if a portion of the effects of REER uncertainty on output are explained by the high degree of dollarization of the economies under analysis, then more flexible exchange rate arrangements may induce firms to internalise the risk of borrowing in foreign currency, and contribute to a reversal of dollarization, which may in turn reduce the vulnerability of output to REER uncertainty.

Notice that, as argued above, our results suggest that some Central Bank intervention in the foreign exchange market, with a clear rationale — like keeping a "competitive exchange rate" — may make the forecast exercise simpler for agents, thus eliminating some of the uncertainty attached to expectations. Two clarifications need to be made in this respect. First, the episodes of highest uncertainty in these economies have been generated by collapses of regimes that involved substantial Central Bank intervention. That type of intervention did not reduce uncertainty and made forecasting simple, but on the contrary, as it was unsustainable and perceived to be so by agents, it actually increased uncertainty. Second, even if some type of intervention does reduce uncertainty by enhancing predictability, our results suggest that, if the economy is within the benign range of uncertainty values, reductions do not necessarily increase output.

The second implication is related to trade policy. If REER uncertainty affects the output of manufacturing sectors negatively, and if those sectors trading predominantly with other Mercosur countries are particularly affected, because of their substantially higher volatility records, then policies that contribute to the diversification of export markets are likely to be beneficial. One example is to promote negotiations of free trade agreements with other trading blocs or countries. Another, is to strengthen the international networks that each country has already established in the form of their foreign service offices. Given that in the context of trade in differentiated manufactures, the connections between sellers and buyers are made through search processes that are costly, and given that these costs tend to increase, the further away the potential buyer is from the seller, the role that foreign service offices have in partnering with the private sector to contribute to the diversification of export markets may be substantial.

As argued in the text, happily, some of the policies implemented since 2003 in Southern Cone economies have been in line with the recommendations that emerge from this study. Since 2003, the three countries have moved —although to different extents of intervention — to relatively freely floating exchange rate regimes. In addition, there have been several policy initiatives for the diversification of export destinations. Examples of these are the increase in free trade agreements (or negotiations to that end) that the bloc has implemented with other countries or regions, and the increasing role played by the Secretariats of Foreign Affairs in these countries in promoting exports of goods and services.

Finally, the analyses conducted in this thesis present some limitations that, although discussed in the text, are reiterated here to restate the motivations that have led to particular methodological choices despite their shortcomings, and, in particular, to provide some suggestions for future research.

In the first chapter, the simple production model presented assumes that exchange rates are exogenous to the production decision of the firm. This may seem restrictive, however, the choice has been made because in these economies exchange rates are mainly affected by capital flows, and are unlikely to be driven by output decisions of individual manufacturing firms.

In the second chapter a similar concern arises around the assumed exogeneity for the REER. The potential endogeneity of REER is not fully addressed because of the lack of suitable instruments. However, we examine which are the sectors with the highest contributions to total exports (and thus, that explain the highest inflows of foreign exchange in the economy), exclude them from the sample, and find no substantial changes in the results. In addition to this, the identification of the uncertainty effect on output relies on being able to control for the output effects of currency and banking crises that tend to occur concomitantly with high REER uncertainty. This makes the identification of a 'pure' uncertainty effect difficult. To tackle this problem, we control for these effects using the Reinhart and Rogoff (2009) indicator of crises. We take comfort in the fact that this variable is systematically well determined, yielding a reasonably sized estimated coefficient, which is discussed at length in the text. Finally, in this chapter we cannot identify whether the average negative effect of uncertainty is related to risk aversion, or to some other factors, such as agents contracting dollar debt and facing bankruptcy costs. We have no measure of risk aversion, or data on balance-sheet currency mismatches. We try to control for the latter with the trade orientation of the sector, but this is clearly an imperfect indicator. Here we are constrained once again by data availability. Industrial surveys with firm-level data on a number of firm characteristics that may affect output decisions and the vulnerability of output to changes in REER uncertainty would have allowed us to shed more light on the research questions posed in this thesis. Unfortunately, very stringent regulations in terms of data confidentiality prevailing in the National Statistics Offices of some of these countries imply that although taxpayers finance firm-level data collection, no outsider to these offices can use them.

In the fourth chapter we use interest rate differentials as an indirect measure of expectations. Even if, given the characteristics of Uruguay, there are no differences in transaction costs associated with holding dollar or peso assets, within those differentials there is a risk-premium. We have argued above why these results are not likely to be driven by the risk premium, though strictly, we would need to use survey data on exchange rate expectations, which unfortunately are not available for Uruguay over the whole of the period of analysis. In the next chapter we actually use survey expectational data for the period in which these are available. Second, we have not found a way of simultaneously treating the ARCH effects and the non-invertible moving average process in the residuals. The ad-hoc approach used attempted to do so, although this has not proved to be entirely satisfactory. On the one hand, we obtain ARCH estimates exceeding unity in some cases, which violates the stationarity condition for the conditional variance. This is suggesting that the processes are not stable in how they absorb shocks to volatility. On the other hand, there is still some evidence of serial correlation, which led us to re-estimate all models using the Newey-West correction procedures. The results found are in line with those obtained using ARCH models. Finally, it is worth noting that both ARCH models and Newey-West procedures rely on asymptotic properties, while our sample size is relatively modest. For these reasons, the reported estimates of the standard errors should be interpreted with some caution.

In the fifth chapter we use average survey expectational data. Although these data constitute an improvement over interest rate differentials to explore expectation formation mechanisms, the fact that they are averages prevent us from asking a number of interesting questions. For example, given that we find evidence of several expectation formation mechanisms at work (both in this and in the previous chapter), it would be interesting to explore whether this is determined by agents' heterogeneity, or by the presence of a representative agent in the market that uses several rules at the same time. Disaggregated, micro data on expectations would allow us to shed light on this issue. Here again, the stringent confidentiality regulations of the Central Bank of Uruguay prevent us from attempting to answer them.

Finally, a general limitation of this thesis relates to the fact that the cases analysed are rather idiosyncratic, and results may just be valid for Southern Cone economies. However, it should be remembered that the most salient particularities of the Southern Cone economies refer to a highly uncertain economic environment, a high degree of liability dollarization, and the lack of hedging instruments for most of the period. These characteristics are, by no means, specific to Southern Cone economies, and they can be found elsewhere in the developing world.

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Appendix A

Indifference curves as loci of constant expected utility of wealth.

It is necessary to explain the indifference curves that are considered in this analysis. We have argued that if A1 or A2 held, then, the expected utility maximization could be reduced to the mean and variance space. Still, the slope and curvature of the indifference curves need to be explained. Here, we will assume that A2 holds.

Suppose that the probability distribution of Π can be described by a two-parameter density function $f_\Pi(\Pi;\mu_\Pi,\sigma_\Pi)$. Then, the expected value of utility is:

$$E[U(\Pi)] = \int_{-\infty}^{\infty} U(\Pi) f_\Pi(\Pi;\mu_\Pi,\sigma_\Pi) d\Pi \tag{A.1}$$

$$\text{Let} \quad z = \frac{\Pi - \mu_\Pi}{\sigma_\Pi}.$$

$$\text{Then} \quad P(Z \leq z) = P(\frac{\Pi - \mu_\Pi}{\sigma_\Pi} \leq z) = P(\Pi \leq \sigma_\Pi z + \mu_\Pi) F_z(z) = F_\Pi(\sigma_\Pi z + \mu_\Pi)$$

So, taking derivatives, we find the density function for z:

$$f_z(z) = f_\Pi(\sigma_\Pi z + \mu_\Pi) \times \sigma_\Pi$$

And recalling that $d\Pi = \sigma_\Pi dz$, and that $\Pi = \sigma_\Pi z + \mu_\Pi$ then, we can re-express equation A.1 as:

$$\begin{aligned} E[U(\Pi)] &= \int_{-\infty}^{\infty} U(\sigma_\Pi z + \mu_\Pi) f_\Pi(\Pi; \mu_\Pi, \sigma_\Pi) \sigma_\Pi dz \\ &= \int_{-\infty}^{\infty} U(\sigma_\Pi z + \mu_\Pi) f_z(z) dz \end{aligned} \tag{A.2}$$

An indifference curve is a locus of points (μ_Π, σ_Π) along which expected utility is constant. We may find the slope of such a locus by differentiating equation (A.2) with respect to σ_Π, and solving for $d\mu_\Pi/d\sigma_\Pi$:

$$0 = \int_{-\infty}^{\infty} U'(\mu_\Pi + \sigma_\Pi z) \left(\frac{d\mu_\Pi}{d\sigma_\Pi} + z \right) f(z; 0, 1) dz \tag{A.3}$$

$$\frac{d\mu_\Pi}{d\sigma_\Pi} = -\frac{\int_{-\infty}^{\infty} z U'(\Pi) f(z; 0, 1) dz}{\int_{-\infty}^{\infty} U'(\Pi) f(z; 0, 1) dz} \tag{A.4}$$

The denominator of equation A.4 is always positive, as $U'(\Pi) > 0$, for all values of Π. Then, if the agent is risk-averse the numerator is negative. The mean of z is zero. The numerator weights z by marginal utilities. Because U'', all the weights on negative z exceed all the weights on positive z. Therefore the integral is negative, which makes the expression in equation A.4 positive. For a risk-averse agent, the slope of the indifference curve between risk and expected profits is positive, given the negative sign preceding the quotient.

To explore the curvature of the indifference loci, take (μ_Π, σ_Π) and (μ'_Π, σ'_Π). Assume they are in the same indifference curve, so that the expected utility derived from the two points is the same: i.e.: $V(\mu_\Pi, \sigma_\Pi) = V(\mu'_\Pi, \sigma'_\Pi)$. Will $((\mu_\Pi + \mu'_\Pi)/2), (\sigma_\Pi + \sigma'_\Pi)/2)$ be on the same locus, on a higher or on a lower one?

If marginal utility is declining in Π, Jensen's inequality tells us that for every z:

$$\frac{1}{2}U(\mu_\Pi + \sigma_\Pi z) + \frac{1}{2}U(\mu'_\Pi + \sigma'_\Pi z) < U(\frac{\mu_\Pi + \mu'_\Pi}{2} + \frac{\sigma_\Pi + \sigma'_\Pi}{2}z)$$

And so,

$$V(\frac{\mu_\Pi + \mu'_\Pi}{2}, \frac{\sigma_\Pi + \sigma'_\Pi}{2}) > V(\mu_\Pi, \sigma_\Pi) \tag{A.5}$$

or greater than $V(\mu'_\Pi, \sigma'_\Pi)$ - as we assumed that (μ_Π, σ_Π) and (μ'_Π, σ'_Π) are on the same indifference curve.

The point $((\mu_\Pi + \mu'_\Pi)/2, (\sigma_\Pi + \sigma'_\Pi)/2)$ lies on a line between (μ_Π, σ_Π) and (μ'_Π, σ'_Π) but belongs to a higher indifference curve than the other two points. This shows that a risk-averter's indifference curve is convex provided A2 holds and $U'' < 0$.

The same type of argument shows that risk-lover's indifference curve is concave.

Appendix B

Series of growth rates of the relative price and growth rates of output are calculated on the basis of data obtained from the PADI dataset, complied by ECLAC. The indicator of relative prices results from the variation of the quotient between the deflator of value added and a general production price index. The former is sector, country and year specific while the latter is country, year specific. Hence, the growth rate of relative prices varies along time and across sector and country. Figure B.1 shows the distribution of the series of growth of output (top) and relative prices (bottom) over the whole dataset (left) and excluding atypical observations (right). There are a number of atypical observations that exhibit extremely large values for these variables.

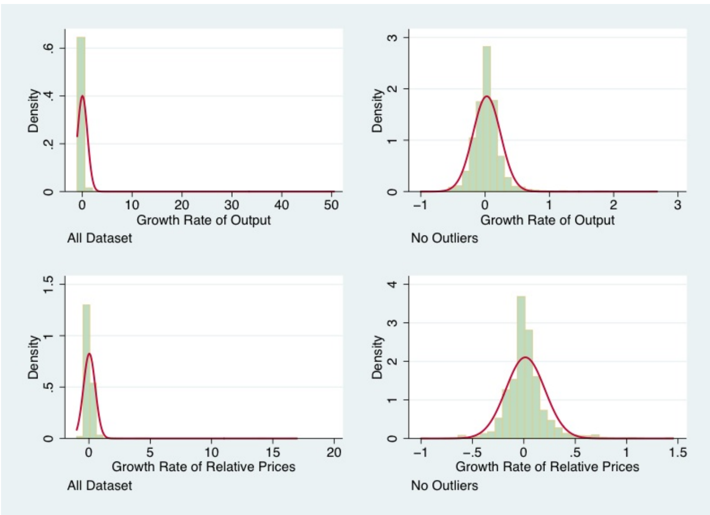

Figure B.1: Distribution of the Price and Output Changes with and without Outliers

Table B.1 reports summary statistics for the two series. The mean relative price growth

Variable	Mean	Std Dev	Max	Min	Skewness	Kurtosis
Growth of Rel Prices	0.0318	0.4854	16.970	-1.0000	25.156	804.427
Growth of Rel Prices (No Out.)	0.0203	0.2392	4.578	-1.0000	5.8238	91.907
Growth of Output	0.0724	0.9812	47.383	-1.0000	41.936	2016.576
Growth of Output (No Out.)	0.0486	0.3356	1.9853	-1.0000	2.387	12.372

Table B.1: Summary Statistics for Price and Output Changes with and without Outliers

is positive as well as output growth. The series are right-skewed, suggesting that large price increases are more common than large price decreases, and their kurtosis departs substantially from normality. The fat tails indicate the frequency of extreme outcomes, even when outliers have been excluded.

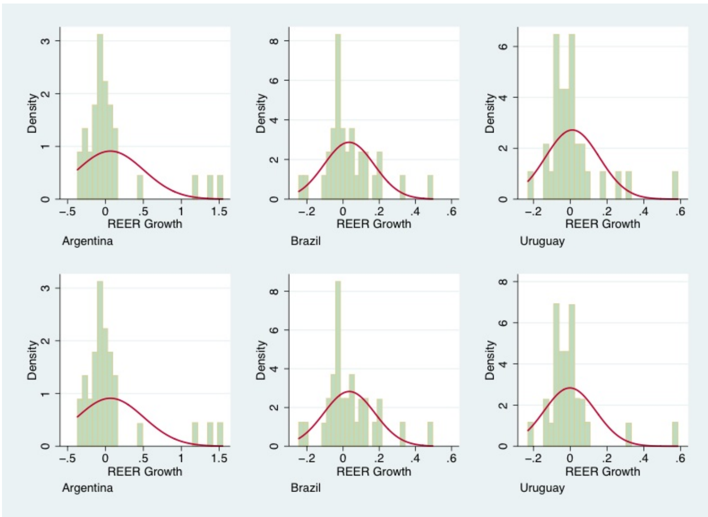

Figure B.2: Distribution of the Growth Rate of the REER

Country	Mean	Std. Dev	Min	Max	Skewness	Kurtosis
Argentina	0.007	0.150	-0.343	2.205	8.894	114.0
Brazil	0.002	0.038	-0.113	0.247	1.964	13.83
Uruguay	0.001	0.068	-0.241	0.874	9.217	117.1

Table B.2: Summary Statistics for the Growth Rate of the REER

Distribution over time and by country of the BCDI Crises Index.

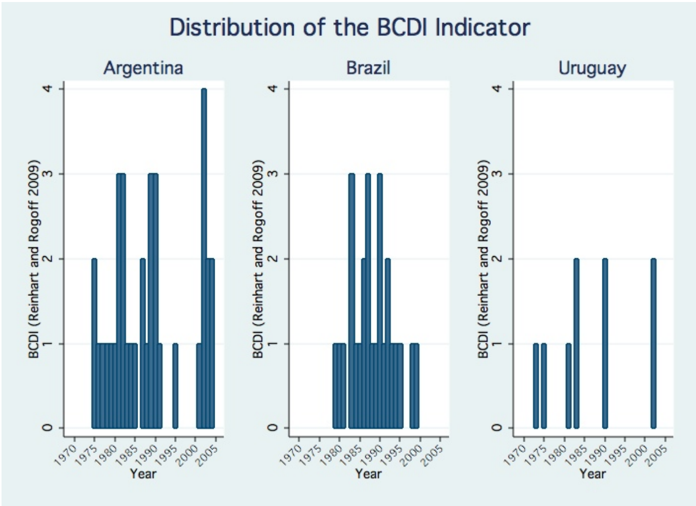

Figure B.3: Distribution of the BCDI Index

Table B.3: Ratios of Means of Volat-GARCH across Periods

Argentina	**1970**	**1980**	**1990**
1980	0.950		
1990	1.447**	1.524***	
2000	1.479**	1.558**	1.021
Brazil	**1970**	**1980**	**1990**
1980	0.461***		
1990	0.467***	1.014	
2000	0.271***	0.589***	0.581***
Uruguay	**1970**	**1980**	**1990**
1980	0.992		
1990	1.644***	1.658***	
2000	1.457**	1.470***	0.885

Notes: '***' indicates differences are significant at 1%,
'**' significant differences at 5% and '*' significant diff. at 10%

Appendix C

Table C.1: International Comparison of Instability of Selected Economic Indicators

Variable	Mean	Std. Dev.	Min.	Max.	C.V.	Obs.
Real GDP Growth						
Argentina	2.494	5.421	-10.894	10.579	3.62	40
Brazil	4.133	3.951	-4.234	13.948	0.995	40
Uruguay	2.542	4.816	-11.032	11.82	2.699	40
Australia	3.261	1.717	-0.888	6.735	0.552	40
Canada	2.933	2.155	-2.859	6.964	0.654	40
New Zealand	2.703	2.548	-3.284	8.471	1.002	40
United Kingdom	2.211	2.197	-4.92	7.196	0.843	40
CPI Inflation						
Argentina	2.458	6.068	-0.012	30.793	2.218	39
Brazil	4.032	7.498	0.032	29.477	1.559	29
Uruguay	0.443	0.315	0.044	1.125	0.565	39
Australia	0.06	0.041	0.003	0.151	0.622	39
Canada	0.046	0.034	0.002	0.125	0.669	39
New Zealand	0.07	0.056	0.003	0.171	0.723	39
United Kingdom	0.066	0.055	-0.006	0.242	0.768	39
Depreciation of the NER						
Argentina	4.63	20.741	-0.063	130.109	4.054	39
Brazil	0.401	0.656	-0.242	2.694	1.219	27
Uruguay	0.412	0.463	-0.18	1.923	0.902	39
Australia	0.023	0.113	-0.214	0.362	2.835	39
Canada	0.016	0.087	-0.13	0.208	2.868	39
New Zealand	0.028	0.105	-0.184	0.304	2.444	39
United Kingdom	0.026	0.098	-0.117	0.339	3.385	39

Notes: Annual data obtained from IMF IFS database expressed in percentage changes

Table C.2: Replication of Table 2.2 with Heteroscedasticity and Autocorrelation Consistent Standard Errors

Dep. Var.:	(1)		(2)		(3)		(4)		(5)		(6)		(7)	
Growth Ind Output	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Growth of Rel Prices	0.11	(0.07)	0.08	(0.06)	0.12*	(0.07)	0.12*	(0.07)	0.09	(0.06)	0.12*	(0.07)	0.10	(0.07)
REER Growth	0.91***	(0.03)	0.90***	(0.03)	0.91***	(0.03)	0.90***	(0.03)	0.89***	(0.03)	0.90***	(0.03)	0.90***	(0.03)
REER Uncert GARCH	-23.43	(21.26)					-9.91	(22.36)			-12.26	(22.54)		
BCDI	-0.04***	(0.01)	-0.04***	(0.01)	-0.05***	(0.01)	-0.05***	(0.01)	-0.04***	(0.01)	-0.05***	(0.01)	-0.04***	(0.01)
Dummy Floating	-0.02	(0.02)	-0.02	(0.02)	-0.01	(0.02)	-0.01	(0.02)	-0.01	(0.02)	-0.01	(0.02)	-0.02	(0.02)
Dummy Interm	-0.01	(0.02)	-0.01	(0.02)	-0.01	(0.02)	-0.02	(0.02)	-0.02	(0.02)	-0.02	(0.02)	-0.02	(0.02)
REER Uncert RollVar			-27.96***	(10.56)					-21.59*	(11.04)			-20.77*	(11.15)
Variance REER					-0.22	(0.17)								
REER Skewness							0.03***	(0.01)	0.03**	(0.01)	0.03**	(0.01)	0.02**	(0.01)
REER Kurtosis							-0.02**	(0.01)	-0.01**	(0.01)	-0.01**	(0.01)	-0.01**	(0.01)
REER Misalignment											0.01	(0.01)	0.00	(0.01)
Observations	2563		2563		2563		2563		2563		2563		2563	
Time Dummies	✓		✓		✓		✓		✓		✓		✓	
Sector-Country FE	✓		✓		✓		✓		✓		✓		✓	
Hansen Overid Test	1.944		0.617		2.380		2.345		0.907		2.498		1.129	
K&P Statistic	25.258		25.821		24.991		25.146		25.716		24.957		25.403	
C Statistic	7.190		2.909		11.247		10.635		8.126		11.079		8.693	

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The Hansen Overid and the C tests are distributed χ^2_1, the K&P statistic is distributed χ^2_2.

Table C.3: Replication of Table 2.5 with HAC standard errors

Dep. Var.:	(1)		(2)	
Growth Ind Output	Coeff.	S.E.	Coeff.	S.E.
Growth of Rel Prices	0.26*	(0.14)	0.29**	(0.14)
REER Growth	0.87***	(0.03)	0.86***	(0.03)
REER Uncert RollVar	65.13***	(21.66)		
Sq REER Uncert Roll Var	-26589.69***	(6219.99)		
REER Skewness	0.03**	(0.01)	0.03***	(0.01)
REER Kurtosis	-0.02**	(0.01)	-0.02**	(0.01)
BCDI	-0.04***	(0.01)	-0.05***	(0.01)
REER Misalignment	0.01	(0.01)	0.01	(0.01)
Dummy Floating	-0.02	(0.02)	-0.03	(0.02)
Dummy Interm	-0.03	(0.02)	-0.03	(0.02)
lv1290			50.12***	(17.38)
hv1290			-23.13**	(10.25)
Observations	2563		2563	
Time Dummies	✓		✓	
Sector-Country FE	✓		✓	
Hansen Overid Test	1.320		2.255	
K&P Statistic	6.243		5.242	
C Statistic	8.502		8.895	

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C.4: Replication of Table 2.6 with HAC standard errors

Dep. Var.:	(1)		(2)		(3)		(4)	
Growth Ind Output	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Growth of Rel Prices	0.19	(0.13)	0.27*	(0.15)	0.26*	(0.15)	0.13	(0.17)
REER Growth	0.88***	(0.03)	0.87***	(0.03)	0.87***	(0.03)	0.89***	(0.04)
REER Uncert RollVar	-33.86***	(10.71)	-31.94***	(11.11)	-33.05***	(11.44)	23.40	(21.43)
REER Skewness	0.03**	(0.01)	0.03**	(0.01)	0.03**	(0.01)	0.01	(0.01)
REER Kurtosis	-0.01**	(0.01)	-0.01**	(0.01)	-0.01*	(0.01)	-0.00	(0.01)
BCDI	-0.04***	(0.01)	-0.05***	(0.01)	-0.05***	(0.01)	-0.03**	(0.01)
REER Misalignment	0.00	(0.01)	0.01	(0.01)	0.01	(0.01)	0.01	(0.01)
Dummy Floating	-0.01	(0.02)	-0.00	(0.02)	-0.00	(0.02)	-0.01	(0.03)
Dummy Interm	-0.01	(0.02)	0.00	(0.02)	0.00	(0.02)	-0.02	(0.03)
Uncert*Lagged Exp/Out	16.13***	(4.37)						
L.Exp/Out	0.00	(0.00)						
Uncert*5-y Ave Exp/Out			7.63**	(3.85)				
5-y Ave Exp/Out			-0.01***	(0.01)				
Uncert*10-y Ave Exp/Out					7.75**	(3.92)		
10-y Ave Exp/Out					-0.01***	(0.00)		
Uncert*Q1 Exp/Out							-68.15***	(24.03)
Uncert*Q2 Exp/Out							-42.13*	(23.35)
Uncert*Q3 Exp/Out							-45.81	(28.24)
Q1 Exp/Out							0.04	(0.03)
Q2 Exp/Out							0.02	(0.03)
Q3 Exp/Out							0.03	(0.02)
Observations	2563		2563		2563		1992	
Time Dummies	✓		✓		✓		✓	
Sector-Country FE	✓		✓		✓		✓	
Hansen Overid Test	0.727		1.279		1.126		1.041	
K&P Statistic	6.527		5.717		6.006		9.451	
C Statistic	6.385		8.263		8.081		1.676	

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The Hansen Overid and the C tests are distributed χ^2_1, the K&P statistic is distributed χ^2_2.

Table C.5: Replication of Table 2.7 with HAC standard errors

Dep. Var.:	(1)		(2)		(3)		(4)		(5)	
Growth Ind Output	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Growth of Rel Prices	-0.01	(0.12)	0.12	(0.14)	0.37	(0.28)	0.10	(0.14)	-0.03	(0.18)
REER Growth	0.98***	(0.03)	0.93***	(0.04)	0.93***	(0.05)	0.94***	(0.04)	0.95***	(0.04)
REER Uncert RollVar	-33.85**	(15.96)	-50.50***	(12.96)	-6.61	(16.63)	41.82	(25.86)	-40.14**	(17.00)
REER Skewness	0.02**	(0.01)	0.01	(0.01)	-0.00	(0.01)	0.02	(0.01)	0.01	(0.01)
REER Kurtosis	-0.00	(0.01)	-0.01	(0.01)	0.00	(0.01)	-0.01	(0.01)	-0.01	(0.01)
BCDI	-0.06***	(0.01)	-0.05***	(0.01)	-0.08***	(0.02)	-0.05***	(0.01)	-0.03**	(0.01)
REER Misalignment	0.01	(0.01)	0.00	(0.01)	-0.00	(0.01)	0.00	(0.01)	-0.01	(0.01)
Dummy Floating	0.00	(0.03)	-0.00	(0.02)	0.04	(0.03)	-0.01	(0.02)	-0.00	(0.03)
Dummy Interm	-0.01	(0.03)	0.00	(0.02)	0.06*	(0.04)	-0.00	(0.02)	-0.02	(0.02)
Uncert*L.Prod	150.87***	(49.88)								
Labour Productivity	0.01***	(0.00)								
Uncert*L.Prod			3.92**	(1.89)						
Average L.Prod			0.00	(0.00)						
Uncert*1st Qtile.LP					-54.53*	(30.05)				
Uncert*2nd Qtile.LP					-42.17*	(25.07)				
Uncert*3rd Qtile.LP					26.29	(23.24)				
Qtiles LP					-0.01	(0.01)				
Uncert*Dist Frontier							-94.87***	(32.06)		
Dist to Frontier							-0.18***	(0.05)		
Uncert*1st Qtile. Dist									27.46	(19.70)
Uncert*2nd Qtile. Dist									25.31	(17.88)
Uncert*3rd Qtile. Dist									15.81	(16.84)
Qtiles Dist Frontier									0.00	(0.01)
Observations	2235		2514		1931		2570		2048	
Time Dummies	✓		✓		✓		✓		✓	
Sector-Country FE	✓		✓		✓		✓		✓	
Hansen Overid Test	0.244		0.303		3.277		0.035		1.359	
K&P Statistic	6.468		7.340		4.765		7.034		8.874	
C Statistic	4.581		3.530		3.776		4.163		0.123	

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C.6: Replication of Table 2.2 excluding Sector 311

Dep. Var.:	(1)		(2)		(3)		(4)		(5)		(6)		(7)	
Growth Ind Output	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Growth of Rel Prices	0.26*	(0.14)	0.15	(0.12)	0.30**	(0.13)	0.29**	(0.14)	0.18	(0.13)	0.31**	(0.15)	0.20	(0.14)
REER Growth	0.88***	(0.03)	0.89***	(0.03)	0.89***	(0.04)	0.87***	(0.04)	0.88***	(0.03)	0.88***	(0.04)	0.88***	(0.03)
REER Uncert GARCH	-18.42	(18.55)					-2.67	(20.69)			-5.85	(20.14)		
BCDI	-0.05***	(0.01)	-0.04***	(0.01)	-0.05***	(0.01)	-0.06***	(0.01)	-0.05***	(0.01)	-0.06***	(0.01)	-0.05***	(0.01)
Dummy Floating	-0.01	(0.02)	-0.01	(0.02)	-0.00	(0.02)	0.00	(0.02)	-0.01	(0.02)	-0.00	(0.02)	-0.01	(0.02)
Dummy Interm	-0.00	(0.02)	-0.01	(0.02)	0.00	(0.02)	-0.00	(0.02)	-0.01	(0.02)	-0.01	(0.02)	-0.01	(0.02)
REER Uncert RollVar			-28.44***	(8.60)					-21.74**	(9.75)			-21.17**	(10.21)
Variance REER					-0.26	(0.19)								
REER Skewness							0.03***	(0.01)	0.03**	(0.01)	0.03**	(0.01)	0.03**	(0.01)
REER Kurtosis							-0.02**	(0.01)	-0.01**	(0.01)	-0.02**	(0.01)	-0.01*	(0.01)
REER Misalignment											0.01	(0.01)	0.01	(0.01)
Observations	2471		2471		2471		2471		2471		2471		2471	
Time Dummies	✓		✓		✓		✓		✓		✓		✓	
Sector-Country FE	✓		✓		✓		✓		✓		✓		✓	
Clustered SE	C&S		C&S		C&S		C&S		C&S		C&S		C&S	
Hansen Overid Test	1.173		0.367		1.354		2.345		0.501		1.444		0.615	
K&P Statistic	4.442		6.503		4.127		3.957		5.564		4.074		6.120	
C Statistic	5.463		3.019		5.650		6.255		3.672		6.632		4.081	

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The Hansen Overid and the C tests are distributed χ^2_1, the K&P statistic is distributed χ^2_2.

Appendix D

Table D.1: Descriptive Statistics on Main Variables

	Depreciation	Expected Depreciation	CPI Inflation
		All Period	
Mean	15.5%	14.6%	16.4%
Std. Dev.	22.0%	11.1%	13.6%
95th Perc..	44.7%	33.7%	38.9%
		Pre-TZ	
Mean	27.9%	24.1%	28.5%
Std. Dev.	24.3%	6.9%	11.1%
95th Perc.	53.6%	35.8%	50.5%
		TZ	
Mean	11.7%	9.2%	10.1%
Std. Dev.	14.3%	5.2%	8.0%
95th Perc.	52.7%	16.7%	23.6%
		Post-TZ	
Mean	-1.8%	5.1%	4.7%
Std. Dev.	8.4%	9.7%	3.7%
95th Perc..	17.3%	25.1%	17.1%
		Tranquil Periods	
Mean	12.2%	14.7%	16.9%
Std. Dev.	13.1%	11.3%	13.7%
95th Perc.	36.4%	33.8%	39.1%
		During Jumps	
Mean	92.3%	12.7%	8.8%
Std. Dev.	38.6%	8.0%	10.0%
95th Perc.	150.3%	23.4%	32.1%
		After Jumps	
Mean	13.2%	30.8%	24.1%
Std. Dev.	8.5%	9.1%	7.9%
95th Perc.	26.8%	53.5%	36.7%

Notes: Variables are measured over a 6-month period.

Table D.2: Unit Root Tests on Main Variables

Actual Depreciation						
Period	**Trend**	**Lags**	**Test Stat**	**CV 1%**	**CV 5%**	**CV 10%**
All	No	1	-5.418	-3.452	-2.876	-2.57
All	No	3	-5.555	-3.452	-2.876	-2.57
All	No	6	-2.968	-3.452	-2.876	-2.57
All	No	12	-2.463	-3.452	-2.876	-2.57
All	Yes	1	-6.54	-3.986	-3.426	-3.13
All	Yes	3	-6.95	-3.986	-3.426	-3.13
All	Yes	6	-4.278	-3.986	-3.426	-3.13
Pre TZ	Yes	3	-4.788	-4.023	-3.443	-3.143
Pre TZ	Yes	6	-2.854	-4.024	-3.443	-3.143
Pre TZ	Yes	12	-2.736	-4.026	-3.444	-3.144
TZ	Yes	1	-2.706	-4.035	-3.448	-3.148
TZ	Yes	3	1.046	-4.035	-3.448	-3.148
TZ	Yes	6	0.281	-4.035	-3.448	-3.148
TZ	Yes	12	1.716	-4.035	-3.448	-3.148
Post TZ	Yes	1	-3.279	-4.071	-3.464	-3.158
Post TZ	Yes	3	-2.85	-4.071	-3.464	-3.158
Post TZ	Yes	6	-2.215	-4.071	-3.464	-3.158
Post TZ	Yes	12	-2.034	-4.071	-3.464	-3.158
Interest Rate Differential						
Period	**Trend**	**Lags**	**Test Stat**	**CV 1%**	**CV 5%**	**CV 10%**
All	No	1	-1.641	-3.451	-2.876	-2.57
All	No	3	-1.686	-3.451	-2.876	-2.57
All	No	6	-1.711	-3.452	-2.876	-2.57
All	No	12	-1.523	-3.452	-2.876	-2.57
All	Yes	1	-2.724	-3.986	-3.426	-3.13
All	Yes	3	-2.828	-3.986	-3.426	-3.13
All	Yes	6	-2.91	-3.986	-3.426	-3.13
All	Yes	12	-2.912	-3.986	-3.426	-3.13
Pre TZ	Yes	1	-1.431	-4.022	-3.443	-3.143
Pre TZ	Yes	3	-1.581	-4.023	-3.443	-3.143
Pre TZ	Yes	6	-0.877	-4.024	-3.443	-3.143
Pre TZ	Yes	12	-0.892	-4.026	-3.444	-3.144
TZ	Yes	1	3.782	-4.035	-3.448	-3.148
TZ	Yes	3	3.456	-4.035	-3.448	-3.148
TZ	Yes	6	2.765	-4.035	-3.448	-3.148
TZ	Yes	12	2.773	-4.035	-3.448	-3.148
Post TZ	Yes	1	-2.08	-4.058	-3.458	-3.155
Post TZ	Yes	3	-2.168	-4.058	-3.458	-3.155
Post TZ	Yes	6	-2.425	-4.058	-3.458	-3.155
Post TZ	Yes	12	-2.522	-4.058	-3.458	-3.155

Augmented Dickey-Fuller Test Results Displayed Above. CV stands for Critical Value

Table D.3: Newey-West: Expectation Generating Mechanism Regressions

Dep.Var: $i - i^*$	(1) Extrap		(2) MILERA		(3) ADL Extrap	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Lagged Dep	0.704***	(0.030)	0.454***	(0.040)	0.102***	(0.020)
Lagged Jump	0.257***	(0.046)	0.201***	(0.037)	-0.005	(0.021)
Inter Lagged Jump*Dep	-0.620***	(0.057)	-0.367***	(0.057)	-0.019	(0.031)
Trend Tablita	0.001**	(0.001)	0.003***	(0.001)	0.001***	(0.000)
Slope TZ to come	0.028	(0.019)	0.008	(0.014)	-0.004	(0.006)
Mexican Debt Crisis	0.002	(0.034)	0.013	(0.029)	-0.003	(0.020)
Tablita Argentina	-0.021	(0.028)	0.006	(0.023)	-0.059***	(0.015)
Austral Collapse	0.043	(0.028)	0.009	(0.020)	0.000	(0.010)
Cruzado Collapse	0.032	(0.027)	-0.003	(0.019)	0.010	(0.009)
Cruzeiro Depreciation	0.053	(0.039)	-0.005	(0.030)	0.006	(0.019)
Forward Contracts BROU	-0.005	(0.022)	-0.003	(0.016)	-0.010	(0.007)
Forward Contracts BCU	-0.012	(0.031)	-0.020	(0.023)	-0.022*	(0.013)
Hyper in Argentina	0.041**	(0.020)	0.021	(0.014)	0.013**	(0.006)
Collor	-0.036	(0.037)	-0.012	(0.031)	0.003	(0.020)
1st SlopeTZ	0.012	(0.012)	0.021**	(0.010)	0.002	(0.003)
2nd SlopeTZ	-0.031*	(0.019)	0.011	(0.014)	-0.007	(0.005)
3rd SlopeTZ	-0.039**	(0.020)	0.006	(0.015)	-0.007	(0.006)
4th SlopeTZ	-0.022	(0.017)	0.006	(0.012)	-0.005	(0.005)
Tequila	0.011	(0.038)	0.023	(0.030)	0.013	(0.019)
Real	-0.022	(0.017)	0.015	(0.013)	-0.000	(0.005)
Argentina	-0.009	(0.029)	0.036*	(0.021)	0.015	(0.009)
Var in Forex Reserves	0.028*	(0.016)	0.016	(0.014)	-0.007	(0.009)
Lagged Δ CPI			0.249***	(0.043)		
L. Fore Error			0.130***	(0.043)		
L. Diseq E			-0.122***	(0.027)		
L. Actual Dev					0.060***	(0.018)
L2. Actual Dev					-0.038***	(0.013)
L.Expected Depreciation					0.712***	(0.053)
L2.Expected Depreciation					0.314***	(0.067)
L3.Expected Depreciation					-0.424***	(0.065)
L4.Expected Depreciation					0.161**	(0.066)
L5.Expected Depreciation					0.233***	(0.063)
L6.Expected Depreciation					-0.164***	(0.049)
Constant	0.050***	(0.007)	0.031***	(0.006)	0.006***	(0.002)
Observations	351		345		351	
AIC	-1218.887		-1357.233		-1720.353	
BIC	-1091.481		-1218.866		-1585.226	
ADF on Res	-6.275		-7.773		-13.025	

Standard errors in parentheses. CV for ADF on Res with 2 non-stationary vars. 3.78 at 1%, 3.25, at 5%, 2.98 at 10%
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table D.4: Newey-West Time-Varying Extrapolating Factor Regressions

Dep.Var: $i - i^*$	(1) Pre TZ		(2) TZ		(3) Post-TZ		(4) Whole Per. TV	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Lagged Dep	0.426***	(0.061)	0.253***	(0.053)	0.137***	(0.041)	-2.134***	(0.326)
Lagged Jump	0.178***	(0.044)					0.133***	(0.036)
Inter Lagged Jump*Dep	-0.459***	(0.081)					-0.280***	(0.056)
Lagged Δ CPI	0.211***	(0.039)	0.220***	(0.053)	0.436***	(0.110)	0.107**	(0.043)
L. Fore Error	0.103	(0.085)	0.041	(0.089)	0.081**	(0.033)	0.043	(0.039)
L. Diseq E	-0.097	(0.067)	-0.037	(0.023)	0.003	(0.015)	-0.122***	(0.024)
Slope TZ to come	0.003	(0.011)					-0.006	(0.012)
Tablita Argentina	0.105**	(0.044)					0.033	(0.021)
Austral Collapse	0.009	(0.015)					0.029	(0.018)
Cruzado Collapse	-0.010	(0.014)					0.015	(0.017)
Cruzeiro Depreciation	-0.015	(0.020)					-0.013	(0.026)
Hyper in Argentina	0.013	(0.010)					0.006	(0.012)
Collor	0.008	(0.022)					-0.030	(0.026)
Var in Forex Reserves	-0.028**	(0.014)	-0.018	(0.012)	0.015	(0.016)	0.030**	(0.012)
1st SlopeTZ			0.041***	(0.009)			0.016*	(0.009)
2nd SlopeTZ			0.018**	(0.007)			-0.005	(0.013)
3rd SlopeTZ			0.000	(0.006)			-0.004	(0.013)
4th SlopeTZ			-0.002	(0.004)			0.001	(0.011)
Tequila			0.008	(0.008)			0.017	(0.026)
Real			-0.002	(0.003)			0.011	(0.011)
Argentina			0.032***	(0.006)			0.028	(0.018)
T.V. Extrapol							0.014***	(0.002)
T.V. Extrapol Sq.							-0.000***	(0.000)
Trend Tablita							0.004***	(0.001)
Mexican Debt Crisis							0.014	(0.025)
Forward Contracts BROU							0.021	(0.014)
Forward Contracts BCU							-0.005	(0.020)
Constant	0.063***	(0.019)	0.038***	(0.010)	-0.003	(0.004)	0.035***	(0.005)
Observations	119		113		81		345	
AIC	-539.131		-760.972		-501.504		-1456.860	
BIC	-469.653		-698.242		-463.193		-1310.805	
ADF on Res	-4.956		-4.229		-3.969		-7.707	

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

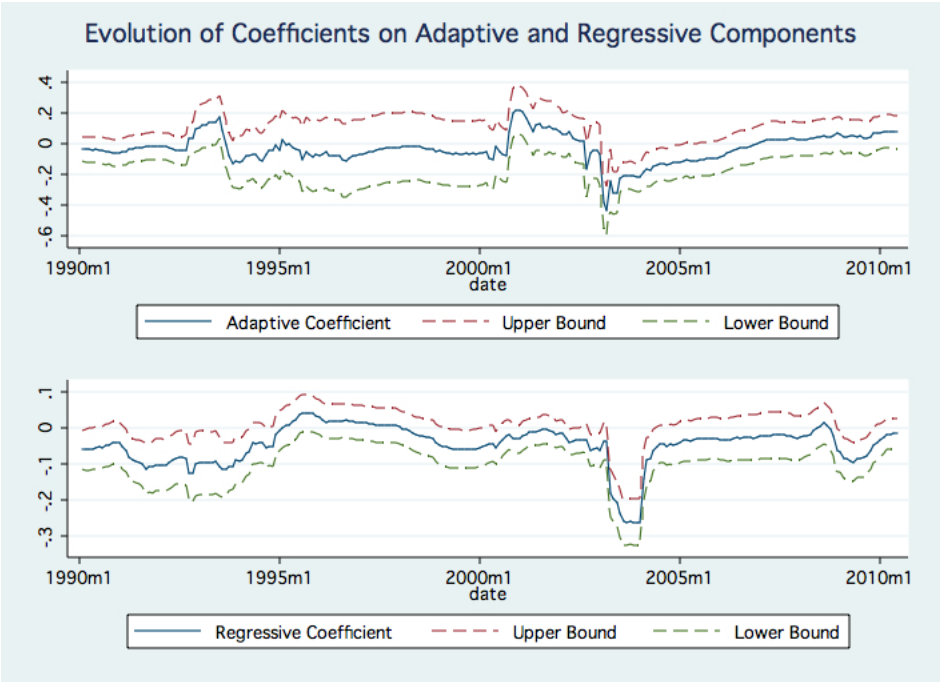

Figure D.1: Coefficients of Adaptive and Regressive Components - Rolling Regressions

Table D.5: Newey-West Results on Expectations' Hypotheses

Dep. Var.: $i - i^*$	**All Period**		**Pre-TZ**		**TZ**		**Post-TZ**	
Table 1	Coefficient	t-stat	Coefficient	t-stat	Coefficient	t-stat	Coefficient	t-stat
Lagged Dep.	0.703***	(23.48)	0.528***	(8.45)	0.393***	(6.54)	0.180***	(5.48)
Lagged Jump	0.250***	(5.52)	0.202***	(4.79)				
Lagged Jump*Dep.	-0.612***	(-10.80)	-0.557***	(-7.88)				
Table 2								
Lagged Dep.	-2.721***	(-8.10)	-0.500***	(-3.83)	1.029***	(2.76)	4.534***	(9.10)
Lagged Jump	0.177***	(4.58)	0.114***	(3.64)				
Lagged Jump*Dep.	-0.426***	(-8.10)	-0.268***	(-4.58)				
T.V. Extrapol	0.0179***	(10.44)	0.00277***	(8.04)	-0.00143*	(-1.74)	-0.00748***	(-7.97)
T.V. Extrapol Sq.	-0.0000219***	(-10.63)						
Table 3								
Lagged Dep.	0.596***	(16.72)	0.426***	(7.33)	0.331***	(5.35)	0.242***	(3.43)
Lagged Jump	0.207***	(4.72)	0.153***	(3.86)				
Lagged Jump*Dep.	-0.495***	(-8.40)	-0.447***	(-6.72)				
Lagged Inflation*Dep.	2.453***	(4.56)	1.511***	(4.16)	3.447***	(2.58)	29.14***	(5.34)

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table D.6: Newey-West Results on the Unbiasedness Hypothesis

Dep. Var.: Δs	**All Period**		**Pre-TZ**		**TZ**		**Post-TZ**	
Table 4	Coefficient	t-stat	Coefficient	t-stat	Coefficient	t-stat	Coefficient	t-stat
Actual Depreciation	0.969***	(5.62)	0.758***	(2.74)	0.967**	(2.02)	0.138	(0.86)
Constant	0.0121	(0.38)	0.0681	(0.90)	0.0275	(0.54)	-0.0256	(-1.31)
Observations	357		120		114		86	
AIC	-162.6		-252.1		-130.7		-181.3	
BIC	-154.9		-246.6		-125.2		-176.4	

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table D.7: Trace Test for Cointegration Rank

Lags VECM	Max Rank	Parms	LL	Trace Stat	Crit. Val.
1	0	2	-695.230	70.288	15.41
	1	5	-660.387	0.600	3.76
2	0	6	-596.810	86.031	15.41
	1	9	-554.259	0.929	3.76
3	0	10	-582.578	88.932	15.41
	1	13	-538.377	0.531	3.76
4	0	14	-571.298	98.650	15.41
	1	17	-522.299	0.653	3.76
5	0	18	-553.729	156.965	15.41
	1	21	-475.517	0.541	3.76
6	0	22	-486.736	102.931	15.41
	1	25	-435.586	0.631	3.76
7	0	26	-357.183	36.983	15.41
	1	29	-339.183	0.984	3.76
8	0	30	-293.360	68.535	15.41
	1	33	-259.721	1.257	3.76
9	0	34	-262.241	38.650	15.41
	1	37	-243.558	1.285	3.76
10	0	38	-255.553	51.058	15.41
	1	41	-230.593	1.138	3.76
11	0	42	-251.784	50.062	15.41
	1	45	-227.256	1.007	3.76
12	0	46	-232.636	53.187	15.41
	1	49	-206.392	0.699	3.76

Table D.8: Information Criteria for Determination of Lag Order

Lags	LL	LR	df	P-Value	FPE	AIC	HQIC	SBIC
0	-2024.57				433.758	11.748	11.757	11.771
1	-650.429	2748.3	4	0.000	0.154	3.805	3.832	3.872
2	-547.997	204.86	4	0.000	0.087	3.235	3.279	3.346
3	-533.26	29.474	4	0.000	0.082	3.173	3.235	3.328
4	-518.003	30.514	4	0.000	0.077	3.107	3.187	3.308
5	-472.683	90.64	4	0.000	0.060	2.868	2.965	3.113
6	-433.741	77.884	4	0.000	0.049	2.665	2.781	2.955
7	-338.787	189.91	4	0.000	0.029	2.138	2.271	2.472
8	-260.073	157.43	4	0.000	0.019	1.705	1.856	2.084
9	-243.79	32.567	4	0.000	0.018	1.634	1.802	2.057
10	-230.681	26.218	4	0.000	0.017	1.581	1.767	2.049
11	-227.09	7.1828	4	0.127	0.017	1.583	1.787	2.096
12	-206.043	42.095	4	0.000	0.015	1.484	1.706	2.041

Table D.9: Serial Correlation Criteria for Determination of Lag Order

Lags VECM	Lags in Test	Chi2	DofF	P-Value
1	1	30.465	4	0.000
	2	39.370	4	0.000
	3	37.625	4	0.000
	4	102.124	4	0.000
	5	35.234	4	0.000
2	1	30.147	4	0.000
	2	19.091	4	0.001
	3	63.395	4	0.000
	4	107.869	4	0.000
	5	15.979	4	0.003
3	1	30.400	4	0.000
	2	39.331	4	0.000
	3	37.638	4	0.000
	4	102.043	4	0.000
	5	35.260	4	0.000
4	1	89.437	4	0
	2	20.619	4	0.0004
	3	52.458	4	0.000
	4	133.492	4	0.000
	5	20.521	4	0.0004
5	1	75.836	4	0.000
	2	177.733	4	0.000
	3	130.787	4	0.000
	4	33.967	4	0.000
	5	63.294	4	0.000
6	1	183.944	4	0.000
	2	261.372	4	0.000
	3	84.496	4	0.000
	4	15.404	4	0.004
	5	32.493	4	0.000
7	1	150.680	4	0.000
	2	7.206	4	0.125
	3	31.019	4	0.000
	4	30.407	4	0.000
	5	66.865	4	0.000
8	1	31.097	4	0.000
	2	46.080	4	0.000
	3	10.355	4	0.035
	4	6.382	4	0.172
	5	23.969	4	0.000
9	1	24.844	4	0.000
	2	17.122	4	0.002
	3	9.032	4	0.060
	4	10.190	4	0.037
	5	26.617	4	0.000
10	1	6.874	4	0.143
	2	16.972	4	0.002
	3	13.662	4	0.008
	4	11.764	4	0.019
	5	7.297	4	0.121
11	1	39.197	4	0.000
	2	7.851	4	0.097
	3	14.444	4	0.006
	4	19.421	4	0.001
	5	7.222	4	0.125
12	1	15.264	4	0.004
	2	5.401	4	0.249
	3	6.798	4	0.147
	4	6.463	4	0.167
	5	2.188	4	0.701

Table D.10: Weak Exogeneity Tests

Lags	Equation	Coefficient	S.E.	t-stat	P-Value	Lower Bound	Upper Bound
1	Forward Eq	-0.162	0.021	-7.77	0	-0.202	-0.121
	Spot Eq.	-0.049	0.012	-4.08	0	-0.073	-0.026
2	Forward Eq	-0.193	0.020	-9.74	0	-0.232	-0.154
	Spot Eq.	-0.002	0.012	-0.17	0.864	-0.025	0.021
3	Forward Eq	-0.220	0.022	-9.92	0	-0.263	-0.176
	Spot Eq.	-0.0003	0.013	-0.02	0.983	-0.025	0.025
4	Forward Eq	-0.254	0.024	-10.5	0	-0.301	-0.207
	Spot Eq.	-0.001	0.015	-0.07	0.947	-0.029	0.028
5	Forward Eq	-0.342	0.025	-13.49	0	-0.392	-0.292
	Spot Eq.	0.033	0.016	2.06	0.04	0.002	0.065
6	Forward Eq	-0.292	0.029	-10.23	0	-0.348	-0.236
	Spot Eq.	0.046	0.020	2.26	0.024	0.006	0.086
7	Forward Eq	-0.142	0.025	-5.62	0	-0.191	-0.092
	Spot Eq.	0.034	0.024	1.46	0.145	-0.012	0.081
8	Forward Eq	-0.163	0.021	-7.64	0	-0.205	-0.121
	Spot Eq.	0.042	0.024	1.74	0.082	-0.005	0.090
9	Forward Eq	-0.129	0.023	-5.59	0	-0.174	-0.083
	Spot Eq.	0.027	0.027	0.98	0.328	-0.027	0.080
10	Forward Eq	-0.163	0.024	-6.92	0	-0.209	-0.117
	Spot Eq.	0.001	0.028	0.04	0.97	-0.054	0.056
11	Forward Eq	-0.167	0.025	-6.58	0	-0.217	-0.118
	Spot Eq.	0.026	0.030	0.87	0.384	-0.033	0.086
12	Forward Eq	-0.181	0.026	-6.96	0	-0.232	-0.130
	Spot Eq.	0.017	0.033	0.52	0.6	-0.047	0.081

Table D.11: Cointegration Coefficient

Lags in VECM	Coeff.	S.E.	t-stat	P-Value	Upper Bound	Lower Bound
1	0.944	0.021	45.100	0.000	0.985	0.903
2	0.947	0.017	55.310	0.000	0.981	0.914
3	0.946	0.015	63.330	0.000	0.975	0.917
4	0.943	0.012	75.650	0.000	0.968	0.919
5	0.944	0.008	114.120	0.000	0.961	0.928
6	0.948	0.009	110.140	0.000	0.965	0.931
7	0.956	0.013	71.180	0.000	0.982	0.930
8	0.965	0.009	102.170	0.000	0.984	0.947
9	0.962	0.012	81.460	0.000	0.985	0.939
10	0.964	0.010	98.970	0.000	0.983	0.945
11	0.963	0.009	104.360	0.000	0.981	0.945
12	0.959	0.008	115.580	0.000	0.975	0.943

Appendix E

Country	2005	2006	2007	2008	2009
Argentina	9.64	10.90	8.83	8.58	6.27
Brazil	6.87	4.18	3.64	5.66	4.89
Uruguay	4.70	6.40	8.11	7.86	7.10

Source: International Financial Statistics, IMF. Figures are in percentage changes.

Table E.1: CPI Inflation Rate

Table E.2: Summary of the Literature Exploiting Survey Data on Expectations

Author	**ER**	**S. Period**	**Horizon**	**PST?**	**UT?**	**Error Orthog.?**	**Exp. Formation?**
Frankel and Froot (1986)	4/5 pairs	1983-1984	1, 2 W 1, 3, 6, 12 M	Yes. Finds support	Yes. Finds bias. due to expect.	Yes Rejects.	No
Frankel and Froot (1987)	4/5 pairs	1983-1984	1, 2 W 1, 3, 6, 12 M	No	Yes. Finds bias.	No.	Yes. No Bandwagon.
Dominguez (1986)	Four pairs	1984-1986	1, 2 W	No	Yes. Finds bias.	Yes. Weak and Semi-Str. Rejects orthog.	No.
MacDonald and Torrance (1988)	DM/USD	Feb85-Dec86	1, 4 W	No.	Yes. Using FP and Surv.Data. Finds biases in both cases.	Yes. Weak and Semi-Str. Rej. orthog.	Yes. Extrap. but low t stats.
Frankel and Froot (1990)	5 pairs	Jun81-Aug88	3, 6, 12M	Yes. Finds support	Yes. Finds bias.	Yes Rejects.	Yes. BW short Hor. Stab. longer Hor.
MacDonald and Torrance (1990)	Four Curr.	Jul82-Feb85	1 W, 1M	Yes. Rejects.	Yes. Finds biases.	Yes. Semi-Str. Rej. orthog.	No
MacDonald (1990)	BP/USD, DM/USD, JY/USD, SF/USD	Jul84-Apr87	1 W, 1 M	No.	Yes. Finds bias.	Yes. Weak and semi str. Rej. with FP, not with f.e.	No.
Cavaglia et al. (1993)	8 currencies/DM 10 currencies/USD	Jan86-Dec90	3, 6, 12 M	No.	Bias: Peso prob. . and heterog may explain without irrationality	Yes. Semi-Str. Rej. orthog.	Yes. Non-EMS ER: extrap & adapt,. EMS: LR fundam.
Cavaglia et al. (1994)	8 currencies/DM 10 currencies/USD	Jan86-Dec90	3, 6, 12 M	Yes. Rej.	No.	Yes. Semi-Str. Rej. orthog.	No.
Chinn and Frankel (1994)	25 ER	Feb88-Feb91	3, 12 M	No	Yes. Finds bias.	Yes. Semi-Str. Rejects orthog.	No.
Sobiechowski (1996)	23 currencies/USD	Feb88-Feb92	1, 3, 6, 12 M	No	Yes. Finds bias, but $\beta \geq 0$. Smaller bias for developing count.	Yes.Weak and Semi-Str. Often Rej. orthog.	No
Lim and McKenzie (1998)	US/A$ and YEN/US	Jan87-Sep91	1, 4 W	No	Unbiased forecast. Evid. of no serial correl in 7/8 cases.	No	No
Verschoor and Wolff (2001)	NorKr/USD, SweKr /USD SweKr/DM	Jan86-May92	3, 6, 12 M	Yes. Rej.	Yes. Finds slight bias, but right sign.	Rej. orthog. in some cases.	No.

Notes: ER stands for "Bilateral exchange rates considered", S. Period: "Sample Period", PST: "Perfect Substitutability Test", UT: Unbiasedness Tests, W=Week, M=Month