Essays on International Finance

by

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Declaration

I declare that any material contained in this thesis has not been submitted for a degree to any other university. I further declare that one paper titled "What Drives International Portfolio Flows?", drawn from Chapter One of this thesis, is co-authored with Lucio Sarno and Ilias Tsiakas.

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Abstract

This thesis comprises three essays on international finance, focusing on international capital flows, foreign exchange market and official foreign exchange intervention. The first chapter assesses the relative contribution of common (push) and country specific (pull) factors to the variation of bond and equity flows from the US to 55 other countries. Using a Bayesian dynamic latent factor model, we find that more than 80% of the variation in bond and equity flows is due to push factors from the US to other countries. Hence global economic forces seem to prevail over domestic economic forces in explaining movements in international portfolio flows. The dynamics of push and pull factors can be partially explained by US and foreign macroeconomic indicators respectively.

The second chapter presents new evidence on the microstructure of exchange rates in emerging markets. Using a novel dataset that records all spot US dollar transactions in the Chilean foreign exchange intraday market over 4 weeks in 2008 and 6 weeks in 2009, we investigate the relationship between exchange rates and order flows. We find supporting evidence that the contemporaneous relationship between exchange rates and order flows is time-varying. In this market, interbank order flow only accounts for a small portion of the exchange rate impact of total order flow, and the central bank orders influence private order flow behaviour. Compared to advanced economies, cointegration tests and long run relationship estimations between exchange rate and order flow indicate slow reversion from long run trend deviations.

In the third chapter, we examine the intraday effects and success rates of official intervention in the Chilean foreign exchange market. The impact of official intervention on exchange rate daily returns has been widely revised in the literature, confirming in many cases the signalling channel for the transmission of the intervention effects. Our investigation at a higher frequency indicates that microstructure channels also work for the Chilean case. Specifically, the central bank's order flow directly affects the exchange rate returns contemporaneously and within a 2 hours range around the intervention event. In addition, actual interventions affect the price impact of private order flows, and are successful at moderating its trend.

Overview

This thesis comprises three essays on international finance, focusing on international capital flows, foreign exchange market and official foreign exchange intervention. What drives international portfolio flows? This is an important question that lies at the center of a long-standing debate in international economic policy and research. The overall level of international capital flows (that includes foreign direct investment and portfolio flows) has risen dramatically over the years, from an average of less than 5 percent of global GDP during 1980-1999 to a peak of about 20 percent by 2007 (IMF, 2012). In the context of an increasingly globalized world with a high degree of international capital mobility, portfolio flows can have a significant effect on domestic asset prices and economic growth prospects. For example, a surge in portfolio inflows can lead to a real estate boom and inflation, whereas a sudden stop can lead to slow growth, higher interest rates and a sharp currency depreciation. It is therefore critical for recipient countries to be able to manage to some extent the size, direction and volatility of international flows. Understanding the dynamic determinants of international portfolio flows can help countries design an effective policy mix that may consist of structural reforms, targeted macroeconomic policies or capital controls.[1]

The literature typically distinguishes between two types of determinants for in-

[1]For instance, countries may implement a combination of the following: structural reforms that increase the capacity of their domestic capital markets or improve the transparency of the regulatory framework; macroeconomic policies such as accumulating reserves or allowing their currency to appreciate; and different types of capital controls such as discriminating financial activity on the basis of residency, differentiating transactions on the basis of currency or imposing minimum holding periods and taxes in certain investments (IMF, 2011). See also Cardarelli, Elekdag, and Kose (2010) and Kose, Prasad, Rogoff, and Wei (2010) for the macroeconomic implications and policy responses to surges in capital flows.

ternational capital flows: push factors and pull factors (see, e.g., Calvo, Leiderman, and Reinhart, 1996; Fernandez-Arias, 1996; Taylor and Sarno, 1997; Agénor, 1998; Chuhan, Claessens, and Mamingi, 1998; Forbes and Warnock, 2012; Fratzscher, 2012).[2] Push factors reflect the global economic forces that push capital flows from the US to other countries, and may be related to low US interest rates, low US potential growth, low global risk aversion and international portfolio diversification. Pull factors reflect the domestic economic forces that pull capital into a country and hence capture the relative attractiveness of different destinations for investment opportunities. These factors include high domestic interest rates, low domestic inflation, high potential growth and trade openness. In other words, push factors are external to the economies receiving the flows, whereas pull factors are internal to these economies.[3]

Building on a large literature in international economics, the first chapter empirically assesses the relative contribution of push and pull factors to the variation of international portfolio flows. In particular, we focus on monthly bond and equity flows from the US to 55 other countries for the period of January 1988 to July 2009. The main contribution of our empirical analysis is the use of a dynamic latent factor model, which is designed to separate the common from the country-specific components of movements in international portfolio flows. This is a sophisticated and flexible model that is used for the first time in the study of international portfolio flows.[4] More importantly, the dynamic factor model allows us to provide a comprehensive answer to the initial question of what drives international bond and

[2]Literature related to this explores the role of contagion in the context of push and pull factors (e.g. Forbes and Chinn, 2004). For studies of cross-border equity flows, see Griffin, Nardari, and Stulz (2004), Portes and Rey (2005), Goldstein, Razin, and Tong (2008), Hau and Rey (2008), and Tong and Wei (2011).

[3]Consistent with the broad literature on capital flows, we use the terms "global" and "US" interchangeably. This is a sensible convention because the data are portfolio flows from the US to 55 other countries. Having said that, we certainly recognize that the US does not fully capture global economic forces.

[4]For example, Kose, Otrok, and Whiteman (2003, 2008) employ this dynamic factor model to estimate common components in aggregate output, consumption and investment across countries.

equity flows. The model specifies three types of latent persistent factors, which are independent of one another: (i) the global factor that is common to all countries and all flows; (ii) two asset-specific (or flow-specific) factors, one that is common to all bond flows and one that is common to all equity flows; and (iii) a set of 55 country-specific factors. The contribution of the push factor to the variation of bond flows is captured by the global and bond factors, whereas the push factor for equity flows is captured by the global and equity factors. The pull factor is simply the same as the model's country-specific factor.

The model is highly flexible as it can deal with a large cross-section of countries over a long sample period for two types of portfolio flows.[5] More importantly, it specifies latent factors that capture the different types of common and country-specific variation without having to rely on a limited number of relevant observed macroeconomic variables that may not capture the full effect of push and pull factors. The high flexibility of the model comes at the cost of being high dimensional: for two types of flows and 55 countries, it requires estimation of 397 parameters. We estimate the parameters of the dynamic factor model using the Bayesian Monte Carlo Markov Chain (MCMC) algorithm of Kose *et al.* (2003, 2008), which builds on the procedures developed by Otrok and Whiteman (1998). Bayesian estimation offers the advantage of dealing effectively with the high dimension of the model and making estimation feasible and efficient.

Our main finding is that for both bond and equity flows the push factor tends to contribute more than 80% to the variance in international portfolio flows, whereas the pull factor contributes less than 20%. In fact, for more than half of the countries, the push factor contribution is higher than 90%. Over the past 20 years, therefore, global economic forces seem to prevail over domestic economic forces in explaining movements in international portfolio flows. Overall, the contribution of the push

[5]Prior literature has typically dealt with few countries over shorter sample periods using less general factor specifications. See, for example, Sarno and Taylor (1999).

factor tends to be slightly higher for equity flows (89% on average across all countries) than for bond flows (83%). However, the regional variation is more pronounced for bond flows: for example, countries that belong to the G8, the G20 and the BRICS tend to have a lower push factor (and hence a higher pull factor) than the other countries.[6] Furthermore, over the crisis period of July 2007 to March 2009 the role of the push factor diminishes as, on average, the contribution of the pull factor to the variance of flows effectively doubles. Finally, countries with very high or very low interest rates that are typically involved in the foreign exchange carry trade tend to have a pull factor that is considerably above the world average.

We also find that the push factor for bond and equity flows is significantly related to US macroeconomic variables such as industrial production, interest rates, stock market performance, and measures of market volatility and liquidity. Similarly, the pull factor can be explained by domestic macroeconomic variables such as the growth rate, interest rates, stock market performance and the Chinn and Ito (2008) measure of capital account openness. Note, however, that observed macroeconomic indicators can account for about half of the variation of the latent push factors and about 10% of the variation of the latent pull factors. This provides further justification for adopting a latent factor approach.

Our empirical analysis provides results for 55 countries and several groupings of countries based on geography or economic development. This makes it rather impractical to provide an in-depth discussion of the implications of our findings for each particular country. For this reason, we discuss in greater depth our results for three prominent emerging economies: China, India and Brazil. These countries belong to the G20, are members of the BRICS and, due to their fast-growing economies in recent years, have emerged as global economic powerhouses. For example, it is interesting to note that the three countries exhibit different patterns as the pull factor

[6]The BRICS are five large emerging economies that include Brazil, Russia, India, China and South Africa.

for bond flows is extremely high in Brazil, close to the world average for China and well below average for India. Our country analysis provides further details on what can potentially explain these differences.

The first chapter of this thesis is especially related to two recent studies. First, Fratzscher (2012) provides a similar analysis by identifying the relative importance of push and pull factors in weekly portfolio flows based on a large cross-section of bond and equity funds from 50 countries. The analysis of Fratzscher (2012), however, substantially deviates from our chapter in a number of ways: (i) it uses data on individual mutual funds and hedge funds rather than country-level portfolio flows; (ii) it focuses on the recent global financial crisis using a much shorter 5-year sample from 2005 to 2010; and (iii) it relies exclusively on few observed macroeconomic variables to capture the push and pull factors with particular emphasis on global risk and liquidity variables. Consistent with one of our results, Fratzscher (2012) finds that push factors capture most of the variation of flows before and during the crisis (65% and 73% respectively), but after the crisis pull factors are more important (55%) than push factors (45%).

Second, Forbes and Warnock (2012) use 30 years of quarterly data on gross inflows and outflows to analyze waves in international capital flows. They identify episodes of "surge", "stop", "flight" and "retrenchment" as measures of sharp increases (or decreases) in gross capital inflows (or outflows). Forbes and Warnock (2012) also find that global factors, and especially global risk, are the key determinants of waves in international capital flows, while domestic factors are generally insignificant.

More generally, our analysis is highly related to a recent global policy debate culminating in November 2012, when the International Monetary Fund (IMF) published its new institutional view on how to manage and control international capital flows. This view states that "[t]he IMF has developed a comprehensive, flexible, and balanced view on the management of global capital flows to help give countries

clear and consistent policy advice."[7] Indeed, the new view of the IMF constitutes a historical shift, as after years of calling for the abolition of capital controls, the IMF agreed that capital controls may be a useful tool for managing inflows and may be used on a case-by-case basis in appropriate circumstances.[8]

The institutional view of the IMF is consistent with two implications of our main empirical finding. First, if global economic forces are the primary drivers of international portfolio flows, then an effective policy mix for managing these flows should include capital controls. And second, targeted domestic macroeconomic policies have a rather limited role in determining international portfolio flows. Therefore, although we do not provide direct evidence on the effectiveness of capital controls, our empirical results show the predominance of the push over the pull factor, and hence support the new institutional view of the IMF that capital controls may indeed be a useful tool for managing flows.

The second chapter of this thesis presents new evidence on the microstructure of exchange rates in emerging markets through investigating the relationship between exchange rates and order flows in Chile. Understanding the associations between exchange rates and order flow[9] in different markets has been a concern amongst researchers for several reasons. Firstly, examining the explanatory power of order flow for exchange rate has allowed literature on exchange rate modelling to solve differences between theoretical models and empirical findings. Thus considering order flow as a key determinant of exchange rate returns could improve policy and investment assessments. Secondly, research on the interrelations between order flow

[7] See IMFSurvey (2012).

[8] Key features of the IMF institutional view include: (i) a recognition that capital flows can have both substantial benefits and risks for countries; (ii) capital flow liberalization is generally more beneficial for countries that have surpassed a certain threshold of financial and institutional development; (iii) liberalization needs to be well planned, timed and sequenced, especially for countries with long-standing measures to limit capital flows; and (iv) rapid capital inflow surges require appropriate policy responses both for recipient countries of capital flows and for countries from which flows originate. For a recent discussion of monetary, macroprudential and financial policies, see also Gourinchas and Kose (2011), and Gourinchas, Kose, and Claessens (2012).

[9] Order flow is the net of buyer-initiated orders and seller-initiated orders.

and exchange rate also provides evidence regarding price formation and market participant dynamics.

Several studies have addressed microstructure questions in the context of exchange rates for developed countries. Data limitations have constrained research on emerging market economies (EMEs) using a microstructure approach. However, knowledge on EMEs have become more valuable recently, as these countries have experienced increasing participation in the global economy, shown resilience during the global crisis, and in some cases become strongly financially developed (Kose and Prasad, 2010).

Our research aims to contribute to the literature with new empirical evidence about EMEs through the analysis of the associations between exchange rates and order flow in the Chilean Foreign Exchange (FX) market. Chile is a small open economy under inflation target and flexible exchange rate regimes, and one of the largest copper producer countries in the world. Furthermore, one of the few countries that used official FX intervention as unconventional policy response during 2008-2009 financial crisis. In addition, we count with a novel dataset at tick frequency which to the best of our knowledge has never been analysed before. We propose to answer the following questions: What is the contemporaneous relationship between order flow and exchange rate movements in the Chilean FX market? Are there non-linearities in the order flow impact on exchange rate? Is there an anticipation, pressure or feedback effect? Is there evidence of the degree of informativeness behind the order flow of different participants? Is there a long-run relationship between order flow and exchange rates? In doing so, we aim to provide directions for the development of FX microstructure research for other EMEs.

The association between order flow and exchange rates has been extensively documented. In their seminal paper, Evans and Lyons (2002b) analyse the contemporaneous relationship between the Deutsche mark - US dollar (USD) rate and order

flow, and show that interdealer order flow has strong explanatory power for exchange rate returns at daily frequency. Whilst Evans and Lyons (2005, 2006, 2008) have further analysed the features of their micro-based model, several other studies have confirmed the link between order flow and exchange rate for other currency pairs.[10] In this setting, causality runs strictly from order flow to price, which is consistent with all the canonical models (see, e.g., Glosten and Milgrom, 1985; Kyle, 1985), where price innovations are a function of order flow innovations. In these models, the underlying driver of order flow is non-publicly available information, such as uncertain demands or payoffs, and order flows are the channel through which this type of information is incorporated into prices.

However, the timing of order flow in relation to price adjustments can be seen in three ways: (1) order flow precedes price adjustments; (2) order flow is concurrent with price adjustments; (3) order flow lags price adjustments. These three adjustment mechanisms are known respectively as the *anticipation*, *pressure*, and *feedback* hypotheses. Statistically, they translate into three possible causality patterns: the first hypothesis implies that order flow causes prices changes; the second allows for bi-directional causality; the third implies that price adjustment causes order flows. Empirically, these causality patterns between order flow and exchange rate returns have been examined for the French franc - Deutsche mark rate by Killeen *et al.* (2006). They find that, under a flexible exchange rate regime, order flow Granger causes returns, but not the other way round. However, Daníelsson and Love (2006) argue that feedback trading is an inevitable result when aggregating the data. Furthermore, Sager and Taylor (2006) proposes that in the FX market there are *push* and *pull* customers. The former initiate price rises and falls, the latter are those

[10] In fact, there is a large list of papers that examine the relationship between exchange rate and order flow from different perspectives and using different estimation strategies. Some relevant papers for this study are Payne (2003), Bjønnes, Rime, and Solheim (2005), Boyer and van Norden (2006), Daníelsson and Love (2006), Killeen, Lyons, and Moore (2006), Berger, Chaboud, Chernenko, Howorka, and Wright (2008), King, Sarno, and Sojli (2010), and Chinn and Moore (2011).

agents that are attracted by these movements in prices.

Indeed, the price impact of order flow can vary with agent types. Osler (2008) explains that opposite price impacts of commercial and financial customers order flow are due to the nature of their trade responses, i.e. whether they are driven by demand pressures of goods or assets. Bjønnes *et al.* (2005) observe that the different relationships between exchange rates and financial or non-financial customer order flow indicate the side from which liquidity is provided. King *et al.* (2010) note that the order flow of financial clients are always positively related to exchange rate returns and those of commercial clients are negatively related. This is due to the fact that commercial and non-financial clients are liquidity providers, matching the financial client demands.

Besides the different disaggregated order flow effects on exchange rates, it has also been seen that the price impact can vary throughout the day and across time (see, e.g., Berger *et al.* 2008). In addition, the goodness of fit of such linear models usually improves at lower frequencies, benefit that arises with the reduction of microstructure noise.[11] Knowledge on the relationship between order flow and exchange rate has also been enriched with the investigation of short versus long-run relationships. Studies of this kind usually test for cointegrating relationships between exchange rate and the order flow accumulated from a fixed initial period in each point in time (see, e.g., Bjønnes *et al.*, 2005; Boyer and van Norden, 2006; Killeen *et al.*, 2006; Berger *et al.*, 2008; and Chinn and Moore, 2011). Most of the cases, a long-run relationship between order flow and exchange rate cannot be rejected.

There are not many studies on FX microstructure available for EMEs. For instance, the cases of Brazil, Czech Republic and Russia are studies by Wu (2012), Scalia (2008) and Melvin, Menkhoff, and Schmeling (2009) respectively. The find-

[11] Bacchetta and Wincoop (2006) provide a broader framework in which they note that changes in horizon would impact the strength of the relationship between exchange rates and order flow.

ings for different EMEs have differed and led to ambiguous evidence for this group of countries. In fact, Menkhoff and Schmeling (2008) examine the permanence of the order flow effects on price for different countries, concluding that the effects of order flows on exchange rate returns vary across regions. Therefore, relying on the literature to characterise the Chilean FX market is not plausible. There are no studies on the intraday behaviour of its FX market in a microstructure framework for the Chilean case.[12] Hence examining the relationship between exchange rate and order flow in this market is both a contribution to the literature and of interest for policy makers.

The data we employ in this chapter records all spot USD transactions in terms of Chilean pesos (CLP) in the Chilean FX market during two periods of time: July 2008, and June to mid July 2009. These data consist of price and volume for each transaction recorded, the exact time at which each transaction was executed, the trader category for each transaction, and the type of transactions (sell or buy). The type of transactions allows us to construct an order flow series and investigate its relationship with exchange rate returns. Combining the several approaches mentioned above in the context of the intraday CLP/USD market, our findings are listed as follows. First, we find evidence supporting the contemporaneous relationship between exchange rate returns and order flow found in the literature at different frequencies. That is, net purchases of CLP are associated with appreciation of the Chilean currency. Second, we also evaluate the time-of-the-day effect on the relationship between exchange rate returns and order flow. We find that the more active the market is the lower the impact of order flow on exchange rate returns. This coincides with the liquidity patterns throughout the day and is consistent with the findings of Payne (2003) and Berger *et al.* (2008). Furthermore, a rolling window estima-

[12]The available studies for the FX market in Chile are by Tapia and Tokman (2004), Schmidt-Hebbel (2006), Abarca, Alarcón, Pincheira, and Selaive (2007) and Cowan, Rappoport, and Selaive (2007). Of these studies, none analyse the market intraday features, nor focus on the relationship between exchange rate and order flow.

tion suggests that the effects of order flow varied throughout each sample analysed. Third, Granger causality tests support the anticipation hypothesis found in most of the literature for major currencies, and remain unaltered when considering only interbank trading activity. As throughout the analysed period the Central Bank of Chile (CBC) also carried out interventions, we also evaluate the causality dynamics between private order flow and the CBC order flow: Granger causality tests provide evidence of causality from order flows of CBC to the rest of the market in 2008. Fourth, we evaluate the impact of order flow of different market participants, finding that interbank trades have a much smaller effect on exchange rate returns than total order flow. We observe that the inclusion of the CBC order flow dampens the effect of private order flow. Additionally, we find that a decrease of 1 minute in the average trading intensity is associated with an extra increase in exchange rate return of over 10 basis points. Fifth, our examination of the existence of cointegration relationships between exchange rate and cumulative order flow through the estimation of a Vector Error Correction Model (VECM) suggested by Johansen cointegration tests indicates that between 0.2% and 0.4% of the deviations from a long-run trend dissipate each 15 minutes.

In the third chapter of this thesis, we examine the intraday effects and success rates of official intervention in the Chilean foreign exchange market. What are the effects of official intervention in FX markets? This question has motivated researchers and policy makers for many years generating a wide range of literature on the topic, mainly for advanced economies. However, in the last decade FX intervention had become more popular amongst developing economies compared to the developed world, particularly after the latest global financial crisis, when FX intervention has been one of the main policy responses of EMEs (Ishii, Canales-Kriljenko, Guimarães, and Karacadag, 2006; Menkhoff, 2012). Intervention in the FX market occurs for different reasons, such as to stabilise a misaligned exchange rate, calm stressed markets,

or accumulate international reserves (Ishii *et al.*, 2006).[13] Therefore, a comprehensive examination of the effects of FX intervention on all aspects of FX markets is necessary in order to assess whether this policy response has improved the market's condition beyond having moved the target towards the desired direction.

The literature in this field usually focuses on understanding through which channel sterilised FX intervention[14] is most effective. According to the literature, these channels are: portfolio balance, signaling or expectations, co-ordination, and order flow or microstructure channels (see, e.g., Sarno and Taylor, 2001; Archer, 2005). The portfolio balance channel suggests that the sterilisation operations alter the composition of the portfolios of the agents in the economy. The signalling or expectations channel suggests that agents change their exchange rate expectations responding to communication of policy decisions. This channel is seen as effective when intervention announcements are followed by unusual daily changes in the exchange rate. The co-ordination channel suggests that monetary authorities' communications that are co-ordinated with market views help moving the target in a desired direction. The order flow or microstructure channel suggests that interventions alter the order flow dynamics in the domestic FX market when the monetary authority places its own orders as part of the intervention programme. Neely (2008) surveys a heterogeneous sample of 22 central banks in order to capture their beliefs on the effects of FX intervention. In his study, most central banks usually agree that intervention affects exchange rates through co-ordination and signaling channels.[15]

Typically, the effectiveness of an intervention in the FX market is measured by

[13] In other words, FX intervention can be seen as an alternative or complementary policy tool against inflation in periods of turmoil, for example, when misalignments of the exchange rate require changes in interest rates that are not consistent with output gap and inflationary pressures.

[14] In most cases, policy makers that choose to intervene in the FX market opt for sterilised intervention. Sterilised intervention occurs when the monetary authority complements orders in the FX market with operations involving other assets, in order to offset the effects of changes in official foreign asset holdings on the domestic monetary base.

[15] These beliefs are supported by the literature for advanced economies. For instance, Beine, Bos, and Laurent (2007) find evidence supporting the signalling channel, and Reitz and Taylor (2008) provide evidence in favour of the coordination channel.

its effect on the level or volatility of the exchange rate. For instance, an intervention consisting of selling (purchasing) foreign currency would expect the domestic currency to appreciate (depreciate) with respect to the foreign currency sold (purchased). Moreover, the intervention can be carried out in order to accelerate, moderate or reverse an appreciation or depreciation trend. With respect to the volatility, usually a reduction is expected with the intervention (see, e.g., Payne and Vitale, 2003; Dominguez, 2006; Dominguez and Panthaki, 2007; Fratzscher, 2005, 2006, 2008; Fatum, 2008; Neely, 2011).

In addition, evidence suggesting that FX intervention can increase volatility in the short run and affect other currencies has been found.[16] Furthermore, the literature suggests that oral interventions in advanced economies are more effective than actual interventions, and that intervention effectiveness increases when there is co-ordination amongst central banks, or in periods of high volatility and market uncertainty (see, e.g., Payne and Vitale, 2003; Dominguez, 2006: Dominguez and Panthaki, 2007; Fratzscher, 2008). There is also evidence on the effects of interventions on trading dynamics. Dominguez and Panthaki (2007) find that FX intervention impacts the trading frequency of intraday operations. Fatum and Pedersen (2009) and Fatum, Pedersen, and Sørensen (2013) find that unannounced interventions have an effect on the market perception, thus affecting exchange rate spreads. Marsh (2011) finds that the relationship between the exchange rate and order flow varies during intervention periods.

Emerging markets are interesting cases of study. Usually, their currency markets are smaller than those of advanced economies. Therefore, central bank interventions could be more effective (for instance, through the portfolio channel) compared to

[16] In his survey, Neely (2008) indicates that central banks mostly agree that intervention affects currencies other than the one in which it is conducted, and it is effective on reducing (or at least not increasing) its volatility and restoring liquidity. Beine *et al.* (2007) also show that intervention tends to primarily raise volatility, whilst Nikkinen and Vähämaa (2009) notes that intervention ultimately increases the correlation between the domestic currency with foreign currencies other than the one purchased.

the effects that actions of monetary authorities in advanced economies could have on their currency markets. However, most of the papers available analyse the impact of intervention on FX markets using daily data for advanced economies, who intervene on a regular basis, or whose data is publicly available. For developing countries, interventions occur more sporadically, hence research on the effects of intervention on their FX market is rare. This gap in the literature may be due to both data availability issues and the scarcity of intervention events.[17] Overall, the evidence found for EMEs is mixed. On the one hand, in most of the cases announcements have an impact on exchange rate returns. On the other hand, actual interventions could in some cases move the exchange rate levels, reduce its short-term volatility and spreads, and change the price impact of private order flows. However in other cases a reversal or slowing down of the appreciation trend is not obtained and increases in volatilities are observed.

In this chapter, we investigate the effects of official interventions in the Chilean FX market at intraday frequency. Since the adoption of a flexible exchange rate regime, the Chilean monetary authority kept its right to intervene in the FX market. However, it had not actively participated nor intervened in the market for several years until the early signs of the last global financial crisis. When it did intervene, in 2008 and 2011, these policy responses were previously announced as precautionary actions of international reserve accumulation.[18] Chile is an inflation-targeting small open economy, whose real sector strength relies heavily on commodity trade (copper), and official intervention is discretional yet pre-announced. There is not

[17] Recent theoretical papers that study the intervention strategies of EMEs focus on modelling these economies assuming that their unconventional monetary policy responses are driven by exchange rate rules (see, e.g., Parrado, 2004; Ho, 2004; Galí and Monacelli, 2005; Kumhof, 2010; Benigno and Fornaro, 2012; Benes, Berg, Portillo, and Vavra, 2013). However, given the heterogeneous nature of the intervention mechanisms observed in the developing world, such theoretical models lack applicability. Unfortunately, comprehensive empirical work on FX intervention of EMEs has been limited. The most common country cases studied are: Brazil, Colombia, Czech Republic, Mexico, Russia, and Turkey. We expose a more comprehensive literature review on intervention in EMEs in Section 2.

[18] In addition, the intervention in 2011, was the largest in terms of duration in the Chilean history.

much work focussing on the effects of intervention on the Chilean FX market during and posterior to the financial crisis at a microstructural level.[19] Given the lack of research available for Chile and the novelty of our data, we believe that this chapter contributes to the literature on official intervention with new evidence that provides some directions for other EMEs.

For our analysis, we continue to explore our novel dataset that records all spot USD transactions in the Chilean FX market during two subperiods within 2008 and 2009 respectively. Our intraday data report price, volume and type of each transaction, and the exact time of transaction. The characteristics of this dataset allows us to analyse the impact of intervention from different perspectives: first, we evaluate the effect of central bank order flow on exchange rate returns through linear regression analysis;[20] then we carry out an event study where we incorporate leads and lags of intervention into the order flow regressions in order to examine time delay/anticipation of the effect of intervention on intraday exchange rate returns. Last, we examine the effectiveness of intervention in 2008 and the effects of central bank trades in 2009, according to the different success criteria for exchange rate movements and order flow changes. We find that the impact of central bank order flows on the intraday returns of the spot rate is significant but small in comparison with the effects of the order flows of other agent types. Central bank order flows also have an indirect impact in the private order flow dynamics, which corroborates intervention effectiveness through microstructure channel. Furthermore, our event study on an intraday basis shows that the effect of the participation of the central bank in the market is incorporated two hours prior to its occurrence when precautionary intervention takes place. Finally, the rates of intervention success indicate that intervention is successful in moderating exchange rate and order flow trends.

[19] The existing studies for Chile are by Morandé and Tapia (2002), Gregorio and Tokman (2004), Tapia and Tokman (2004) and Schmidt-Hebbel (2006). These studies provide a description of the effectiveness of interventions and announcements up to 2004, using daily data.

[20] Expanding the work done in chapter 2 of this thesis.

Chapter 1

What Drives International Portfolio Flows?

1.1 Introduction

What drives international portfolio flows? This is an important question that lies at the center of a long-standing debate in international economic policy and research. The overall level of international capital flows (that includes foreign direct investment and portfolio flows) has risen dramatically over the years, from an average of less than 5 percent of global GDP during 1980-1999 to a peak of about 20 percent by 2007 (IMF, 2012). In the context of an increasingly globalized world with a high degree of international capital mobility, portfolio flows can have a significant effect on domestic asset prices and economic growth prospects. For example, a surge in portfolio inflows can lead to a real estate boom and inflation, whereas a sudden stop can lead to slow growth, higher interest rates and a sharp currency depreciation. It is therefore critical for recipient countries to be able to manage to some extent the size, direction and volatility of international flows. Understanding the dynamic determinants of international portfolio flows can help countries design an effective policy mix that may consist of structural reforms, targeted macroeconomic policies or capital controls.[1]

[1]For instance, countries may implement a combination of the following: structural reforms that increase the capacity of their domestic capital markets or improve the transparency of the regulatory framework; macroeconomic policies such as accumulating reserves or allowing their currency to appreciate; and different types of capital controls such as discriminating financial activity on the basis of residency, differentiating transactions on the basis of currency or imposing minimum holding periods and taxes in certain investments (IMF, 2011). See also Cardarelli, Elekdag, and Kose (2010)

The literature typically distinguishes between two types of determinants for international capital flows: push factors and pull factors (see, e.g., Calvo, Leiderman, and Reinhart, 1996; Fernandez-Arias, 1996; Taylor and Sarno, 1997; Agénor, 1998; Chuhan, Claessens, and Mamingi, 1998; Forbes and Warnock, 2012; Fratzscher, 2012).[2] Push factors reflect the global economic forces that push capital flows from the US to other countries, and may be related to low US interest rates, low US potential growth, low global risk aversion and international portfolio diversification. Pull factors reflect the domestic economic forces that pull capital into a country and hence capture the relative attractiveness of different destinations for investment opportunities. These factors include high domestic interest rates, low domestic inflation, high potential growth and trade openness. In other words, push factors are external to the economies receiving the flows, whereas pull factors are internal to these economies.[3]

Building on a large literature in international economics, this chapter empirically assesses the relative contribution of push and pull factors to the variation of international portfolio flows. In particular, we focus on monthly bond and equity flows from the US to 55 other countries for the period of January 1988 to July 2009. The main contribution of our empirical analysis is the use of a dynamic latent factor model, which is designed to separate the common from the country-specific components of movements in international portfolio flows. This is a sophisticated and flexible model that is used for the first time in the study of international portfolio flows.[4] More importantly, the dynamic factor model allows us to provide a comprehensive

and Kose, Prasad, Rogoff, and Wei (2010) for the macroeconomic implications and policy responses to surges in capital flows.

[2] A related literature explores the role of contagion in the context of push and pull factors (e.g. Forbes and Chinn, 2004). For studies of cross-border equity flows, see Griffin, Nardari, and Stulz (2004), Portes and Rey (2005), Goldstein, Razin, and Tong (2008), Hau and Rey (2008), and Tong and Wei (2011).

[3] Consistent with the broad literature on capital flows, we use the terms "global" and "US" interchangeably. This is a sensible convention because the data are portfolio flows from the US to 55 other countries. Having said that, we certainly recognize that the US does not fully capture global economic forces.

[4] For example, Kose, Otrok, and Whiteman (2003, 2008) employ this dynamic factor model to estimate common components in aggregate output, consumption and investment across countries.

answer to the initial question of what drives international bond and equity flows. The model specifies three types of latent persistent factors, which are independent of one another: (i) the global factor that is common to all countries and all flows; (ii) two asset-specific (or flow-specific) factors, one that is common to all bond flows and one that is common to all equity flows; and (iii) a set of 55 country-specific factors. The contribution of the push factor to the variation of bond flows is captured by the global and bond factors, whereas the push factor for equity flows is captured by the global and equity factors. The pull factor is simply the same as the model's country-specific factor.

The model is highly flexible as it can deal with a large cross-section of countries over a long sample period for two types of portfolio flows.[5] More importantly, it specifies latent factors that capture the different types of common and country-specific variation without having to rely on a limited number of relevant observed macroeconomic variables that may not capture the full effect of push and pull factors. The high flexibility of the model comes at the cost of being high dimensional: for two types of flows and 55 countries, it requires estimation of 397 parameters. We estimate the parameters of the dynamic factor model using the Bayesian Monte Carlo Markov Chain (MCMC) algorithm of Kose *et al.* (2003, 2008), which builds on the procedures developed by Otrok and Whiteman (1998). Bayesian estimation offers the advantage of dealing effectively with the high dimension of the model and making estimation feasible and efficient.

Our main finding is that for both bond and equity flows the push factor tends to contribute more than 80% to the variance in international portfolio flows, whereas the pull factor contributes less than 20%. In fact, for more than half of the countries, the push factor contribution is higher than 90%. Over the past 20 years, therefore, global economic forces seem to prevail over domestic economic forces in explaining

[5]Prior literature has typically dealt with few countries over shorter sample periods using less general factor specifications. See, for example, Sarno and Taylor (1999).

movements in international portfolio flows. Overall, the contribution of the push factor tends to be slightly higher for equity flows (89% on average across all countries) than for bond flows (83%). However, the regional variation is more pronounced for bond flows: for example, countries that belong to the G8, the G20 and the BRICS tend to have a lower push factor (and hence a higher pull factor) than the other countries.[6] Furthermore, over the crisis period of July 2007 to March 2009, the role of the push factor diminishes as, on average, the contribution of the pull factor to the variance of flows effectively doubles. Finally, countries with very high or very low interest rates that are typically involved in the foreign exchange carry trade tend to have a pull factor that is considerably above the world average.

We also find that the push factor for bond and equity flows is significantly related to US macroeconomic variables such as industrial production, interest rates, stock market performance, and measures of market volatility and liquidity. Similarly, the pull factor can be explained by domestic macroeconomic variables such as the growth rate, interest rates, stock market performance and the Chinn and Ito (2008) measure of capital account openness. Note, however, that observed macroeconomic indicators can account for about half of the variation of the latent push factors and about 10% of the variation of the latent pull factors. This provides further justification for adopting a latent factor approach.

Our empirical analysis provides results for 55 countries and several groupings of countries based on geography or economic development. This makes it rather impractical to provide an in-depth discussion of the implications of our findings for each particular country. For this reason, we discuss in greater depth our results for three prominent emerging economies: China, India and Brazil. These countries belong to the G20, are members of the BRICS and, due to their fast-growing economies in recent years, have emerged as global economic powerhouses. For example, it is in-

[6]The BRICS are five large emerging economies that include Brazil, Russia, India, China and South Africa.

teresting to note that the three countries exhibit different patterns as the pull factor for bond flows is extremely high in Brazil, close to the world average for China and well below average for India. Our country analysis provides further details on what can potentially explain these differences.

This chapter is especially related to two recent studies. First, Fratzscher (2012) provides a similar analysis by identifying the relative importance of push and pull factors in weekly portfolio flows based on a large cross-section of bond and equity funds from 50 countries. The analysis of Fratzscher (2012), however, substantially deviates from our chapter in a number of ways: (i) it uses data on individual mutual funds and hedge funds rather than country-level portfolio flows; (ii) it focuses on the recent global financial crisis using a much shorter 5-year sample from 2005 to 2010; and (iii) it relies exclusively on few observed macroeconomic variables to capture the push and pull factors with particular emphasis on global risk and liquidity variables. Consistent with one of our results, Fratzscher (2012) finds that push factors capture most of the variation of flows before and during the crisis (65% and 73% respectively), but after the crisis pull factors are more important (55%) than push factors (45%).

Second, Forbes and Warnock (2012) use 30 years of quarterly data on gross inflows and outflows to analyze waves in international capital flows. They identify episodes of "surge", "stop", "flight" and "retrenchment" as measures of sharp increases (or decreases) in gross capital inflows (or outflows). Forbes and Warnock (2012) also find that global factors, and especially global risk, are the key determinants of waves in international capital flows, while domestic factors are generally insignificant.

More generally, our analysis is highly related to a recent global policy debate culminating in November 2012, when the International Monetary Fund (IMF) published its new institutional view on how to manage and control international capital flows. This view states that "[t]he IMF has developed a comprehensive, flexible, and balanced view on the management of global capital flows to help give countries

clear and consistent policy advice."[7] Indeed, the new view of the IMF constitutes a historical shift, as after years of calling for the abolition of capital controls, the IMF agreed that capital controls may be a useful tool for managing inflows and may be used on a case-by-case basis in appropriate circumstances.[8]

The institutional view of the IMF is consistent with two implications of our main empirical finding. First, if global economic forces are the primary drivers of international portfolio flows, then an effective policy mix for managing these flows should include capital controls. And second, targeted domestic macroeconomic policies have a rather limited role in determining international portfolio flows. Therefore, although we do not provide direct evidence on the effectiveness of capital controls, our empirical results show the predominance of the push over the pull factor, and hence support the new institutional view of the IMF that capital controls may indeed be a useful tool for managing flows.

The remainder of the chapter is organized as follows. In the next section we describe the dynamic latent factor model and how it is used to capture the push and pull factors. Section 1.3 briefly reviews the Bayesian estimation methodology. The data and the empirical results are discussed in Section 1.4. Section 1.5 highlights the effect of the foreign exchange carry trade in determining portfolio flows, whilst Section 1.6 analyzes in more detail three country cases: China, India and Brazil. In Section 1.7, we relate the push and pull factors to macroeconomic variables in the US and other countries. Finally, Section 1.8 summarizes the key results and concludes.

[7] See IMFSurvey (2012).

[8] Key features of the IMF institutional view include: (i) a recognition that capital flows can have both substantial benefits and risks for countries; (ii) capital flow liberalization is generally more beneficial for countries that have surpassed a certain threshold of financial and institutional development; (iii) liberalization needs to be well planned, timed and sequenced, especially for countries with long-standing measures to limit capital flows; and (iv) rapid capital inflow surges require appropriate policy responses both for recipient countries of capital flows and for countries from which flows originate. For a recent discussion of monetary, macroprudential and financial policies, see also Gourinchas and Kose (2011), and Gourinchas, Kose, and Claessens (2012).

1.2 Modeling International Portfolio Flows

1.2.1 The Dynamic Latent Factor Model

Our empirical analysis uses a linear dynamic latent factor model, which is designed to separate the common from the country-specific components of movements in international portfolio flows. The model specifies three types of latent factors, which are independent of one another: (i) a global factor that is common to all countries and all flows; (ii) two asset-specific (or flow-specific) factors, one that is common to all bond flows and one that is common to all equity flows; and (iii) a set of country-specific factors. In this model specification, the common component of bond flows is captured by the global and bond factors, whereas the common component of equity flows is captured by the global and equity factors. The country-specific factors are the idiosyncratic (or domestic) component of bond and equity flows. All factors are specified as latent persistent processes that follow a normal distribution.

Define $y_{j,n,t}$ as the international portfolio flow of type $j = 1, ..., J$, for country $n = 1..., N$ at time $t = 1, ..., T$. Our data set is for $J = 2$, where $j = 1$ denotes bond flows and $j = 2$ denotes equity flows, and all flows are from the US to $N = 55$ other countries. A positive flow is a flow from the US to another country (i.e., a US outflow), whereas a negative flow is a US inflow. The flows are in millions of US dollars. The model is specified as follows:

$$y_{j,n,t} = \beta_{0;j,n} + \beta_{1;j,n} g_t + \beta_{2;j} a_{j,t} + c_{n,t} + \varepsilon_{j,n,t}, \qquad \varepsilon_{j,n,t} \sim NID\left(0, \sigma_\varepsilon^2\right), \quad (1.1)$$

where $\beta_{0;j,n}$ is a constant, $\beta_{1;j,n}$ is the global factor loading, g_t is the global factor, $\beta_{2;j}$ is the flow-specific factor loading, $a_{j,t}$ is the flow-specific factor (i.e., $a_{1,t}$ is the bond factor and $a_{2,t}$ the equity factor), $c_{n,t}$ is the country-specific factor, and the error term $\varepsilon_{j,n,t}$ is Gaussian white noise with constant variance σ_ε^2. Note that $c_{n,t}$ is the country-specific regular (i.e., persistent and hence predictable) component and $\varepsilon_{j,n,t}$ is the country-specific irregular (i.e., random and unpredictable) component.

In this model, there is one global factor, $J = 2$ flow-specific factors and $N = 55$ country specific factors. The factor loadings are all constant over time.

The factors are persistent and follow an AR(2) process:

$$g_t = \rho_{1,g} g_{t-1} + \rho_{2,g} g_{t-2} + u_{g,t}, \tag{1.2}$$

$$a_{j,t} = \rho_{1,a_j} a_{j,t-1} + \rho_{2,a_j} a_{j,t-2} + u_{a_j,t}, \qquad j = 1, 2 \tag{1.3}$$

$$c_{n,t} = \rho_{1,c_n} c_{n,t-1} + \rho_{2,c_n} c_{n,t-2} + u_{c_n,t}, \qquad n = 1, .., N \tag{1.4}$$

where $u_{g,t} \sim NID(0, \sigma_g^2)$, $u_{a_j,t} \sim NID(0, \sigma_{a_j}^2)$, and $u_{c_n,t} \sim NID(0, \sigma_{c_n}^2)$. The factor error terms are independent to each other.[9]

For this model specification, it is straightforward to show that the factor variances are given as follows:

$$Var(g_t) = \frac{\sigma_g^2}{1 - \rho_{1,g}^2 - \rho_{2,g}^2}, \tag{1.5}$$

$$Var(a_{j,t}) = \frac{\sigma_{a_j}^2}{1 - \rho_{1,a_j}^2 - \rho_{2,a_j}^2}, \qquad j = 1, 2 \tag{1.6}$$

$$Var(c_{n,t}) = \frac{\sigma_{c_n}^2}{1 - \rho_{1,c_n}^2 - \rho_{2,c_n}^2}, \qquad n = 1, .., N. \tag{1.7}$$

The structure described so far does not uniquely identify a factor model as there is an indeterminacy on the factor rotation. This implies that the sign and the scale of each dynamic factor is not separately identified from that of its factor loading. Following Kose *et al.* (2003, 2008), we solve the sign problem by requiring the first element of each vector of factor loadings to be positive, and the scale problem by setting the variance of the innovations to each factor $\left\{\sigma_g^2, \sigma_{a_j}^2, \sigma_{c_n}^2\right\}$ to be constant.

The dynamic factor model is high-dimensional. It requires estimation of the parameters $\Theta = \left\{B, \rho, \sigma^2\right\}$:

- $B = (\beta_0, \beta_1, \beta_2)$, where $\beta_0 \in \Re^{J \times N}$, $\beta_1 \in \Re^{J \times N}$, and $\beta_2 \in \Re^J$;
- $\rho = \{\rho_g, \rho_{a_j}, \rho_{c_n}\}$, where $\rho_g \in \Re^2$, $\rho_{a_j} \in \Re^{J \times 2}$, and $\rho_{c_n} \in \Re^{N \times 2}$; and

[9] In estimating different versions of the model, we find that AR(2) factors work well. Adding more lags did not change our results qualitatively but made the model less parsimonious and hence more difficult to estimate.

- $\sigma^2 = \{\sigma^2_\varepsilon, \sigma^2_g, \sigma^2_{a_j}, \sigma^2_{c_n}\}$, where $\sigma^2_\varepsilon \in \Re$, $\sigma^2_g \in \Re$, $\sigma^2_{a_j} \in \Re^J$, and $\sigma^2_{c_n} \in \Re^N$.

For $J = 2$ and $N = 55$, as in our sample, we must estimate 222 parameters for B, 116 for ρ and 59 for σ^2, for a total of 397 parameters.

1.2.2 Push and Pull Factors

The dynamic factor model allows us to investigate the extent to which the bond and equity flows from the US to another country are due to: (i) a push factor captured by the global and asset-specific factors, which together reflect the global economic forces that push capital from (into) the US into (from) another country; and (ii) a pull factor captured by the country-specific factor that reflects the domestic economic forces that pull capital into or out of a country other than the US. The extent to which push or pull factors determine international portfolio flows has important policy implications. For example, if countries wish to exert some control on the size, direction and volatility of their capital flows, it is helpful to know whether their policies need to be coordinated globally or whether instead they should focus on improving their domestic institutions and macroeconomic policies.

For each type of flow j and country n, the push factor is defined simply as:

$$Push_{j,n,t} = \beta_{1;j,n} g_t + \beta_{2;j} a_{j,t}, \qquad j = 1, 2; \quad n = 1, .., N. \tag{1.8}$$

Note that there is a push factor for the bond flows of every country and another push factor for the equity flows of every country.

For each country n, the pull factor is defined as:

$$Pull_{n,t} = c_{n,t}, \qquad n = 1, .., N. \tag{1.9}$$

Note that for a given country n there is one pull factor that is the same for both bond and equity flows.

1.2.3 Variance Contributions

The model implies that the variance of each flow j for each country n is equal to:

$$Var(y_{j,n,t}) = \beta^2_{1;j,n} Var(g_t) + \beta^2_{2;j} Var(a_{j,t}) + Var(c_{n,t}) + Var(\varepsilon_{j,n,t}). \quad (1.10)$$

Recall that all factors are independent of one another, and hence no covariance terms enter the equation above.

We are interested in assessing the relative contribution of each factor to the total variation of $y_{j,n,t}$ that we can explain by the model. This will allow us to evaluate the extent to which each of the global, asset-specific and country-specific factors can explain the variance of international portfolio flows. We compute the variance contribution of each factor for each flow j and country n as follows:

$$VC_{j,n}(g_t) = \frac{\beta^2_{1;j,n} Var(g_t)}{\beta^2_{1;j,n} Var(g_t) + \beta^2_{2;j} Var(a_{j,t}) + Var(c_{n,t})}, \quad (1.11)$$

$$VC_{j,n}(a_{j,t}) = \frac{\beta^2_{2;j} Var(a_{j,t})}{\beta^2_{1;j,n} Var(g_t) + \beta^2_{2;j} Var(a_{j,t}) + Var(c_{n,t})}, \quad (1.12)$$

$$VC_{j,n}(c_{n,t}) = \frac{Var(c_{n,t})}{\beta^2_{1;j,n} Var(g_t) + \beta^2_{2;j} Var(a_{j,t}) + Var(c_{n,t})}. \quad (1.13)$$

In this setup, the push factor contribution to the variance of flow j for country n is given by $VC_{j,n}(g_t) + VC_{j,n}(a_{j,t})$. The pull factor contribution to the variance of flow j for country n is given by $VC_{j,n}(c_{n,t})$.

1.3 Estimation

We estimate the dynamic factor model using the Bayesian MCMC algorithm of Kose *et al.* (2003, 2008), which builds on the procedures developed by Otrok and Whiteman (1998) and Chib and Greenberg (1994). The algorithm constructs a Markov chain with data augmentation, whose limiting distribution is the target posterior density of the parameters. Bayesian estimation offers two important advantages in estimating our model specification. First, the Markov chain is a Gibbs sampler in which large blocks of parameters are drawn sequentially from their full conditional

posterior distribution. This aspect of the algorithm deals effectively with the high dimension of the model and makes Bayesian estimation feasible and efficient. Second, data augmentation provides a straightforward way for sampling the latent factors conditional on the data. The sampled factors are then used as an intermediate step for sampling the model parameters conditional on these latent factors. The Gibbs sampler is iterated 10,000 times and the sampled draws, beyond a burn-in period of 1,000 iterations, are treated as variates from the target posterior distribution.

The dynamic latent factor model involves a set of parameters $\Theta = \left\{B, \rho, \sigma^2\right\}$ and a set of latent factors $f_t = \{g_t, a_{j,t}, c_{n,t}\}$, where the latter must be estimated as an intermediate step for estimating Θ. The MCMC algorithm sets initial values for the latent factors and their parameters, and implements three steps:

1. Sample the latent factors f_t from the full conditional posterior distribution $p\left(f_t \mid y_t, \Theta\right)$, which can be shown to be a normal distribution, thus implementing the data augmentation method of Tanner and Wong (1987).

2. Sample all parameters Θ from the full conditional posterior distribution $p\left(\Theta \mid y_t, , f_t\right)$ using the method of Chib and Greenberg (1994).

3. Repeat for 10,000 iterations, beyond a burn-in period of 1,000 iterations, and use the sampled draws to compute the posterior means of the parameters.

We implement the Bayesian MCMC estimation algorithm using the following priors set out by Kose *et al.* (2003, 2008). For all factor loadings B we use the prior $N(0, 1)$. For the factor autoregressive parameters ρ we use the prior $N(0, diag\left\{1, 0.5\right\})$, thus placing zero prior mass on ρ values which are non-stationary. Finally, the prior for the factor variances σ^2 is $IG(6, 0.001)$. All priors are diffuse.[10]

[10]We have experimented with alternative priors and our results remain qualitatively the same.

1.4 Empirical Results

1.4.1 International Portfolio Flows Data

Our empirical analysis uses an extensive data set of monthly international bond and equity flows from the US to 55 other countries. The data are taken from the *Treasury International Capital System* (TIC) of the US Treasury Department. The bond flows are defined as the sum of gross sales by foreigners of their domestic bonds to US residents. The equity flows are defined as the difference between gross purchases and gross sales by foreigners of US corporate stocks.[11] A positive flow is an inflow into a country other than the US (i.e., a US outflow), whereas a negative flow is a US inflow. All flows are in millions of US dollars. Our sample includes the 55 countries listed in Tables 1.1 and 1.2, and ranges from January 1988 to July 2009.

One advantage of our data selection is its coverage. This data set comprises a relevant fraction of the capital accounts of several countries over more than two decades on a monthly basis. Furthermore, the TIC is a reliable source for it consists of all capital in and out flows reported to the US Treasury. Given the above, we believe the data set chosen is a good representation of a great portion of the world's dynamic on capital flows and helps tackle issues that have important policy implications to the global economy. Despite the fact that the TIC also includes data on foreign direct investment (FDI) and commercial bank claim flows, one of the reasons for not including these flows to our data selection is that their frequency and coverage differ from portfolio flows. Further to that, as we build on a long literature that uses the same data – as in Sarno and Taylor (1999) – our choice assures the comparability of our results to earlier research. Besides, whilst bank flows are very sensitive to liquidity constraints and FDI are more long-termed fo-

[11] Following a number of studies, we use a gross measure of bond flows and a net measure of equity flows. For bond flows it is preferable to use a gross measure in order to abstract from the effect of sterilization policy actions and other types of reserve operations by the monetary authorities (see, e.g., Sarno and Taylor, 1999).

cused, portfolio flows are intermediate cases since they do not react as straightaway as the bank flows, but are more sensitive than FDI (Milesi-Ferretti and Tille, 2011). Although total portfolio flows are as prone as bank flows to suffer sudden stops (Calvo, Izquierdo, and Mejía, 2008), there are not many documents examining how portfolio flow categories differ from each other. A limitation of our data is that it considers only bilateral transactions with the US. Ideally, research would consider international financial trade with the rest of the world. However, being the US the largest international investor to other countries, we consider these data useful and appropriate in the current context.

Tables 1.1 and 1.2 report descriptive statistics. For bond flows, about half of the countries on average experience inflows and the other half outflows. In contrast, most of the equity flows are on average negative, i.e., they are flows into the US. Equity flows are much larger than bond flows: \$25 billion of equity flows on average left foreign countries and entered the US every month, compared to \$676 million of bond flows. The highest bond flows are from the US into Japan and Brazil, and from the UK and the Netherlands into the US. The highest equity flows are from the UK by far, then from Japan, China and Hong Kong.

The tables show that most flows exhibit high standard deviation, negative skewness and high kurtosis. They are also quite persistent with a first order serial correlation ranging from -0.34 to 0.66 for bond flows, and from -0.14 to 0.63 for equity flows. This motivates the specification of the dynamic latent factors, which are designed to capture the persistence of flows. It is interesting to note that the standard deviation of equity flows is of the same magnitude as their mean, but for bond flows the standard deviation is 13 times higher than the mean. This is reflected in Figure 1.1, which displays the time-variation in the cross-country average of flows (i.e., what we refer to as World in the tables). As seen in the figure, flows have been increasingly volatile in recent years, which is especially true for bond flows.

Before estimating the dynamic factor model, it is important to establish that portfolio flows are stationary. Otherwise, the model will not be suitable for capturing the push and pull factor components of the variation in portfolio flows. To this end, we perform a series of unit root tests applied to the panel of all flows. The Breitung (2002) and Levin, Lin, and Chu (2002) tests are for the null hypothesis that there is a common unit root in all portfolio flows. In contrast, the panel Augmented Dickey-Fuller, Phillips and Perron (1988) and Im, Pesaran, and Shin (2003) tests allow the serial correlation to be different across flows. The unit root tests can be performed with or without fixed effects and linear trends. The results for this battery of tests are reported in Table 1.3, which shows that non-stationarity is rejected in all cases. Hence there is overwhelming evidence that international portfolio flows are stationary.[12]

As the last diagnostic of our preliminary analysis, we perform principal component analysis to determine how many common components are needed to capture the variation of bond and equity flows. We find that three principal components explain 75% of the variance of flows: the first component 59%, the second one 12%, and the third one 4%. The three principal components are plotted in Figure 1.2. This analysis provides a static decomposition of the variance of portfolio flows, and hence it is not directly related to our specification of the dynamic factor model. It does, however, motivate our core empirical analysis as it suggests that few common factors can capture a large part of the movements in international portfolio flows. In what follows, we explore this in more detail as we discuss the empirical results from estimating the dynamic factor model.

[12]Some earlier studies find a unit root in international capital flows (e.g., Sarno and Taylor, 1999). In contrast to these studies, we use panel (as opposed to individual) unit root tests for a much longer sample period, which adds significant power to the tests and allows us to clearly reject non-stationarity. This is reassuring since it is generally difficult to explain why capital flows would be non-stationary.

1.4.2 The Dynamics of Factors

The main feature of the dynamic factor model is that it decomposes the time variation of flows into a push factor (captured by global and flow-specific factors) and a pull factor (captured by the country factor). The factor dynamics are captured by their serial correlation at two lags (ρ_1 and ρ_2) as specified in Equations (2)-(4). Estimates of these serial correlations are reported in Table 1.4 for the common factors as well as groupings of the country-specific factors based on geography and economic development.

The regional groupings of countries are formed as follows. *Europe* includes Austria, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Romania, Serbia-Montenegro, Spain, Sweden, Switzerland and United Kingdom. *North America* is Canada and Mexico. *Latin America* includes Argentina, Brazil, Chile, Colombia, Ecuador, Guatemala, Jamaica, Panama, Peru, Trinidad-Tobago, Uruguay and Venezuela. *Asia and Oceania* include Australia, China, Hong Kong, India, Indonesia, Israel, Japan, Lebanon, Malaysia, Pakistan, Philippines, Russia, Singapore, South Korea, Taiwan, Thailand and Turkey. *Africa* includes Egypt, Liberia, Morocco and South Africa.

We also report results for the G8 vs. the non-G8 countries, the G20 vs. the non-G20 countries, and for the large emerging economies collectively known as BRICS (Brazil, Russia, India, China and South Africa) vs. the non-BRICS countries. Finally, World is the average across all 55 countries in the sample.

As shown in Table 1.4, ρ_1 revolves mostly between 0.3 and 0.4, and ρ_2 mostly between 0.2 and 0.3. Notably, the global factor has the highest serial correlation, whereas the bond factor is more persistent than the equity factor. The country factors seem to have similar persistence across geographic regions and the G8, G20 and BRICS groupings of countries. To provide a visual illustration of some of these results, Figure 1.3 plots the three common factors (global, bond and equity factors)

over time. The global factor (top panel of Figure 1.3) shows an interesting behaviour. Its notable downward trend in late 2000s possibly reflects a retrenchment of US flows, consistent with the analysis on the US dollar shortage by McGuire and von Peter (2009), who explain how the sudden redemptions faced by the US dollar money market was experienced by international banks during the last financial crisis. As Milesi-Ferretti and Tille (2011) point out, investors repatriated funds invested abroad during the financial crisis, and that "[t]he collapse in capital flows reflects an active reduction of the portfolio share of foreign assets by investors, and not just a portfolio adjustment following a reduction in wealth."

Milesi-Ferretti and Tille (2011) also note that this retrenchment of capital flows from countries with weakest fundamentals and higher exposure to financial sector did not performed equally across flow types. Whilst bank flows behaved globally as severely affected, portfolio flows were not as vulnerable to these constraints in liquidity. In fact, one of their main findings is the heterogeneity with which the pull-back of capital flows was observed amongst flow categories: bank flows showing the most severe reaction, FDI the least severe response, and portfolio flows observing moderate retrenchment during the last financial crisis. In light of this, our estimated bond and equity factors (middle and bottom panel of Figure 1.3) also show interesting features. One the one hand, the bond factor becomes more unstable during the 2008-2009 crisis, although its volume is much smaller than the equity factor across time, except in the late 2000s. The equity factor is more volatile and reflects larger swings than the bond flows: one around the dotcom bubble, and the other around the 2008-2009 crisis. After the dotcom bubble, the equity factor also shows a positive trend, in line with the increasing financial integration observed in the last decade, driven by increases in actual investment and steady raise in portfolio share during early 2000s (see, e.g., WorldBank, 2006b; McGuire and von Peter (2009); Milesi-Ferretti and Tille (2011)). It is reassuring to note that, as expected, the bond

and equity factors seem to have similar time-variation to the actual bond and equity flows, respectively, illustrated in Figure 1.1.

1.4.3 The Variance Contribution of Push and Pull Factors

The main objective of our empirical analysis is to determine the contribution of push and pull factors to the variation of international bond and equity flows. The push factor is the sum of the contributions of the global and bond factors for bond flows or of the global and equity factors for equity flows. The pull factor is simply the contribution of the country factor. We estimate the dynamic factor model and use the parameter estimates to compute the variance contribution of each factor as in Equations (1.11)-(1.13). The results for all 55 countries are reported in Table 1.5 for bond flows and Table 1.6 for equity flows.

Our main finding is that the push factor tends to contribute more than 80% to the variance of portfolio flows, whereas the pull factor tends to contribute less than 20%. For bond flows, the push factor contribution is higher than 90% for half of the countries, whereas for equity flows this is the case for two thirds of the countries. For example, the pull factor can be as low as 0.7% for Argentina (bonds), the Philippines (equities) and Singapore (equities). Overall, the contribution of the push factor tends to be higher for equity flows than bond flows.

In addition to the country results in Tables 1.5 and 1.6, we also report regional results in Table 1.7. Across regions, the push factor for bonds ranges from 77.3% for Europe to 88.5% for North America, and for equities from 86.3% for Europe to 98.0% for North America.[13] Finally, for the World, the push factor is 83.0% for bond flows and 89.0% for equity flows. Hence, irrespective of which region we examine, our main finding remains that about 80% or more of the variation in bond and equity flows is driven by common factors.

[13]The high value of the push factor for North America is not surprising. North America includes only Canada and Mexico, which are the two economies most highly integrated with the US economy.

A similar picture emerges if we group countries by their level of development. Let us first consider bond flows, where the regional variation is the largest. For the G8 countries, the push factor contributes 73.6%, whereas for the non-G8 countries 84.3%. Therefore, although the push factor remains high, it is higher for developing countries. The gap closes a bit when we consider the G20 countries (77.9% for push factor) vs. non-G20 countries (85.2%). However, for the BRICS the gap remains high at 73.7% vs. 83.9% for non-BRICS countries. It is interesting to note that the decomposition of push-pull factors for the bond flows of the BRICS is the same as for the G8. The differences are slightly less pronounced for equity flows.

Recall that the sample period used in our main analysis ranges from January 1988 to July 2009. In Table 1.8, we provide further results using a subsample that captures the recent financial crisis period beginning in July 2007 and ending in March 2009. This sample range is consistent with the crisis period examined by Fratzscher (2012).[14] The results indicate that, over the crisis period, the contribution of the push factor falls and that of the pull factor rises. However, although clear, this change is not dramatic in the sense that the size of the push factor still overshadows that of the pull factor. For example, the World push factor for bond flows falls from 83.0% to 67.7%, whereas for equity flows it falls from 89.0% to 75.8%.[15] Finally, over the crisis period, the push factor remains higher for developing economies outside the G8, G20 and the BRICS. In short, we conclude that the push factor dominates the pull factor even during the recent financial crisis, albeit to a lesser extent.

1.5 Bond Flows and the Carry Trade

The carry trade is a popular currency trading strategy that invests in high-interest currencies by borrowing in low-interest currencies. This strategy is at the core of

[14] Fratzscher (2012) defines the financial crisis from August 7, 2007 to March 15, 2009.

[15] It is interesting to note that the reduction in the push factor is almost exclusively driven by a reduction in the flow-specific (bond or equity) factor, not a reduction in the global factor. In other words, the common component of the variation across all countries and all flows (i.e., the global factor) is the same before and during the crisis.

active currency management and is designed to exploit deviations from uncovered interest parity (UIP). If UIP holds, the interest rate differential is on average offset by a commensurate depreciation of the investment currency and the expected carry trade return is zero. There is extensive empirical evidence dating back to Bilson (1981) and Fama (1984) that UIP is empirically rejected. In practice, it is often the case that high-interest rate currencies appreciate rather than depreciate. As a result, over the last four decades, the carry trade has delivered sizeable excess returns and a Sharpe ratio more than twice that of the US stock market (e.g., Burnside, Eichenbaum, Kleshchelski, and Rebelo, 2011). It is no surprise, therefore, that the carry trade has attracted enormous attention among academics and practitioners. Indeed, by early 2007 it was estimated that about one trillion US dollars was at stake just in the yen carry trade (Economist, 2007), where investors borrow in Japanese yen at very low rates to fund investments in high-interest currencies. In short, carry trades (interest rate differentials) are likely to be very important drivers of bond flows.

The carry trade strategy for a particular currency (or a portfolio of currencies) can be implemented in one of two equivalent ways. First, the investor may buy a forward contract now for exchanging the domestic currency into foreign currency in the future. She may then convert the proceeds of the forward contract into the domestic currency at the future spot exchange rate. Second, and alternatively, the investor may buy a foreign bond and, at the same time, sell a domestic bond. The foreign bond yields a riskless return in the foreign currency but a risky return in the domestic currency of the investor. Hence the investor who buys the foreign bond is exposed to foreign exchange risk. It is straightforward to show that the returns to the two strategies are exactly equal due to the covered interest parity (CIP) condition that holds in the absence of riskless arbitrage. As a result, there is an equivalence between, on the one hand, trading currencies through spot and forward contracts

and, on the other hand, trading international bonds.

In this context, it is interesting to use our empirical results to examine the size of the push and pull factors for the bond flows of some of the countries most affected by the carry trade in foreign exchange. As interest rates, the drivers of the carry trade, are predominantly determined by domestic monetary policies, we would expect that countries most affected by the carry trade would have a higher-than-average pull factor in their bond flows. In a recent paper, Cenedese, Sarno, and Tsiakas (2012) find that two prominent low-interest countries involved in the carry trade are Japan and Switzerland, whereas two prominent high-interest countries are Australia and South Africa. For these countries, the size of the pull factor for bond flows as shown in Table 1.5 is as follows: 19.1% for Japan, 36.8% for Switzerland, 38.1% for Australia and 44.3% for South Africa. These values are substantially higher than the world average of 17%. We conclude, therefore, that the carry trade is a likely contributor to the higher-than-average effect of the pull factor in determining bond flows for countries with the lowest and highest interest rates.

1.6 Country Cases

In this section we analyze a subset of our results in greater depth by focusing on three of the most prominent emerging economies: China, India and Brazil. These countries belong to the G20, are members of the BRICS and, due to their fast-growing economies in recent years, have emerged as global economic powerhouses. An interesting aspect of our empirical analysis is that in terms of portfolio flows the three countries exhibit different patterns. For example, the pull factor for bond flows is extremely high in Brazil, close to the world average for China and well below average for India. Our country analysis follows with further details.

China

China is the world's second largest economy by nominal GDP after the US. It is also the world's fastest-growing major economy with an average annual growth rate of about 10% over the past 30 years. The management of international capital flows has been a key factor in supporting China's economic miracle (see, e.g., Yu, 2010). In the 1980s and 1990s, the majority of capital flows were due to foreign direct investment, but since the early 2000s equity and bond flows have grown significantly. For example, the surge in bond flows is related to China's accumulation of large foreign exchange reserves and the dramatic increase of foreign bond purchases by Chinese financial institutions. The surge in equity flows is due to recent structural reforms of the equity market and the wave of initial public offerings of Chinese enterprises abroad, especially in the Hong Kong stock exchange.

Despite the increased prominence of China's economy in the last three decades, in terms of the relative importance of push and pull factors for portfolio flows, China is close to the world average. Specifically, the empirical results reported in Tables 1.5 to 1.8 indicate that the pull factor for China accounts for 17.5% of the variation in bond flows and 5.8% for equity flows. These are similar to the world average value of the pull factor, which is 17% for bond flows and 11% for equity flows. Hence our analysis shows that China is a rather typical country in terms of the push-pull factor decomposition.

India

India is the tenth-largest economy in the world by nominal GDP and, over the last decade, it is one of the fastest-growing economies in the world. Portfolio flows were liberalized in the early 1990s, when in the face of a balance of payments crisis, India followed an IMF structural adjustment program (see, e.g., Shah and Patnaik, 2010). This resulted in a sustained increase of equity inflows primarily by foreign

institutional investors increasing their holdings of Indian companies. There has also been a large increase of bond outflows by massive purchases of US Treasury bills and other foreign assets by the Indian central bank in building its foreign exchange reserves. At the same time, however, debt inflows have been hampered as India has no sovereign debt program.

In this context, our empirical results indicate that the pull factor for India accounts only for 4.2% of the variation in both bond and equity flows. This is far below the world average value of the pull factor of 17% for bond flows and 11% for equity flows. Therefore, our analysis shows that India's portfolio flows are largely dominated by global economic forces.

Brazil

Brazil is the world's sixth largest economy by nominal GDP, the largest in Latin America and one of the fastest-growing major economies in the world. In recent years, Brazil has dominated capital inflows to Latin America due its deep capital markets, very high interest rates (11.25% in 2010) and the accumulation of large foreign exchange reserves. As estimated by the IMF (2011), these conditions have reinforced the effect of pull factors as, for example, high domestic interest rates have increased carry trading activity investing in Brazilian bonds.

This is clearly confirmed by our empirical results, which indicate that the pull factor for Brazil accounts for an enormous 64.0% of the variation in bond flows, which is the second highest among all countries and 47% higher than the world average. In contrast, Brazil's pull factor for equity flows is 11.5%, which is roughly equal to the world average. Hence our analysis shows that Brazil is quite a distinct country as bond flows are largely determined by domestic economic conditions.

Beyond the Numbers

Literature built during the 1990s and 2000s have agreed that the significant increase in capital flows into the developing world has been driven by both push and pull factors. In particular, the last decade has been a combination of rapid EMEs growth and less attractive financial conditions in advanced economies. Added to that, continuous financial integration and improvement of institutional quality of EMEs has also encouraged more capital to these economies.

According to WorldBank (2006a), the BRICS are amongst the top ten recipients of portfolio flows to the developing world. The comparison with other developing countries is astonishing not only at the levels: in 2010, the BRICS showed a much higher increase on their net capital inflows (around 75%) compared to the increase in the other 125 countries (around 58%). However, despite being considered as the major developing countries, the BRICS also differ amongst each other, hence capital flows into each individual member would be expected to be driven by different factors, or at least by different degrees of their common factors.

More specifically, whilst China is the least indebted of the BRICS, Brazil is the most heavily indebted in relation to export earnings. In terms of income there are also important differences: although India is the poorest of the BRICS and Russia the richest, the literature still consideres both countries as comparable capital flow recipients. In terms of shares of the total, China has received the highest portion of the aggregate equity flows that has been received by the BRICS in the last decade (WorldBank, 2006a).

Goldfajn and Minella (2005) note that Brazil has shown much greater volatility of the portfolio component compared to the FDI component of its capital account. Furthermore, sudden stops in Brazil have been much more pronounced during domestic crises compared to the responses observed in capital flows during the other

external crises that the Brazilian economy has faced.[16]

With regards to India, this is an intermediate case between China and Brazil. As mentioned above, India started increasing its financial openness in the 1990s. However, this is a still ongoing process compared to the Brazilian experience (Economist, 2007). As noted by Mohan (2008), the potential for sudden stops and reversals had kept Indian authorities cautiously handling the international financial trade requirements. India has increased more than five times its gross capital flows as percent of GDP in 2000s. As most EMEs, India has favoured of sustained fundamentals that might have attracted flows. However, contrary to most EMEs that have seen FDI flows increases in the last decades, India has received relatively much more equity flows. This is consistent with the search for yield due to the low interest rates in advanced economies as push factors.

To sum up, the interesting feature about the BRICS – and the reason for analysing Brazil, India and China as country cases – is that, although representing some of the greatest EMEs, not only they differ in terms of economic structure and policy frameworks, but also in terms of capital flow drivers. The latter is corroborated with our results.

1.7 Push Factors, Pull Factors and Macroeconomic Information

Having identified the variance contribution of push and pull factors, we turn to the economic determinants of these latent factors. The first question we address is about the push factor: which observed US macroeconomic indicators can explain the push factor for portfolio flows from the US to other countries? We answer this question by regressing combinations of the monthly common (global, bond and equity) factors on six monthly macroeconomic variables: (i) the US industrial production gap

[16]The authors identify the Mexican crisis in 1994, the Asian crisis in 1997, the Russian crisis in 1998, and the Argentinean crisis in 2001.

estimated using the Hodrick and Prescott (1997) filter, which is based on seasonally adjusted US industrial production data taken from the Federal Reserve Board; (ii) the US 7-year nominal bond yield also taken from the Federal Reserve Board; (iii) the ratio of the 12-month returns of the US/World MSCI stock market indices taken from Datastream; (iv) the 12-month change in the VIX index (ΔVIX) taken from Bloomberg, which is based on the 1-month model-free implied volatility of the S&P 500 equity index and is generally regarded as a measure of global risk appetite (e.g., Brunnermeier *et al.*, 2009); (v) the TED spread, which is a measure of liquidity defined as the difference between the 3-month LIBOR interbank market interest rate and the 3-month risk-free T-bill rate both taken from Bloomberg;[17] and (vi) a lagged value of the factors. Conditioning on this set of variables allows us to determine whether US forces relating to the real economy, long interest rates, performance of the US stock market relative to the world, global risk aversion and liquidity can explain the push of flows from the US to other countries.

Table 1.9 reports the results for the global factor, the bond factor and the equity factor.[18] We can summarize our main results as follows. First, the effect of the global factor in determining flows from the US to other countries is higher when US industrial production is low, the US stock market performs worse relative to the rest of the world, and liquidity is high (i.e., the TED spread is low). Second, the effect of the bond factor in determining bond flows from the US to other countries is higher when US long bond yields are low, the US stock market performs better than the rest of the world, and global risk aversion increases (i.e., high ΔVIX). Finally, the effect of the equity factor in determining equity flows from the US to other countries

[17] The LIBOR rate reflects uncollateralized lending in the interbank market that is subject to default risk, whereas the T-bill rate is generally considered riskless because it is guaranteed by the US government. When banks face liquidity problems the TED spread typically increases, and the T-bill yield often falls due to "flight-to-liquidity" or "flight-to-quality" (e.g., Brunnermeier *et al.*, 2009).

[18] We do not report results for the global plus bond factor and the global plus equity factor because these summations are not equal to the push factor for bonds and equities, respectively. Recall that the latter are weighted by the relevant factor loadings so that they are specific to each flow and country (see Eq. (1.8)).

is higher when US industrial production is low, US long bond yields are high, and global risk aversion decreases.

These results tend to be consistent with what we would expect ex ante based on standard economic theory. In particular, high equity outflows are related to slow economic activity in the US and an underperforming US stock market. High bond outflows are related to low US interest rates. High liquidity facilitates higher outflows. And finally, when global risk aversion increases there are higher bond outflows, whereas when it decreases there are higher equity outflows. In short, therefore, our findings seem to make perfect economic sense.

Overall, the adjusted R^2 values indicate that the macroeconomic variables can explain 61% of the global factor, 38% of the bond factor, and 13% of the equity factor. We conclude, therefore, that observed US macroeconomic variables at best can explain about half (or less) of the variation of the latent common factors. This motivates our use of a latent factor model since a considerable amount of the variation of the latent factors is difficult to explain by observed variables.[19]

The second question we address is about the pull factor: which domestic macroeconomic indicators can explain the pull factor for portfolio flows for each individual country? We answer this question by estimating a panel regression of all monthly pull factors on a set of domestic monthly macroeconomic variables for each individual country. The explanatory variables for each country include: (i) real annual economic growth rate, which is seasonally adjusted and taken from Datastream; (ii) the nominal 7-year bond yield taken from Datastream; (iii) the monthly MSCI national stock index return taken from Datastream; (iv) the Chinn and Ito (2008) measure of capital account openness taken from Hiroyuki Ito's website; and (v) lagged values

[19]To back up this conclusion, we test whether these variables are redundant for the equations estimated for each factor, we estimated a AR(1) model for each case. The coefficients of the lagged global, bond and equity factor were respectively 0.74, 0.56 and 0.14, and the adjusted R^2 were 51%, 22%, and 0% respectively – only lagged global and bond factors were significant. The Wald test for the null hypothesis of the macroeconomic variables coefficients being jointly equal to zero (to which results are also summarised in Table 1.9) indicates that the variables chosen are relevant in the model, and that the improvement of the goodness of fit is economically significant.

of the pull factors. Due to lack of data availability for some countries, the panel regressions include 26 of the 55 countries for a sample that begins in January 1996 and ends in July 2009. For this reason, we also use the same sample range of January 1996 to July 2009 for the push factor results in Table 1.9 discussed above. This way the results in Table 1.9 on the push factor and Table 1.10 on the pull factor are directly comparable in terms of sample range.[20]

The results in Table 1.10 on the pull factor indicate the following. The growth rate is positively related to the pull factor: the higher the domestic growth the higher the effect of the pull factor in attracting flows into a country. The long bond yield is significantly positively related to the pull factor: the higher the domestic interest rate, the more important the pull factor, and this is the carry trade effect. The openness degree is positively related to the pull factor: the more open an economy is the more important the pull factor in determining international portfolio flows.[21] The lagged country factors also have a significant positive effect. Note, however, that of these variables only the long interest rate and the lagged pull factor are significant, with the openness degree being borderline insignificant. Finally, the adjusted R^2 in this panel regression is 9.8% indicating that the observed macroeconomic variables capture a rather small portion of the explanatory power of the latent pull factors. Again, this further motivates the use of a latent factor methodology to capture the dynamics of international portfolio flows.

1.8 Conclusion

An important challenge to policymakers across the world is the design of effective policies that deal with movements in international portfolio flows. These policies

[20] The panel regressions include the following 26 countries: Australia, Austria, Brazil, Canada, Chile, Denmark, Finland, France, Germany, Greece, India, Israel, Italy, Japan, Malaysia, Netherlands, Norway, Philippines, Portugal, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand and United Kingdom.

[21] See, also, Kose *et al.* (2009), who find that capital account openness has a strong effect on output growth.

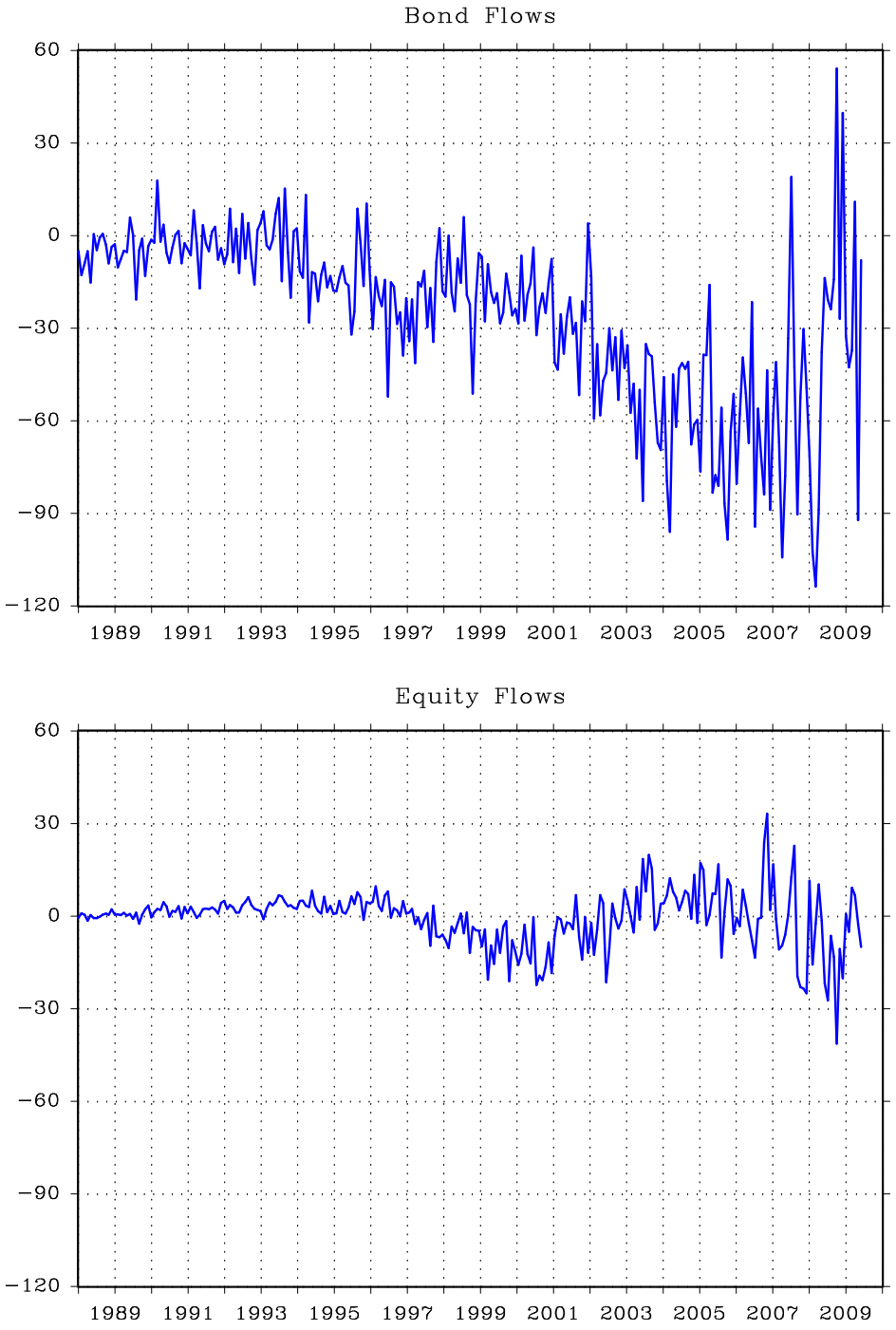
are better informed if we can empirically disentangle the relative importance of push factors that are external to the economies receiving the flows and pull factors that are internal. Our study contributes to the debate on what drives international portfolio flows by estimating a dynamic latent factor model using more than 20 years of monthly international bond and equity flows from the US to 55 other countries. The advantage of this model is that it provides a flexible way for assessing the relative importance of the contribution of push and pull factors to the variation in international bond and equity flows.

We find that the push factor dominates the pull factor by explaining more than 80% of the variance of international portfolio flows. This holds for the vast majority of countries, all geographic regions and for both bond and equity flows. The strength of the push factor is even more pronounced for equity flows than bond flows, and for developing countries than advanced economies. However, the pull factor tends to be higher for the G8, the G20 and the BRICS countries. It is even higher for countries involved in the foreign exchange carry trade, than it is for countries with very low or very high interest rates. Notably, over the crisis period, the role of the push factor diminishes as on average the contribution of the pull factor to the variance of flows effectively doubles. Furthermore, the dynamics of push and pull factors can be explained to some extent by US and foreign macroeconomic indicators respectively.

The empirical evidence reported in this chapter essentially confirms the public perception that forces related to financial globalization are the primary determinants of international portfolio flows. Therefore, countries exposure to global (rather than domestic) risks appear to be more important in informing the domestic policy response to time-varying international portfolio flows. This suggests that compared to domestic macroeconomic policies, capital controls may be a more effective policy tool for countries aiming to stimulate economic growth partly by managing the consequences of international portfolio flows. Indeed, the new institutional view of

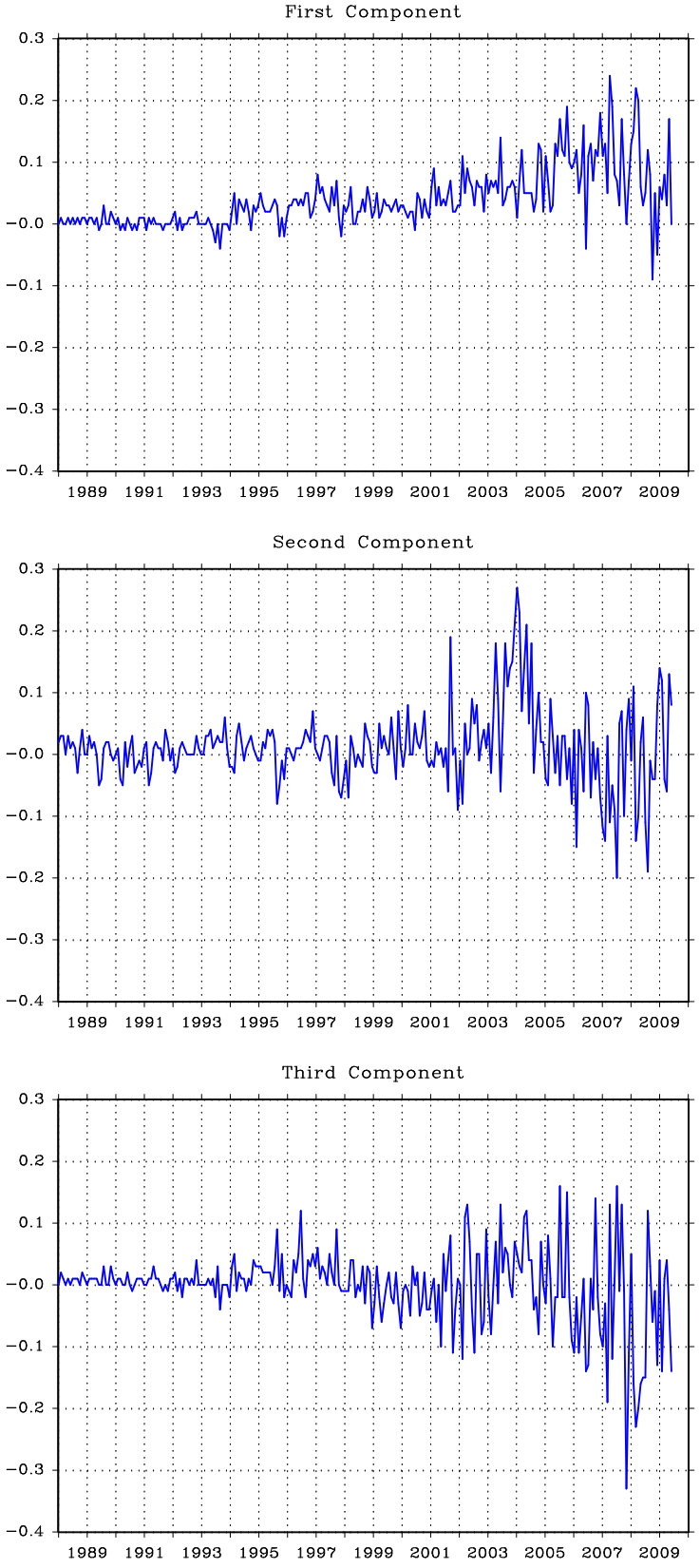
the IMF announced in November 2012 recognizes that this may be the case. Although we do not explicitly provide direct evidence on the effectiveness of capital controls, our empirical findings contribute to this debate and lend support to the new institutional view of the IMF on capital controls.

Figure 1.1: International Portfolio Flows



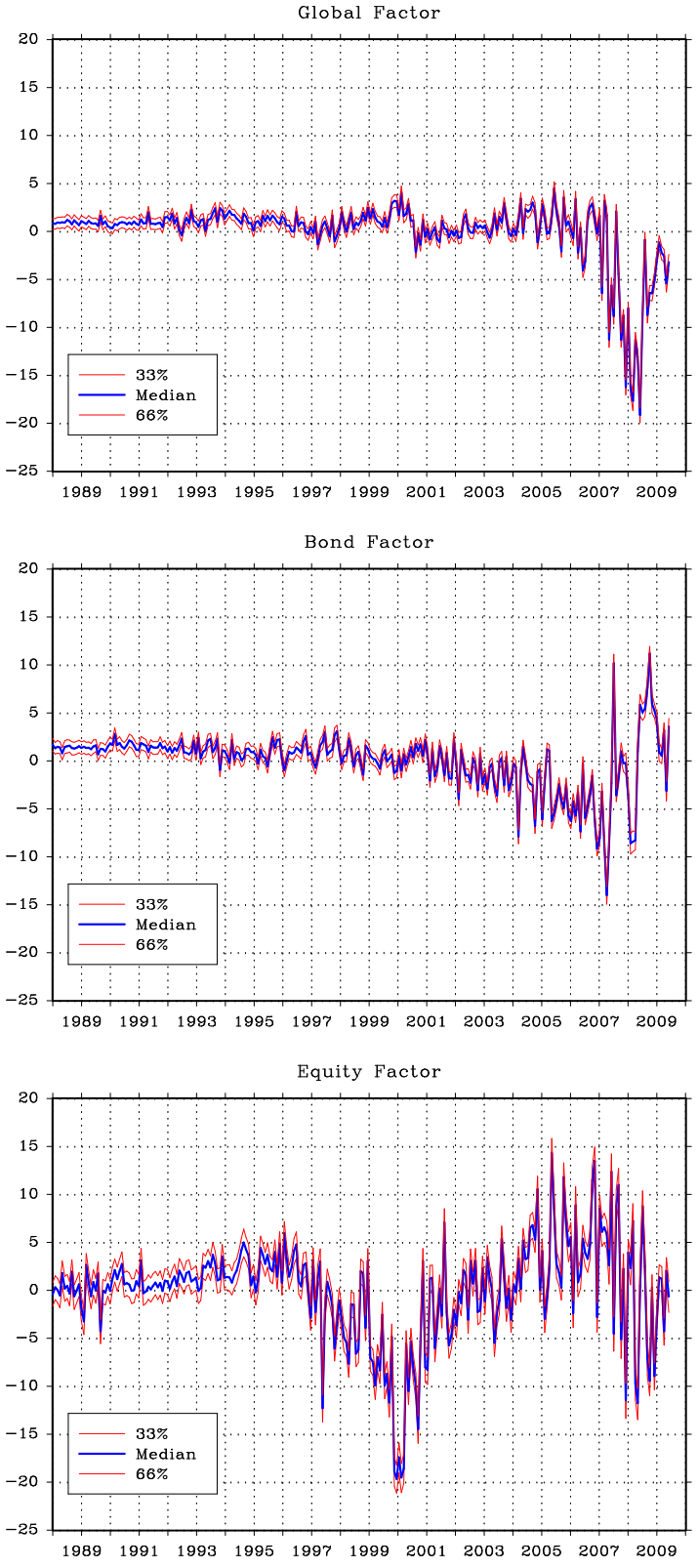
The figure displays the cross-country average of monthly international portfolio flows from the US to 55 other countries. The top panel shows the bond flows and bottom panel the equity flows. A positive flow is a flow from the US to another country (i.e., a US outflow), whereas a negative flow is a US inflow. All flows are in millions of US dollars. The sample period ranges from January 1988 to July 2009.

Figure 1.2: Principal Components



The figure illustrates the first three principal components that explain the variance of monthly international bond and equity flows from the US to 55 other countries. A positive flow is a flow from the US to another country (i.e., a US outflow), whereas a negative flow is a US inflow. All flows are in millions of US dollars. The sample period ranges from January 1988 to July 2009.

Figure 1.3: Dynamic Push Factors



The figure shows the three dynamic push factors that explain the common variation in monthly international portfolio flows from the US to 55 other countries. The top panel shows the global factor, the middle panel the bond factor and the bottom panel the equity factor. The dashed lines display the 33% and 66% quantile bands of the factors' posterior distribution. A positive flow is a flow from the US to another country (i.e., a US outflow), whereas a negative flow is a US inflow. All flows are in millions of US dollars. The sample period ranges from January 1988 to July 2009.

Table 1.1: Descriptive Statistics

		Bond Flows				
		Mean	*St. Dev*	*Skew*	*Kurt*	*AR(1)*
1	Argentina	0.36	136.44	−0.23	8.79	0.16
2	Australia	68.28	468.03	0.96	8.13	0.23
3	Austria	−13.17	87.97	−0.48	4.26	0.37
4	Brazil	216.04	528.12	3.59	15.70	0.53
5	Bulgaria	0.92	8.22	5.18	52.00	0.28
6	Canada	−148.52	1252.70	−0.73	3.20	0.15
7	Chile	−4.73	125.63	0.98	16.65	0.08
8	China	33.92	351.69	1.91	53.66	0.06
9	Colombia	−2.43	46.82	4.29	41.79	0.05
10	Czech Republic	−5.82	64.34	−6.41	67.81	0.34
11	Denmark	−43.06	219.80	0.76	11.27	0.17
12	Ecuador	−3.08	17.94	−0.93	7.48	0.18
13	Egypt	3.01	38.84	1.53	10.00	0.18
14	Finland	−3.87	204.20	−2.11	19.18	0.12
15	France	−158.59	1918.75	−0.19	5.36	−0.28
16	Germany	−109.02	1604.79	0.74	10.02	0.41
17	Greece	3.38	73.26	−0.30	8.28	0.14
18	Guatemala	−0.53	5.72	4.69	56.99	0.16
19	Hong Kong	−86.83	1757.36	−2.28	13.49	0.52
20	Hungary	−1.17	36.70	3.05	40.01	0.02
21	India	23.82	307.92	−0.39	36.09	0.15
22	Indonesia	11.95	76.42	1.24	11.20	0.17
23	Israel	26.90	198.72	0.04	24.84	0.14
24	Italy	−55.10	579.94	−1.93	7.34	0.61
25	Jamaica	−1.62	6.32	−3.84	24.96	0.33
26	Japan	656.71	2562.90	0.23	2.13	0.66
27	Lebanon	−3.59	15.17	−0.86	4.19	0.10
28	Liberia	13.86	75.71	3.78	19.46	0.41
29	Malaysia	23.85	121.58	1.13	5.92	0.29
30	Mexico	4.46	384.02	0.05	3.85	0.41
31	Morocco	0.10	9.07	−7.78	79.74	0.06
32	Netherlands	−236.62	1074.97	−3.69	33.99	0.13
33	Norway	−150.14	429.23	−2.57	9.34	0.57
34	Pakistan	3.46	22.97	2.14	10.98	0.35
35	Panama	−38.11	317.77	−14.23	220.69	0.00
36	Peru	6.46	73.94	8.65	117.51	0.09
37	Philippines	9.28	35.82	−0.18	12.51	0.22
38	Poland	4.49	23.35	1.39	5.31	0.46
39	Portugal	7.08	118.74	3.65	43.39	0.06
40	Romania	−0.76	15.16	−15.53	246.97	0.01
41	Russia	−0.13	91.36	0.37	13.06	0.30
42	Serbia-Montenegro	0.44	10.56	4.14	93.09	0.01
43	Singapore	−165.98	1410.48	−0.42	6.25	0.44
44	South Africa	25.36	123.41	3.56	34.21	0.29
45	South Korea	64.23	343.44	−0.90	6.47	0.32
46	Spain	−41.17	334.43	−1.38	5.32	0.25
47	Sweden	−88.34	595.00	−0.46	4.72	0.50
48	Switzerland	−101.22	912.54	−0.56	6.60	0.38
49	Taiwan	164.62	849.86	5.61	40.33	0.57
50	Thailand	5.93	57.40	−0.77	8.44	0.20
51	Trinidad-Tobago	−1.44	15.83	−1.56	13.59	−0.34
52	Turkey	22.06	147.21	4.98	44.83	0.20
53	United Kingdom	−594.78	4546.91	−0.28	2.60	0.20
54	Uruguay	−14.52	36.84	1.05	19.64	0.37
55	Venezuela	−3.11	94.04	3.29	30.01	−0.04
	World	−12.30	453.93	0.04	30.98	0.23

The table reports descriptive statistics for the monthly bond flows from the US to 55 other countries. A positive number implies a flow from the US to another country (i.e., a US outflow). All flows are in millions of US dollars. *World* is the average across all 55 countries in the sample. The sample period ranges from January 1988 to July 2009. AR(1) is the first order autocorrelation.

Table 1.2: Descriptive Statistics *(cont.)*

		Equity Flows				
		Mean	*St. Dev*	*Skew*	*Kurt*	*AR(1)*
1	Argentina	−34.33	440.30	0.82	4.94	0.22
2	Australia	121.35	1357.02	1.57	7.35	0.20
3	Austria	−38.19	378.46	0.36	6.90	0.22
4	Brazil	−364.77	2853.28	−0.09	16.81	0.53
5	Bulgaria	−2.18	30.59	−0.22	30.15	−0.01
6	Canada	−494.82	2514.62	0.35	2.59	0.09
7	Chile	−85.92	352.26	−1.90	13.21	0.21
8	China	−3343.89	5921.25	−2.09	7.09	0.69
9	Colombia	1.66	442.99	2.49	18.77	0.09
10	Czech Republic	−37.41	219.62	−0.80	13.00	0.05
11	Denmark	−34.67	596.59	3.21	25.33	−0.04
12	Ecuador	−1.36	80.47	5.17	40.10	0.04
13	Egypt	−14.18	195.57	1.51	14.39	0.01
14	Finland	5.28	255.63	2.21	14.69	0.13
15	France	−232.30	2244.60	−0.18	4.78	0.17
16	Germany	−715.02	2322.77	1.04	6.77	0.20
17	Greece	−48.42	287.61	−4.46	35.99	0.25
18	Guatemala	0.05	60.21	1.39	17.60	0.06
19	Hong Kong	−1485.59	2187.97	−1.12	2.19	0.63
20	Hungary	13.29	244.99	5.18	64.71	0.18
21	India	−22.98	458.33	−0.82	14.78	0.15
22	Indonesia	24.51	406.97	0.92	4.94	0.16
23	Israel	−42.28	644.40	−0.36	4.83	0.18
24	Italy	−158.93	811.19	0.85	7.33	0.03
25	Jamaica	−9.52	61.29	2.79	19.54	0.17
26	Japan	−4449.34	8412.84	−1.24	2.92	0.54
27	Lebanon	−4.71	23.07	−0.92	25.74	0.17
28	Liberia	−24.15	108.88	−3.05	18.52	0.34
29	Malaysia	−56.14	617.19	−0.96	6.43	0.39
30	Mexico	−363.81	1882.65	−1.63	12.94	0.06
31	Morocco	14.51	71.82	1.72	6.28	0.63
32	Netherlands	90.46	1478.02	0.97	4.12	0.07
33	Norway	−292.21	3565.08	−0.50	10.19	0.22
34	Pakistan	10.90	61.96	8.95	105.20	0.26
35	Panama	−55.92	182.42	2.52	12.45	0.20
36	Peru	−66.97	244.14	−1.40	19.85	0.41
37	Philippines	3.81	259.04	0.84	4.80	0.06
38	Poland	−55.49	463.90	−1.23	12.12	0.02
39	Portugal	−47.41	292.55	3.30	37.45	0.17
40	Romania	−18.29	141.25	−0.54	7.54	−0.10
41	Russia	−324.46	1388.36	−0.53	8.92	0.58
42	Serbia-Montenegro	−4.12	37.28	0.00	19.29	0.12
43	Singapore	−393.85	1554.00	−0.40	0.49	0.02
44	South Africa	21.54	204.82	3.24	38.03	0.13
45	South Korea	−291.63	1683.12	2.15	16.05	0.31
46	Spain	−149.34	1423.61	−0.21	3.86	0.37
47	Sweden	−84.15	888.72	−0.22	22.15	0.02
48	Switzerland	−273.53	1318.48	−1.81	18.50	0.11
49	Taiwan	−552.31	1531.45	0.29	3.21	0.38
50	Thailand	−22.24	692.31	−0.97	24.65	0.12
51	Trinidad-Tobago	−6.21	75.08	6.90	80.42	0.12
52	Turkey	4.42	585.21	0.35	5.99	−0.14
53	United Kingdom	−10603.85	14037.86	−1.49	2.95	0.65
54	Uruguay	−35.54	179.04	1.01	9.09	0.07
55	Venezuela	−16.35	465.92	6.79	75.88	0.09
	World	−455.40	1258.89	0.72	18.45	0.20

The table reports descriptive statistics for the monthly equity flows from the US to 55 other countries. A positive number implies a flow from the US to another country (i.e., a US outflow). All flows are in millions of US dollars. *World* is the average across all 55 countries in the sample. The sample period ranges from January 1988 to July 2009. AR(1) is the first order autocorrelation.

Table 1.3: Panel Unit Root Tests

	Exogenous variables		
	Individual effects and linear trends	*Individual effects*	*None*
common unit root process			
Breitung (2002)	-5.1^{***}		
Levin, Lin and Chu (2002)	-168.7^{***}	-126.4^{***}	-111.8^{***}
individual unit root process			
Augmented Dickey-Fuller (1984)	-93.7^{***}	-89.2^{***}	-93.4^{***}
Phillips-Perron (1988)	-110.9^{***}	-109.6^{***}	-115.8^{***}
Im, Pesaran and Shin (2003)	-133.6^{***}	-120.5^{***}	

The table presents panel unit root tests for monthly bond and equity flows from the US to 55 other countries. The null of the tests is that there is a unit root. The Breitung (2002) and Levin, Lin and Chu (2002) tests are for a common unit root. The Augmented Dickey Fuller (Said and Dickey, 1984), Philips-Perron (1988) and Im, Pesaran and Shin (2003) tests allow the serial correlation to be different across flows. All test statistics are asymptotically normally distributed. *** indicates statistical significance at 1% level, ** at 5%, and * at 10%. The sample period ranges from January 1988 to July 2009.

Table 1.4: The Dynamics of Latent Factors

	ρ_1	ρ_2
Global	0.40	0.36
Bond	0.39	0.21
Equity	0.31	0.24
	Country Factor Averages	
Europe	0.30	0.23
North America	0.37	0.26
Latin America	0.34	0.23
Asia and Oceania	0.36	0.22
Africa	0.34	0.20
G8 countries	0.32	0.21
non-G8 countries	0.35	0.23
G20 countries	0.35	0.21
non-G20 countries	0.34	0.24
BRICS countries	0.42	0.15
non-BRICS countries	0.33	0.24
WORLD	0.34	0.23

The table shows the posterior means of the serial correlation parameters (ρ_1 and ρ_2 for two lags) in the dynamic factors. These include the global factor, the flow (bond/equity) factor and regional averages of the country factors. *Europe* includes Austria, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Romania, Serbia-Montenegro, Spain, Sweden, Switzerland and United Kingdom. *North America* is Canada and Mexico. *Latin America* includes Argentina, Brazil, Chile, Colombia, Ecuador, Guatemala, Jamaica, Panama, Peru, Trinidad-Tobago, Uruguay and Venezuela. *Asia and Oceania* include Australia, China, Hong Kong, India, Indonesia, Israel, Japan, Lebanon, Malaysia, Pakistan, Philippines, Russia, Singapore, South Korea, Taiwan, Thailand and Turkey. *Africa* includes Egypt, Liberia, Morocco and South Africa. *World* is the average across all 55 countries in the sample. The sample period ranges from January 1988 to July 2009.

Table 1.5: Push and Pull Factors for Bond Flows

	Global Factor	+	Bond Factor	=	Push Factor	Pull Factor		Global Factor	+	Bond Factor	=	Push Factor	Pull Factor
Argentina	77.8		21.5		99.3	0.7	Liberia	84.0		14.7		98.7	1.3
Australia	12.5		49.4		61.9	38.1	Malaysia	1.0		96.8		97.8	2.2
Austria	0.6		1.4		2.0	98.0	Mexico	6.1		78.6		84.7	15.3
Brazil	16.2		19.8		36.0	64.0	Morocco	43.4		41.6		85.0	15.0
Bulgaria	5.2		78.4		83.6	16.4	Netherlands	12.4		50.4		62.8	37.2
Canada	75.3		17.0		92.3	7.7	Norway	6.5		82.2		88.7	11.3
Chile	8.7		87.9		96.6	3.4	Pakistan	27.9		40.6		68.5	31.5
China	66.6		15.9		82.5	17.5	Panama	16.9		64.0		80.9	19.1
Colombia	56.3		25.4		81.6	18.4	Peru	11.1		65.6		76.7	23.3
Czech Rep.	89.3		8.0		97.3	2.7	Philippines	55.6		17.4		73.0	27.0
Denmark	1.3		96.9		98.2	1.8	Poland	28.7		58.4		87.0	13.0
Ecuador	26.0		43.6		69.6	30.4	Portugal	32.3		65.4		97.7	2.3
Egypt	4.1		88.7		92.7	7.3	Romania	25.3		69.8		95.1	4.9
Finland	7.5		62.7		70.2	29.8	Russia	5.2		93.3		98.5	1.5
France	16.0		67.8		83.8	16.2	Serbia-Montenegro	33.4		43.2		76.6	23.4
Germany	42.5		36.3		78.8	21.2	Singapore	15.2		77.3		92.5	7.5
Greece	6.6		86.0		92.6	7.4	South Africa	34.3		21.4		55.7	44.3
Guatemala	14.6		84.1		98.7	1.3	South Korea	12.3		86.2		98.5	1.5
Hong Kong	50.4		27.0		77.4	22.6	Spain	67.7		30.9		98.7	1.3
Hungary	7.7		84.7		92.4	7.6	Sweden	1.1		95.7		96.9	3.1
India	88.4		7.5		95.8	4.2	Switzerland	7.2		56.0		63.2	36.8
Indonesia	89.6		7.2		96.8	3.2	Taiwan	24.9		71.3		96.2	3.8
Israel	17.2		79.8		97.0	3.0	Thailand	89.4		8.4		97.8	2.2
Italy	17.6		22.6		40.2	59.8	Trinidad-Tobago	64.4		26.5		90.9	9.1
Jamaica	9.8		84.1		93.9	6.1	Turkey	5.7		92.8		98.5	1.5
Japan	9.5		71.4		80.9	19.1	United Kingdom	16.5		24.0		40.5	59.5
Lebanon	88.5		8.0		96.5	3.5	Uruguay	51.4		35.7		87.2	12.8
							Venezuela	73.3		12.2		85.5	14.5

The table presents the percent contribution of the push and pull factors to the variance of international bond flows for each country. The variance contribution of the push factor is the sum of the contributions of the global and bond factors. The pull factor is the country factor. The push and pull factor variance contributions sum up to 100%. The sample period ranges from January 1988 to July 2009.

Table 1.6: Push and Pull Factors for Equity Flows

	Global Factor	+	Equity Factor	=	Push Factor	Pull Factor		Global Factor	+	Equity Factor	=	Push Factor	Pull Factor
Argentina	29.8		67.7		97.5	2.5	Liberia	2.4		93.1		95.5	4.5
Australia	52.0		34.1		86.2	13.8	Malaysia	48.3		49.4		97.7	2.3
Austria	64.5		28.8		93.3	6.7	Mexico	92.5		5.4		97.9	2.1
Brazil	22.2		66.4		88.5	11.5	Morocco	46.2		35.0		81.2	18.8
Bulgaria	12.2		69.5		81.7	18.3	Netherlands	43.9		34.8		78.8	21.2
Canada	74.4		23.7		98.1	1.9	Norway	13.6		27.5		41.1	58.9
Chile	82.3		4.6		87.0	13.0	Pakistan	47.8		41.4		89.2	10.8
China	1.8		92.4		94.2	5.8	Panama	55.2		30.4		85.6	14.4
Colombia	70.2		25.8		96.1	3.9	Peru	2.0		93.1		95.1	4.9
Czech Rep.	26.2		73.0		99.2	0.8	Philippines	98.7		0.6		99.3	0.7
Denmark	53.6		15.9		69.5	30.4	Poland	18.9		79.8		98.8	1.2
Ecuador	2.4		90.1		92.5	7.5	Portugal	73.8		25.0		98.9	1.1
Egypt	91.4		4.6		96.0	4.0	Romania	95.3		3.8		99.2	0.8
Finland	23.8		42.8		66.6	33.4	Russia	58.8		22.3		81.1	18.9
France	89.5		4.2		93.7	6.3	Serbia-Montenegro	53.4		41.2		94.6	5.4
Germany	1.9		88.3		90.2	9.8	Singapore	94.0		5.3		99.3	0.7
Greece	1.9		92.9		94.8	5.2	South Africa	9.9		64.8		74.7	25.3
Guatemala	92.3		5.0		97.3	2.7	South Korea	54.0		28.8		82.9	17.1
Hong Kong	14.4		76.1		90.5	9.5	Spain	11.1		50.8		61.9	38.1
Hungary	60.7		32.4		93.1	6.9	Sweden	30.8		62.4		93.2	6.8
India	9.0		86.7		95.8	4.2	Switzerland	31.2		54.0		85.1	14.9
Indonesia	11.2		79.6		90.8	9.2	Taiwan	73.4		13.2		86.6	13.4
Israel	21.5		62.4		83.9	16.1	Thailand	86.2		6.2		92.4	7.6
Italy	93.0		4.0		97.1	2.9	Trinidad-Tobago	6.6		91.2		97.8	2.2
Jamaica	32.0		63.6		95.6	4.4	Turkey	51.8		27.4		79.3	20.7
Japan	7.6		71.5		79.2	20.8	United Kingdom	85.3		9.3		94.6	5.4
Lebanon	12.6		62.1		74.7	25.3	Uruguay	42.4		54.3		96.7	3.3
							Venezuela	79.8		15.2		95.0	5.0

The table presents the percent contribution of the push and pull factors to the variance of international equity flows for each country. The variance contribution of the push factor is the sum of the contributions of the global and equity factors. The pull factor is the country factor. The push and pull factor variance contributions sum up to 100%. The sample period ranges from January 1988 to July 2009.

Table 1.7: Push and Pull Factors for Regional Flows

	Bond Flows					*Equity Flows*				
	Global Factor	+	Bond Factor	=	Push Factor	Pull Factor	Global Factor	+	Equity Factor	=	Push Factor	Pull Factor
Europe	19.8		59.4		79.2	20.8	45.2		40.5		85.7	14.3
North America	40.7		47.8		88.5	11.5	83.4		14.6		98.0	2.0
Latin America	35.5		47.5		83.1	16.9	43.1		50.6		93.7	6.3
Asia and Oceania	43.3		44.3		87.5	12.5	42.2		47.3		89.5	10.5
Africa	41.4		41.6		83.0	17.0	37.5		49.4		86.8	13.2
G8 countries	26.1		47.5		73.6	26.4	58.6		31.9		90.5	9.4
non-G8 countries	32.8		51.5		84.3	15.7	42.7		46.1		88.8	11.2
G20 countries	34.8		43.1		77.9	22.1	43.8		45.7		89.5	10.5
non-G20 countries	30.7		54.5		85.2	14.8	45.2		43.6		88.8	11.2
BRICS countries	42.1		31.6		73.7	26.3	20.3		66.5		86.9	13.1
non-BRICS countries	31.0		52.9		83.9	16.1	47.2		42.0		89.2	10.8
WORLD	32.0		51.0		83.0	17.0	44.8		44.3		89.0	11.0

The table presents the percent contribution of the push and pull factors to the variance of international portfolio flows for each region. The variance contribution of the push factor is the sum of the contributions of the global and bond or the global and equity factors. The pull factor is the country factor. The push and pull factor variance contributions sum up to 100%. The regional figures are averages across all countries in that region. *World* is the average across all 55 countries in the sample. The sample period ranges from January 1988 to July 2009.

Table 1.8: Push and Pull Factors for Regional Flows over the Crisis Period

	Bond Flows					*Equity Flows*			
	Global Factor	+ Bond Factor	= Push Factor	Pull Factor	Global Factor	+ Equity Factor	= Push Factor	Pull Factor
Europe	32.2	30.0	62.2	37.8	37.0	38.0	75.0	25.0
North America	21.6	31.8	53.4	46.6	8.8	38.2	47.0	53.0
Latin America	29.5	38.4	67.9	32.1	46.0	31.8	77.8	22.2
Asia and Oceania	35.5	39.8	75.3	24.7	44.8	32.9	77.7	22.3
Africa	31.5	38.2	69.7	30.3	42.8	37.5	80.3	19.7
G8 countries	35.7	27.7	63.4	36.6	35.5	31.7	67.2	32.8
non-G8 countries	31.7	36.8	68.5	31.5	41.7	35.6	77.3	22.7
G20 countries	33.0	32.0	65.0	35.0	47.6	28.1	75.7	24.3
non-G20 countries	31.7	37.6	69.3	30.7	37.0	39.0	76.0	24.0
BRICS countries	22.8	41.8	64.6	35.4	49.8	31.2	81.0	19.0
non-BRICS countries	33.2	34.8	68.0	32.0	39.9	35.4	75.3	24.7
WORLD	32.2	35.5	67.7	32.3	40.8	35.0	75.8	24.2

The table presents the percent contribution of the push and pull factors to the variance of international portfolio flows for each region over the crisis period defined as July 2007 to March 2009. The variance contribution of the push factor is the sum of the contributions of the global and bond or the global and equity factors. The pull factor is the country factor. The push and pull factor variance contributions sum up to 100%. The regional figures are averages across all countries in that region. *World* is the average across all 55 countries in the sample.

Table 1.9: The Push Factor and Macroeconomic Information

	Global Factor	Bond Factor	Equity Factor
US Industrial Production Gap	-0.312^{**} (0.15)	0.008 (0.12)	-0.120^{*} (0.07)
US 7-year Bond Yield	-0.002 (0.03)	-0.253^{***} (0.06)	0.197^{***} (0.07)
US/World MSCI Return Ratio	-0.233^{*} (0.13)	0.387^{**} (0.17)	-0.141 (0.17)
ΔVIX	0.028 (0.04)	0.270^{***} (0.06)	-0.197^{***} (0.07)
TED	-0.409^{**} (0.18)	-0.057 (0.10)	-0.060 (0.09)
Lagged Factor	0.343^{**} (0.14)	0.193^{*} (0.11)	-0.046 (0.09)
Adj.R^2	0.61	0.38	0.13
F-test	6.13^{***} [0.00]	5.99^{***} [0.00]	4.23^{***} [0.00]

The table reports results of OLS regressions of monthly dynamic common factors on a set of US monthly macroeconomic variables. The macroeconomic variables include: (i) the US industrial production gap measured using the Hodrick and Prescott (1997) filter; (ii) the US 7-year nominal bond yield; (iii) the ratio of the 12-month returns of the US/World MSCI stock market indices; (iv) the 12-month change in the VIX index; (v) the TED spread; and (vi) the lagged value of the factor. All variables have been demeaned and standardized and hence no constant is estimated in the regression. Newey-West (1987) standard errors computed using 4 lags are reported in parentheses. *F-test* corresponds to the Wald test which null hypothesis tests whether coefficients of all variables – except the lagged factor – are jointly equal to zero. P-values are reported in squared brackets. *** indicates statistical significance at 1% level, ** at 5% and * at 10%. The sample begins in January 1996 and ends in July 2009.

Table 1.10: The Pull Factor and Macroeconomic Information

Panel Regression for All Dynamic Country Factors	
Constant	-0.113 (0.132)
Real Annual Growth Rate	0.439^{***} (0.135)
7-year Bond Yield	0.465^{***} (0.114)
MSCI Stock Index Return	0.019 (0.023)
Openness Degree	-0.115^{***} (0.045)
Lagged Country Factors	0.224^{***} (0.015)
Adj.R^2	0.100

The table reports panel regression estimates of all monthly pull (country) factors on a set of monthly macroeconomic variables for each country, which include: (i) the real annual economic growth rate; (ii) the 7-year nominal bond yield; (iii) the monthly MSCI stock index return; (iv) the Chinn and Ito (2008) capital account openness degree; and (v) lagged values of the country factors. The panel regressions include the following 26 countries: Australia, Austria, Brazil, Canada, Chile, Denmark, Finland, France, Germany, Greece, India, Israel, Italy, Japan, Malaysia, Netherlands, Norway, Philippines, Portugal, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand and United Kingdom. Newey-West (1987) standard errors computed using 4 lags are reported in parentheses. *** indicates statistical significance at 1% level, ** at 5% and * at 10%. The sample begins in January 1996 and ends in July 2009.

Chapter 2

Foreign Exchange Intraday Market Behaviour in Emerging Markets: The Case of the Chilean Peso

2.1 Introduction

Understanding the associations between exchange rates and order flow[1] in different markets has been a concern amongst researchers for several reasons. Firstly, examining the explanatory power of order flow for exchange rates has allowed literature on exchange rate modelling to solve differences between theoretical models and empirical findings. Thus considering order flow as a key determinant of exchange rate returns could improve policy and investment assessments. Secondly, research on the interrelations between order flow and exchange rate also provides evidence regarding price formation and market participant dynamics.

Several studies have addressed questions on foreign exchange (FX) microstructure for developed countries. Data limitations have constrained research on emerging market economies (EMEs) using a microstructure approach. However, knowledge on EMEs have become more valuable recently, as these countries have experienced increasing participation in the global economy, shown resilience during the global crisis, and in some cases become strongly financially developed (Kose and Prasad, 2010).

[1] Order flow is the net of buyer-initiated orders and seller-initiated orders.

Our research aims to contribute to the literature with new empirical evidence about EMEs through the analysis of the associations between exchange rates and order flow in the Chilean FX market. Chile is a small open economy under inflation target and flexible exchange rate regimes, and one of the largest copper producer countries in the world. Furthermore, one of the few countries that used official FX intervention as unconventional policy response during 2008-2009 financial crisis. In addition, we count with a novel dataset at tick frequency which to the best of our knowledge has never been analysed before. We propose to answer the following questions: What is the contemporaneous relationship between order flow and exchange rate movements in the Chilean FX market? Are there non-linearities in the order flow impact on exchange rate? Is there an anticipation, pressure or feedback effect? Is there evidence of the degree of informativeness behind the order flow of different participants? Is there a long-run relationship between order flow and exchange rates? In doing so, we aim to provide directions for the development of FX microstructure research for other EMEs.

The association between order flow and exchange rates has been extensively documented. In their seminal paper, Evans and Lyons (2002b) analyse the contemporaneous relationship between the Deutsche mark - US dollar (USD) rate and order flow, and show that interdealer order flow has strong explanatory power for exchange rate returns at daily frequency. Whilst Evans and Lyons (2005, 2006, 2008) have further analysed the features of their micro-based model, several other studies have confirmed the link between order flow and exchange rate for other currency pairs.[2] In this setting, causality runs strictly from order flow to price, which is consistent with all the canonical models (see, e.g., Glosten and Milgrom, 1985; Kyle, 1985),

[2]In fact, there is a large list of papers that examine the relationship between exchange rate and order flow from different perspectives and using different estimation strategies. Some relevant papers for this study are Payne (2003), Bjønnes, Rime, and Solheim (2005), Boyer and van Norden (2006), Daníelsson and Love (2006), Killeen, Lyons, and Moore (2006), Berger, Chaboud, Chernenko, Howorka, and Wright (2008), King, Sarno, and Sojli (2010), and Chinn and Moore (2011).

where price innovations are a function of order flow innovations. In these models, the underlying driver of order flow is non-publicly available information, such as uncertain demands or payoffs, and order flows are the channel through which this type of information is incorporated into prices.

However, the timing of order flow in relation to price adjustments can be seen in three ways: (1) order flow precedes price adjustments; (2) order flow is concurrent with price adjustments; (3) order flow lags price adjustments. These three adjustment mechanisms are known respectively as the *anticipation*, *pressure*, and *feedback* hypotheses. Statistically, they translate into three possible causality patterns: the first hypothesis implies that order flow causes prices changes; the second allows for bi-directional causality; the third implies that price adjustment causes order flows. Empirically, these causality patterns between order flow and exchange rate returns have been examined for the French franc - Deutsche mark rate by Killeen *et al.* (2006). They find that, under a flexible exchange rate regime, order flow Granger causes returns, but not the other way round. However, Daníelsson and Love (2006) argue that feedback trading is an inevitable result when aggregating the data. Furthermore, Sager and Taylor (2006) proposes that in the FX market there are *push* and *pull* customers. The former initiate price rises and falls, the latter are those agents that are attracted by these movements in prices.

Indeed, the price impact of order flow can vary with agent types. Osler (2008) explains that opposite price impacts of commercial and financial customers order flow are due to the nature of their trade responses, i.e. whether they are driven by demand pressures of goods or assets. Bjønnes *et al.* (2005) observe that the different relationships between exchange rates and financial or non-financial customer order flow indicate the side from which liquidity is provided. King *et al.* (2010) note that the order flow of financial clients are always positively related to exchange rate returns and those of commercial clients are negatively related. This is due to the

fact that commercial and non-financial clients are liquidity providers, matching the financial client demands.

Besides the different disaggregated order flow effects on exchange rates, it has also been seen that the price impact can vary throughout the day and across time (see, e.g., Berger *et al.* 2008). In addition, the goodness of fit of such linear models usually improves at lower frequencies, benefit that arises with the reduction of microstructure noise.[3] Knowledge on the relationship between order flow and exchange rate has also been enriched with the investigation of short versus long-run relationships. Studies of this kind usually test for cointegrating relationships between exchange rate and the order flow accumulated from a fixed initial period in each point in time (see, e.g., Bjønnes *et al.*, 2005; Boyer and van Norden, 2006; Killeen *et al.*, 2006; Berger *et al.*, 2008; and Chinn and Moore, 2011). Most of the cases, a long-run relationship between order flow and exchange rate cannot be rejected.

There are not many studies on FX microstructure available for EMEs. For instance, the cases of Brazil, Czech Republic and Russia are studies by Wu (2012), Scalia (2008) and Melvin, Menkhoff, and Schmeling (2009) respectively. The findings for different EMEs have differed and led to ambiguous evidence for this group of countries. In fact, Menkhoff and Schmeling (2008) examine the permanence of the order flow effects on price for different countries, concluding that the effects of order flows on exchange rate returns vary across regions. Therefore, relying on the literature to characterise the Chilean FX market is not plausible. There are no studies on the intraday behaviour of its FX market in a microstructure framework for the Chilean case.[4] Hence examining the relationship between exchange rate and

[3]Bacchetta and Wincoop (2006) provide a broader framework in which they note that changes in horizon would impact the strength of the relationship between exchange rates and order flow.

[4]The available studies for the FX market in Chile are by Tapia and Tokman (2004), Schmidt-Hebbel (2006), Abarca, Alarcón, Pincheira, and Selaive (2007) and Cowan, Rappoport, and Selaive (2007). Of these studies, none analyse the market intraday features, nor focus on the relationships between exchange rate and order flow.

order flow in this market is both a contribution to the literature and of interest for policy makers.

The data we employ in this chapter records all spot USD transactions in terms of Chilean pesos (CLP) in the Chilean FX market during two periods of time: July 2008, and June to mid July 2009. These data consist of price and volume for each transaction recorded, the exact time at which each transaction was executed, the trader category for each transaction, and the type of transactions (sell or buy). The type of transactions allows us to construct an order flow series and investigate its relationship with exchange rate returns. Combining the several approaches mentioned above in the context of the intraday CLP/USD market, our findings are listed as follows. First, we find evidence supporting the contemporaneous relationship between exchange rate returns and order flow found in the literature at different frequencies. That is, net purchases of CLP are associated with appreciation of the Chilean currency. Second, we also evaluate the time-of-the-day effect on the relationship between exchange rate returns and order flow. We find that the more active the market is the lower the impact of order flow on exchange rate returns. This coincides with the liquidity patterns throughout the day and is consistent with the findings of Payne (2003) and Berger *et al.* (2008). Furthermore, a rolling window estimation suggests that the effects of order flow varied throughout each sample analysed. Third, Granger causality tests support the anticipation hypothesis found in most of the literature for major currencies, and remain unaltered when considering only interbank trading activity. As throughout the analysed period the Central Bank of Chile (CBC) also carried out interventions, we also evaluate the causality dynamics between private order flow and the CBC order flow: Granger causality tests provide evidence of causality from order flows of CBC to the rest of the market in 2008. Fourth, we evaluate the impact of order flow of different market participants, finding that interbank trades have a much smaller effect on exchange rate returns than

total order flow. We observe that the inclusion of the CBC order flow dampens the effect of private order flow. Additionally, we find that a decrease of 1 minute in the average trading intensity is associated with an extra increase in exchange rate return of over 10 basis points. Fifth, our examination of the existence of cointegration relationships between exchange rate and cumulative order flow through the estimation of a Vector Error Correction Model (VECM) suggested by Johansen cointegration tests indicates that between 0.2% and 0.4% of the deviations from a long-run trend dissipate each 15 minutes.

The remainder of this chapter is as follows. In Section 2.2 we provide the literature review. In Section 2.3, we describe the Chilean FX market and the data employed. In Section 2.4, we show preliminary descriptive statistics. Section 2.5 reports the findings of the examination of the short and long-run relationship between order flows and the changes in exchange rates for different horizons and specifications. The last section concludes.

2.2 Literature Review

If there is consensus in the FX literature, it is that conventional exchange rate models fail on empirical grounds. It is also agreed that the FX microstructure literature has provided an acceptable alternative to explain fluctuations in exchange rates both theoretically and empirically. Evans and Lyons (2002a, 2002b) are one of the first to introduce a theoretical microstructure framework and test it in order to demonstrate that there is a relationship between exchange rate returns and order flow. In their work, the authors propose that the intraday dynamics of the FX market provides information that is relevant to understand movements in exchange rates. They provide a model of price formation and explain the rationale behind the behaviour of different participants of the FX market. Particularly, order flow – defined as the net of buyer- and seller-initiated FX trades – conveys non-public information from

dealers' quotes to interdealer trades. The empirical exercise in Evans and Lyons (2002b) consists of regressing daily exchange rate returns of major currencies on interdealer order flow and the change in the nominal interest rate differential – the interest differential accounts for public information. They find that the explanatory power of their regressions is mainly due to order flow: regressing exchange rate returns only on public information results with adjusted R^2 of less than 1%, and the inclusion of order flow in such regressions improves it to up to 60%.

After Evans and Lyons, similar results for currencies of developed countries have been found by different authors, using different data sources and frequencies. For example, Killeen *et al.* (2006), Berger *et al.* (2008), King *et al.* (2010) and Rime *et al.* (2010) find that order flow is a determinant of exchange rate movements at daily frequency. This evidence is also found with intraday data by Payne (2003), Daníelsson and Love (2006) and Berger *et al.* (2008). Furthermore, the unidirectional causality from order flow to exchange rate is found to be certain for major currencies by Bjønnes *et al.* (2005), Killeen *et al.* (2006), Boyer and van Norden (2006) and Berger *et al.* (2008).

Another important stylized fact in the FX microstructure is pointed out by Osler (2008). It is found that order flows of different participants might have different impact on exchange rate returns. Specifically, financial customer flow is positively related to exchange rate whereas commercial customer flow is negatively related. The reasons for this could be that, on the one hand, commercial customers respond to the impact of relative prices of international trade on exchange rates and on the demand pressures in the FX market, hence the negative correlation of their order flow with exchange rate returns. On the other hand, financial customers provide overnight liquidity motivated by the state of the economy, hence the positive correlation between financial order flow and exchange rate returns. Bjønnes *et al.* (2005) evaluate whether different participants play different roles in the intraday

dynamics of exchange rates, finding that financial customers are more likely to be overnight liquidity providers. They use the concepts of *push* and *pull* customers introduced by Sager and Taylor (2006) to rationalise it. Push customers are initiators of rises or falls in prices, whereas pull customers are those who are attracted by prices that suit their investment expectations. Thus, push customer order flow is positively correlated to price movements, whereas pull customer order flow is negatively correlated. King *et al.* (2010) also distinguish customer category in their analysis, and find that the price impact of order flow is positive for financial clients, and negative for commercial clients and interbank trades. The negative impact of the interbank order flow on the exchange rate found in King *et al.* (2010) contrasts with the literature. The authors explain that one of the reasons for obtaining such an unusual result is the double-counting given that this order flow might be reflecting transactions with customers from previous trade rounds. Additionally, there could also be a problem of correctly signing trades more pronounced for interbank trades.

It has been also observed in some cases that, unlike suggested by Evans and Lyons, cumulative order flow[5] does not net to zero each day. According to Chinn and Moore (2011), this could mean that dealers are providing liquidity overnight; therefore dealers may not be acting just as intermediaries – if dealers are providing liquidity overnight, it might be profitable to do so. In this context, Evans and Lyons' model would imply the existence of a long-run relationship between exchange rates and cumulative order flow. This hypothesis has been studied in Bjønnes *et al.* (2005), Boyer and van Norden (2006), Killeen *et al.* (2006), Berger *et al.* (2008) and Chinn and Moore (2011). Basically, these studies test for cointegration between cumulative order flow and exchange rates. Particularly, Bjønnes *et al.* (2005) analyse the Swedish krona within a cointegration framework, finding that between 5% and 49% adjustment takes place daily, depending on the horizon. Their model explains

[5]Cumulative order flow is defined as the sum of all flows between time 0 and time t, where $t = \{0, 1, 2, ..., T\}$.

nearly 70% of the exchange rate variations. Killeen *et al.* (2006) find similar results, also at daily frequency. They show that over 25% of the departures from the long-run trend is dissipated daily in the French case, with a goodness of fit of 25%. Chinn and Moore (2011) use monthly data, and find supporting evidence of cointegration in the Japanese market.

Studies for emerging markets are much harder to find. Scalia (2008) analyses the Czech FX market in a microstructure context. He estimates a two-equation system on intraday exchange rate returns and order flow for the Czech krona - Euro rate. Although the analysis particularly focuses on the effects on intervention, his findings on the associations between exchange rates and order flows are in line with the literature for developing countries. Another example is the work of Menkhoff and Schmeling (2008), who examine the permanence of order flow effects on price in different countries. They find that the impact of order flows on exchange rate returns of certain regions is very short-lived. Melvin, Menkhoff, and Schmeling (2009) analyse the Russian case, also focusing on intervention. Amongst their results, they observe that there is a positive significant impact of order flow on exchange rates, which decreases (but does not vanish) during official intervention days. Kohlscheen (2012) and Wu (2012) explore the properties of the Brazilian FX market. Using daily data, Kohlscheen (2012) estimates simple linear regressions in order to examine the effects of customer and central bank order flows on the exchange rates. He corroborates the existence of order flow and exchange rate associations. From his estimations without controls for public information, the explanatory power of order flow reaches 10%. Wu (2012) examines the short and long-run relationships of the main players in the Brazilian market. Through the estimation of a structural model, he finds that commercial customer flow is negatively related to exchange rates, whilst financial customer flow is positively related. The impact of central bank order flow is also found to be positive.

Analysis on the FX market in Chile is also limited. The most recent papers to examine the Chilean market are the ones by Cowan *et al.* (2007) and Abarca *et al.* (2007). These studies are also the closest in addressing the Chilean market from a high frequency perspective. On the one hand, Cowan *et al.* (2007) estimates a VECM for the CLP/USD nominal exchange rate and high frequency proxies for fundamentals using daily data. They find that CLP/USD rate is highly correlated with the commodity prices. They also argue that the investment decisions of the biggest players in the Chilean financial markets (such as pension fund managers) would contribute to changes in the trend of the exchange rate. On the other hand, Abarca *et al.* (2007) evaluate the in- and out-of-sample predictive power of a set of technical analysis indicators for daily returns of the exchange rate. They find evidence supporting the relevance of technical analysis indicators for explaining CLP/USD movements, and that the *relative strength index* is particularly good at forecasting at different horizons. Concerning the main features of the intraday behaviour of the Chilean FX market, there are still no studies available in the literature.

2.3 Preliminaries: Market and Data

2.3.1 The Chilean FX Intraday Market

The main foreign currency traded in the Chilean FX market is the USD. Since 2003, there have been two main trading platforms operating in Chile: the Santiago Stock Exchange (SSE) and the Electronic Exchange (EE). In these platforms, both interbank (IB) and non-bank (NB) trades are performed. The NB participants would include broker dealers and financial institutions (i.e. investment banks, mutual funds, pension funds, and hedge funds). Although traditionally banks would choose the SSE to trade large amounts of USD, the use of the EE has increased across time. In fact, since 2003 the market share of EE rapidly grew until that, in 2008, SSE and EE shared similar portions of the spot market. Moreover, nowadays more than 90% of

the market transactions in the EE platform. The price levels in both markets have not shown major differences on daily averages. Between 2001 and 2009, the price differences between SSE and EE oscillate within ±1 CLP/USD, which is equivalent to no more than 0.2% of the average price of the whole period. The exception was the period prior to the USD purchase programme carried out by the CBC in 2008, where the price differences between SSE and EE were predominantly negative, between 0.5 and 2.5 CLP/USD. In both platforms, the transactions recorded are mainly interbank trades; for instance, around 80% of the total monthly volume was traded amongst banks in 2008. In Chile, NB trades are fundamentally operations made by pension fund managers and broker-dealers. The former can only trade with banks, and they are not allowed to trade in the EE. The broker-dealers act as brokers and as investors. CBC trades were also traditionally carried out in the SSE and it corresponded to about 10% of the total monthly volume traded during the USD purchase programme in 2008. The last time the CBC traded in the SSE was as a fiscal agent in 2009, whilst selling USD on behalf of the Chilean Government. The most recent USD purchase programme carried out by the CBC was in 2011, and for the first time it was done in the EE.

2.3.2 Data

To analyse the intraday behaviour of the Chilean FX market, we use data extracted from the SSE system. The data consist of all USD spot transactions covering the periods July 2008 and June to mid July 2009.[6] The information recorded in these data includes exact time of transaction, price and volume of transactions, the trade sign and market type. Trade sign indicates whether the respective amount (volume) of USD was purchased or sold. One of the advantages of having the sign of each trade is that with this data, which are order flows, we compute the cumulative order

[6]Data collection from the SSE system is usually limited, partly due to privacy policies, and partly due to the strictness of the procedure involved in the data collection itself. In particular, we collected these short span data on a daily basis directly from the money desk of the CBC to which access was granted to us for a limited period of time, and for research purposes only.

flows, so that the long-run relationship between exchange rates and order flow can be tested. Market type indicates whether the transaction was made between dealers, i.e. IB, or whether it included at least one non-dealer participant, i.e. NB. Note however that, in addition to these two types of players in this market, our data also allows us to identify the CBC trades as during the period covered in this chapter the CBC intervened in the FX market.[7] The CBC trades currencies only with banks.

Another feature of our data is that they are irregularly spaced, i.e. the time passed between transactions varies throughout the market opening times, that are from 8am to 6pm. We compute what we call the *durations*, corresponding to the seconds passed between transactions. That is, as the first transaction recorded in our data set in July 2008 occurred at 08:07:08hrs, 428 seconds passed since the opening hour until the first trade was made. The second transaction was recorded at 08:14:02hrs, therefore the duration between the first and the second transaction was 414 seconds. Durations are a measure of the trading intensity of this market. If the agents in this market had the same information and formed expectations in similar ways, this variable would be irrelevant as each agent would be able to anticipate the other's behaviour creating an uniformly distributed intensity. If this is not the case, we would expect that duration would also have explanatory power for the return series.

2.3.3 Descriptive Analysis

Table 2.1 shows how transactions in the SSE are distributed over the Chilean FX market opening times in our samples for 2008 and 2009. Columns 2 and 3 show the percentages of total transactions, and Columns 4 and 5 indicate the average duration of transactions expressed in seconds. We observe here an intraday pattern:

[7]Noteworthy to mention that the only participant specifically identified in our data is the CBC; information about the other banks and institutions is not available to us as this type of information is proprietary and confidential. One drawback of our data sets is that knowing whether a NB trade was made between a bank and a non-bank participant, or between two non-bank participants, is not possible.

there are less transactions recorded during opening hours and in the afternoon. This pattern is also observed in terms of durations. Hence, according to the distribution of the number of trades and trade durations shown in Table 2.1, the most trading intensive period in the Chilean FX market is between 9am and 2pm.

A statistical summary of the intraday log returns and volumes of USD spot transactions in the SSE is presented in Table 2.2 at 15 minutes frequency. On average, duration, order flow, returns and volume seem not to greatly differ between the sample periods analysed. Whilst according to Table 2.2 the average order flow in 2008 was lower than 0, the data indicates that on average it would have actually fluctuated between 8 million USD purchases and 4 million USD sales. In 2009, order flow would have fluctuated between sales by 7 million USDs and purchases by 4 million USDs. In disaggregate terms, IB volume traded is usually larger than NB volume traded, but returns and standard deviations remain similar across markets and transaction types.

Correlation matrices are shown in Table 2.3. Now we examine two alternative measures of order flow: trade and volume based order flow. Each measure of order flow is calculated as purchases minus sales. In the case of trade based order flow, this is equal to 1 when the type of transaction is a 'buy' and -1 when it is a 'sell'. Likewise, the volume based order flow will be signed accordingly and multiplied by volume traded, i.e. if the transaction is a purchase of 0.5 million USD, the volume based order flow equals 0.5, whereas a sale of 0.5 million USD would be equal to -0.5. Additionally, we distinguish between total trade and volume based order flow (OF_t and VOF_t, respectively),[8] IB order flow (OF_t^{IB} and VOF_t^{IB}, respectively), and NB order flow (OF_t^{NB} and VOF_t^{NB}, respectively).

Table 2.3 shows that the correlation between exchange rate returns and all order flow types is positive, which suggests that the CLP tends to depreciate with respect

[8]Total order flow is the sum of CBC, IB and NB trades.

to the USD under buying pressures, regardless of who initiates the trade. It also suggests that there is no clear push or pull agent behaviour. On average, the correlations between order flows and exchange rates are higher in 2008 with respect to 2009. Particularly, the correlation between exchange rate returns and trade based total order flow is only slightly higher than the trade based IB or NB order flow in most of the cases. This is not necessarily true for volume based order flows; however the differences are very small. Note that the correlation between OF_t and OF_t^{IB} is around 90% in both periods, whereas the correlation between OF_t and OF_t^{NB} can go from 46% to 73%. These results are consistent with the fact that IB transactions account for about 80% of the SSE market. The correlation between VOF_t and VOF_t^{IB} is much lower relative to trade based order flows in both periods. This could be associated with the fact that in both periods the CBC traded large amounts in the FX market. Overall, durations do not appear to be highly correlated with either returns or order flow of any kind.

2.4 Empirical Results

In this section, we show the results of the estimations of the relationship between order flow and exchange rate and related statistical tests, in order to answer the questions mentioned earlier in this chapter. In what follows, we aim to verify whether the findings in the literature apply for the case of Chile, to understand the results from an economic perspective, and to discuss their implications.

2.4.1 What is the Contemporaneous Relationship Between Order Flow and Exchange Rate Movements?

We start estimating the basic contemporaneous relationship between the CLP/USD rate and total order flow as:

$$\Delta s_t = \alpha_1 + \beta_1 x_t + \varepsilon_{1,t} \tag{2.1}$$

for our samples of 2008 and 2009 at tick and 15 minutes frequency, using ordinary least squares (OLS). In Equation (2.1), Δs_t represents the percentage change of log exchange rate, x_t the total order flow – trade or volume based –, and ε_t the error term. The results for Equations (2.1) are presented in Table 2.4. The β coefficients on order flow are interpreted as the percentage changes of the CLP/USD rate responding to a net sales (of 1 million USD in the case of volume based order flow). We first notice that trade based order flow has higher explanatory power for the exchange rate returns than volume based order flow: net purchases of the CLP are associated with an appreciation of 34 and 18 basis points respectively. This response comes down to 14 basis points both in 2008 and 2009 when order flows are scaled by volume traded.

To test this contemporaneous relationship between order flow and exchange rate, we also regress Δs_t as in Equation (2.1) on 8 leads and lags for x_t separately. Figure 2.1 shows the results of running these regressions for both sample periods for trade and volume order flows at 15 minutes frequency. The coefficient estimates are shown with their respective significance ranges at 5% level. The most notorious relationship in terms of significance of all alternatives is the contemporaneous relationship, i.e. when no leads or lags are specified for the explanatory variable x_t. We find some cases of significant correlations between exchange rate and order flow at different leads and lags, however the adjusted R^2 associated with each of these regressions are lower than the one that depicts the contemporaneous relationship.

As we cannot ignore that exchange rate movements respond to fundamentals, we estimate augmented specifications of Equations (2.1) as follows:

$$\Delta s_t = \alpha_2 + \beta_2 x_t + \gamma_2 z_t + \varepsilon_{2,t} \tag{2.2}$$

where z_t represents other fundamentals. In our case, we estimate three additional specifications of Equation (2.2) for each order flow measure. In each specification,

z_t represents the interest rate differentials $(i_t - i_t^*)$ (lagged or in first differences) and the first difference of copper price in logarithm Δcop_t. In this setting, i_t is the 1 year domestic swap rate, i_t^* is the 1 year foreign swap rate,[9] and cop_t is the 3 month copper price. These variables were chosen such that we can investigate the value added of order flow to the potential explanatory power of fundamentals and public information on exchange rate returns. Particularly, we choose the copper price as macroeconomic fundamentals following King *et al.* (2010), who note that the exchange rate of a commodity exporter country is closely related to the exported commodity price. Furthermore, the inclusion of copper price in the equation is also consistent with Cowan *et al.* (2007) who show that copper prices are related to the real cycle of the Chilean economy and the terms of trade. The estimation results for Equation (2.2) are shown in Table 2.5. The inclusion of interest rate differential does not increase the adjusted R^2 in both periods, neither does the copper price change in 2008. However, in 2009 the impact of changes in copper price appears to be significant and greater than order flow effect on exchange rate returns, which also increases the adjusted R^2 in 1%.[10]

The adjusted R^2 of our regressions of the returns on trade based order flow reach 21% for 2008 and 8% for 2009, and 5% in both periods for volume based order flow. Comparing with the results of Berger *et al.* (2008), where the excess of buyer-initiated trades of 1 billion USD at 15 minute horizon would be associated with 50-60 basis points of rising prices for the euro and the yen against the US dollar and reaching adjusted R^2 of almost 50%, our results seem insignificant. However, it is worth mentioning that an adjusted R^2 of 20% or even 5% can hardly be achieved

[9] The 1 year swap rates are the shortest terms that are found simultaneously available at intraday frequency.

[10] Estimations for $\Delta s_t = \alpha_2 + \gamma_2^* \Delta cop_t + \varepsilon_{2,t}^*$ compared to estimations for $\Delta s_t = \alpha_2 + \beta_2 x_t + \gamma_2 \Delta cop_t + \varepsilon_{2,t}$ for our two order flow measures indicates that $\gamma_2^* = -1.13$, significant at 1% level, is smaller than the $\hat{\gamma_2}$ in Table 2.5. However, the associated adjusted R^2 is smaller than 1%. We also evaluate whether order flow and copper price correlation could be inflating their explanatory power for exchange rate returns when included simultaneously in Equation (2.2). The *variance inflation factors* are usually smaller than or close to unity, so we discard severe multicollinearity in our model.

by any other variable in exchange rate regressions at high frequency. The results found by Evans and Lyons (2002a), which ranged between 45% and 80%, were of regressions for daily returns of major currencies. Other studies at daily frequency also found relatively high adjusted R^2 for advanced economies. For instance, King *et al.* (2010) find adjusted R^2 around 25% for the Canadian dollar; Rime *et al.* (2010) find adjusted R^2 up to 44% in their study for the UK sterling, the euro, and the Japanese yen markets. Indeed, the evidence indicates that higher data frequency are usually accompanied by lower adjusted R^2: the 50% found at 15 minutes frequency by Berger *et al.* (2008) decreases to 35% at 1 minute frequency; the 25% reached by King *et al.* (2010) at daily frequency increases to 40% when they consider weekly observations.

It is fairer to compare our results to those found for EMEs, given that the size and depth of the market may influence the agents behaviour. Melvin *et al.* (2009) find that the impact of 10 million USD purchases is of 2.5 basis points exchange return increase in the Russian rouble at 30 seconds frequency. Scalia (2008) finds that net purchases of 10 million euros depreciates the Czech krona in 7.6 basis points at hourly frequency, effect that is highly persistent. Kohlscheen (2012) uses daily data to examine the Brazilian FX market, and finds that "a 1 b[illio]n USD sale by an end-used is associated with a 0.25% appreciation of the Real". His estimations include controls for public information, however they indicate that the explanatory power of order flow without controls is around 10% . Given these results, and considering that the average turnover of a 15 minutes interval in the Chilean FX market between the most trading intensive hours is of 17 and 15 million USD in 2008 and 2009 respectively, our results indicate that there is a strong relationship between order flow and the CLP/USD rate.

2.4.2 Are There Non-linearities in the Order Flow Impact on Exchange Rate?

The low explanatory power of these models could also be due to non-linearities present. Simple scatter plots of exchange rate returns and order flows, and the corresponding Kernel fit are shown in Figure 2.2. Clearly, the relationship between returns and order flows is positive, but not necessarily linear at 15 minutes frequency, as suggested by the non-parametric Nadaraya-Watson estimator. The trading intensity asymmetry would suggest that the determinants of the orders at different times of the day or across time might differ. For example, we could think of the orders placed in the early and last hours of the day as obeying to speculative behaviour. Throughout the most trading intensive hours there could be differences due to other non-idiosyncratic factors. The impact of order flow may also vary throughout the days. To evaluate whether there are differences of this kind, we extend our basic model to consider time-of-the-day effects, and we also estimate the basic model for rolling windows.

2.4.2.1 Time-of-the-day Effect

We evaluate the effects of time-of-the-day on the relationship between exchange rate and order flow. To do so, we construct ten dummy variables that equal 1 at each hour of the trading day (from 8am to 6pm). Then, we regress the log exchange rate returns on a constant and the interaction between the order flow variables and these dummies, as follows:

$$\Delta s_t = \alpha + \sum_{i=1}^{10} \beta_i I_t^{h=i} x_t + \varepsilon_t \tag{2.3}$$

where $I_t^{h=i}$ is an indicator function that equals 1 when the hour at which the trade takes place is equal to $i = 1, ..., 10$ such that $i = 1$ represents 8am, $i = 2$ represents 9am, and so on. Thus, the subindexes of the βs also represent each hour of the day,

from 8am to 5pm.[11] The results of the estimation of Equation (2.3) for the tick data are displayed in Table 2.6. We obtain results similar to Payne (2003) and Berger *et al.* (2008): in all cases, the βs are significant at 1% level in the first 6 trading hours. Interestingly, we have observed in the previous section that this is the most intensive trading period of the day. This is consistent with the liquidity provided during the day, which actually concentrates between 9am and 1pm.

The estimations of Equation (2.3) at 15 minutes frequency for trade and volume based order flow are illustrated in Figure 2.3. The results indicate that the effects of order flows at the first trading hour and near lunch-time were notoriously greater in 2008 and 2009, compared to the following trading hours. Differences in the results between the samples could be related to the fact that the economic conditions at which the market operated in 2008 were different than in 2009. In 2008, EMEs were more cautious about foreign economies, some even responded anticipatively to a possible worsening of the global environment. In 2009, markets had already incorporated a good portion of pessimism. That said, we realise that as we do not provide a behavioural model in this chapter, we cannot state whether the differences between the results seen in Figure 2.3 are due to changes in the agents behaviour. However, according to what we observe in the data, in the first trading hours the exchange rate volatility was also high and the number of trades were only around 3% of the total traded on average each day (see Table 2.1). Therefore, although these results could be seen as good news for a policy maker or major agent aiming to impact the CLP/USD rate, we do not interpret our results as meaning that by trading large amounts throughout those times of the day a trader would fully accomplish such an objective.

[11] Note that, in this notation, $i = 1$ contains all transactions recorded from 08:00:00 to 08:59:59hrs, $i = 2$ contains all transactions recorded from 09:00:00 to 09:59:59hrs, and so on.

2.4.2.2 Impact over Time

To further evaluate possible non-linearities in the response of exchange rates to order flow, we estimate Equation (2.1) for rolling windows of one week of trading activity, such that each window starts at 08:00:00hrs of its first corresponding day, and finishes at 14:00:00hrs of its fifth corresponding day. This is to say that each window contains 125 observations and the step between each window is of 25 observations. The results are shown in Figures 2.4 and 2.5. Understanding the limitations in terms of comparability of rolling window estimations, we focus on the results for non-overlapping samples.

It is clear from Figures 2.4 and 2.5 that the impact of order flow on exchange rate could differ from 10 to 20 basis points across time, and its significance is also changing. Particularly, the impact of volume based order flow across time appears to be notoriously less significant in 2008 compared to 2009, relative to trade based order flow. Interesting to note that in 2009 the period when the impact of order flow was highest (and significant) is clearly identified: around the week when the CBC did not trade in the market (the neighborhood of the 20^{th} window).

2.4.3 Is There an Anticipation, Pressure or Feedback Effect?

We have seen previously that there is a strong relationship between order flow and exchange rate during the most intensive trading hours, although this seems to vary over time. We continue to study the intraday behaviour of the Chilean FX market by running bivariate Granger causality tests between exchange rate returns and all customers trade based order flow (OF_t). With these tests, we examine the existence of anticipation, pressure or feedback effects. Recall that when the causality runs from order flow to exchange rate, there is an anticipation effect; when it runs from exchange rate to order flow, that indicates feedback trading; and when there is bi-causality, we are talking about pressure effect. As shown in Daníelsson and

Love (2006), feedback trading can be a result of data aggregation. Taking this into account, this type of causality cannot occur at tick frequency.

Table 2.7 summarises the results of Granger causality tests for 2008 and 2009 at different frequencies.[12] Wu (2012) finds that in the case of the Brazilian FX market, bi-directionality cannot be rejected when testing separately for order flow of different customer types and exchange rates using daily data, supporting the presence of stabilising feedback trading with their structural model. However, according to our results, there is no evidence supporting the feedback trading at 15 minutes frequency as we do not reject the hypothesis that order flow does not cause exchange rate returns. This is also found by Killeen *et al.* (2006) for the French franc - Deutsche mark rate.

We also evaluate the bi-causality between participant types, finding interesting results: whilst in 2008 there is no supporting evidence of order flow leadership amongst participant types, this is not the case for 2009. In fact, for the 2009 sample we cannot reject the hypothesis that central bank flow causes interbank flow, and that the latter causes non-bank flow. Indeed, the motives behind the CBC trade in 2009 were different than in 2008, as in 2008 the CBC was carrying out its official intervention programme, whereas in 2009 it was perceived as another agent of this market, who traded important volumes compared to the daily averages.

To understand whether the positive contemporaneous impact of order flow on exchange rate returns differs across participants, we further investigate the agent type flow effect.

2.4.4 Is There Evidence of the Degree of Informativeness of Order Flows from Different Participants?

We estimate four further specifications including order flow of different participants and durations to the basic model. That is, to the Equation (2.1) we add the IB

[12]The Granger regressions are estimated with 2 lags, based on Schwarz information criteria. The regressions with 1 and 3 lags do not alter the results significantly.

flows (OF_t^{IB}); the CBC flows (OF_t^{CB}); and the durations of transactions (Dur_t), all variables interacting with total order flow (OF_t). The most general specification that we estimate is as follows:

$$\Delta s_t = \alpha + \beta OF_t + \gamma OF_t * OF_t^{IB} + \delta OF_t * OF_t^{CB} + \theta OF_t * Dur_t + \varepsilon_t \qquad (2.4)$$

Tables 2.8 summarises the results of the estimations at 15 minutes frequency.[13] The aggregation to 15 minute intervals is computed as follows: returns and order flows within the corresponding 15 minute intervals are summed, durations are averaged. Overall, the positive impact of an increase of net purchases of USD on the exchange rate returns found in the previous section remains significant when we add the order flows of IB and CBC to the model.

As total order flow includes both IB and CBC order flow, the impact of IB order flow on the exchange rate returns corresponds to $(\beta + \gamma)$ and the impact of the CBC order flow on the exchange rate returns corresponds to $(\beta + \delta)$. In addition, θ corresponds to the additional impact of an increase of the duration by 1 minute has on exchange rate changes. The coefficients associated with OF_t^{IB} and OF_t^{CB} are interpreted as follows. First, the incorporation of the order flow interaction with IB trades indicates that almost 24% of the total effect corresponds to IB trades in 2008 as OF_t^{IB} is associated with 22 basis points impact on the exchange rate, and 38% in 2009 given its impact of 13 basis points. Second, when the CBC trades are also considered as part of the explanatory variables, the impact of IB trades reduces in 2008, but not in 2009. This indicates that official intervention could have been effective through the damping channel as known in the literature.

The estimation of the full specification as in Equation (2.4) indicate that net IB purchases of USD are associated with 10 basis points relative depreciation of the CLP in 2008, and 8 basis points in 2009. Besides, the CBC purchase orders in 2008

[13] In this table, the duration series is re-scaled to minutes for purposes of illustration.

are associated with 6 basis points depreciation of the CLP, whilst its sale orders in 2009 are associated with 18 basis points appreciation of the CLP. The latter could indicate that the actual official interventions of 2008 had a smaller impact than the CBC trades in 2009. Note however that the results of the CBC flow effect in 2009 are significant at 7%. The positive effect of duration on returns show that when trading intensity decreases (i.e. duration increases), the exchange rate returns tend to increase. However, this effect is relatively small as it is measured as per minutes passed, and as seen in Table 2.1, the average duration within the more trading intensive hours is bellow 1 minute.

We estimated the same specifications at higher frequencies. The coefficients decrease in magnitude with respect to the 15 minute samples, as seen in the literature, but remain significant for both order flow measures. We also carried out these estimations at both frequencies using volume based order flow measures. The results become less significant, supporting the idea exposed by Sager and Taylor (2006) that trade based customer order flow (also called sign order flow) is more informative than volume based customer order flow (that consider the nominal value of the trades), due to the different aspects of this group of participants.

2.4.5 Is There a Long-run Relationship Between Order Flow and Exchange Rate?

In microstructure theory, a permanent effect of order flow on exchange rate implies that order flow play a role on absorbing public information about macroeconomic news and fundamentals, and channel it into prices (Killeen *et al.*, 2006; Love and Payne, 2008). In FX terms, this is to say that the price of the foreign currency in t is determined by the accumulated order flows up to period t. An alternative point of view is that order flows only convey information about the deviations of exchange rate from fundamentals, which are related to transitory effects (Froot and Ramadorai, 2005; Berger *et al.*, 2008). Furthermore, market clearing theory implies

that the cumulative order flow would revert to zero, however depending on the size of a market, order imbalances might not be resolved within a day (Wu, 2012). Empirical research has tested these hypotheses using cointegration tests, examining the relationship between exchange rate and cumulative order flow, providing mixed evidence so far.[14]

Figure 2.6 shows the exchange rate and cumulative order flow in our samples for 2008 and 2009. The relationship between these two series in both periods is rather difficult to define: in many periods they seem highly correlated, but this is not a general rule. Given they are non-stationary, we test whether these series are cointegrated.[15] The results for Johansen cointegration tests between CLP/USD rate and the cumulative trade and volume base order flow are summarised in Table 2.10.[16]

The results of cointegration tests according to Johansen's trace and maximum eigen value tests reject the null hypothesis of no cointegrating relationships. This would imply that cumulative order flow might influence exchange rate beyond few seconds around each trade. If these cointegrating relationships were in fact present, a VECM would be a better model for representing the short- and long-term effects of order flow on exchange rate.

We estimate a VECM whose long-run equation includes log exchange rates, log copper price and cumulative order flow measured as $X_t = \sum_{i=1}^{t} x_i$, where x_i is the order flow in period i. From the long-run equation, the error correction term would be a representation of the deviations from the long-run estimated trend. In the

[14] Whilst Bjønnes *et al.* (2005), and Killeen *et al.* (2006) find evidence in favour of cointegration between exchange rate and cumulative order flow, Berger *et al.* (2008) do not find supporting evidence for cointegration. Chinn and Moore (2011) find weaker evidence of cointegration for the euro than for the yen.

[15] For unit root tests, see Table 2.9. From the results, we corroborate the evidence found in the literature that exchange rate levels are usually non-stationary, whilst exchange rate returns overall show a stationary behaviour. Furthermore, order flows are stationary, but the presence of unit root in its cummulative representation cannot be rejected.

[16] The optimal lag length for the cointegration tests is determined by the Schwarz information criterion. In general the lag length selected according to all criteria are short relative to the frequency of our data, ranging between 3 and 7 lags.

short-run equation, the exchange rate log returns is the dependent variable, and the lagged error correction term, and 2 lags of the first differences of exchange rate and cumulative order flow are the explanatory variables.[17] We consider the total order flow series as an additional and exogenous variable on the right hand side of the short-run equation. Estimation results of such VECM would suggest that the velocity of reversion oscillates between 0.2% and 0.4%, considering trade and volume based order flow, respectively. These results are far from the evidence found by Bjønnes *et al.* (2005), Killeen *et al.* (2006) and Chinn and Moore (2011), whose daily reversal reach between 20-25%. However, the goodness of fit of our VECMs is very low, and in all cases the lags of cumulative order flows are not found to have statistically significant impacts.

This leaves us with the following question: why is it that cumulative order flows do not revert to zero each day? As mentioned earlier, Wu (2012) provides a possible explanation, that in small sized markets such as the Brazilian FX market, order imbalances might not be resolved within a day. In addition, this could possibly be because providing liquidity overnight is profitable. We compute de deviations of the cumulative order flow at the end of each trading day from the average inventory on a daily basis, to check whether more than usual overnight holdings are profitable. Comparing these daily deviations with the overnight exchange rate return, we observe a correlation of -7% in 2008 and 18% in 2009 between overnight exchange rate return and cumulative order flow.

2.5 Conclusion

Although the microstructure literature on FX is vast, questions in this area have been addressed mostly for developed countries and little is known for emerging markets mainly due to data limitations. This fact has constrained researchers to understand

[17] Although according to several information criteria the optimum lag length is 1 or 4 in few cases, we decided to include 2 lags, coherent with most of the lags suggested, in order to have comparable results.

emerging FX markets.

In this chapter we present new evidence on the microstructure of exchange rates in emerging markets. We employ a novel dataset that, to the best of our knowledge, has never been analysed before. With this data we are able to examine the features of all spot USD transactions recorded in the Chilean FX intraday market over four weeks in mid 2008 and six weeks in mid 2009. We evaluate the impact of order flow on exchange rate returns and analyse the behaviour of such relationship throughout the day and across time. We also evaluate the differences amongst the impact of dealers, non-dealers and central bank order flow on exchange rates.

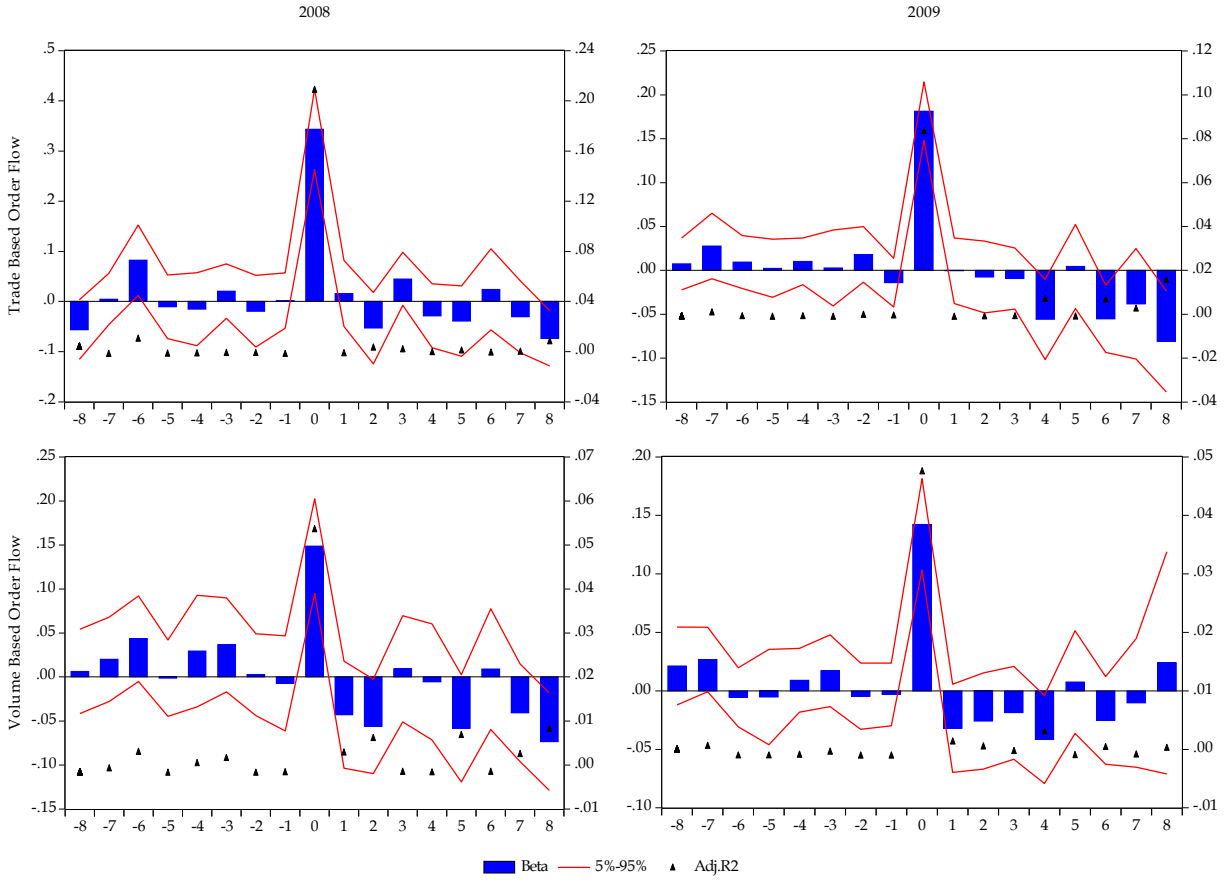
Our findings suggest the existence of a statistically significant relationship between CLP/USD rate and its order flow. Furthermore, the domestic currency tends to depreciate with USD buying pressures, regardless of who initiates the trade. Trade based order flow has higher explanatory power than volume based order flow, as suggested by Sager and Taylor (2006) for customer flows. The impact concentrates in the most intensive trading hours, which is consistent with the liquidity provided during the day. The order flow impact is also changing across time, both in magnitude and significance. Differences in the results between the samples could be related to the fact that the economic conditions at which the market operated in 2008 were different than in 2009. Interesting to note that in 2009 the period when the impact of order flow was highest is around the week were the CBC did not trade in the market.

Unlike evidence found for some EMEs, our findings do not support bi-causality between order flow and exchange rate. However, we find weak evidence suggesting order flow leadership from central bank to dealer, and from dealer to non-dealer trades in 2009. According to our results, the interbank order flow effects are no more than one quarter of the total order flow effect, and trading intensity has also minor impact during the first trading hours. Our findings also suggest that the

official intervention in 2008 had an effect on damping the price effect of interbank order flow, whereas the direct effects of the CBC order flow on exchange rates seem to be stronger in 2009. Regarding the existence of a long-run relationship between exchange rate and cumulative order flow, Johansen's test rejects the hypothesis of no cointegration. Our VECM estimations indicate that between 0.2% and 0.4% of the deviations from the long-run trend return to equilibrium at 15 minute frequency.

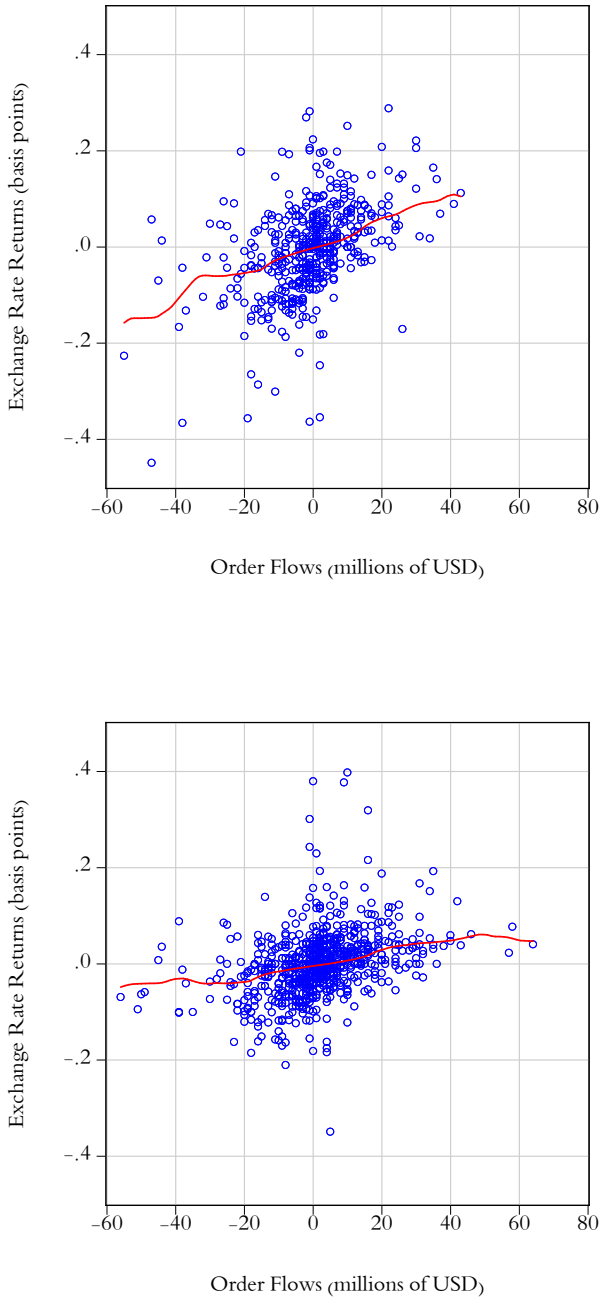
Due to the nature of our data, defining who the liquidity providers in this market are is not an easy task. The presence of the CBC in the market impacts the order flow dynamics in the short run: the interbank order flow effect decreases during official intervention periods, and contents an important portion of the total order flow effect as a fiscal agent. These conclusions are not conditional on the volume traded by the CBC. Overall, our analysis provides directions on future analysis of FX intraday markets in EMEs. As our results imply that the Chilean FX market works differently from some EMEs, future investigation should consider the evaluation of possible extensions to Evans and Lyons' model applicable to small FX markets.

Figure 2.1: Basic Relationship Between Exchange Rate Returns and Order Flows



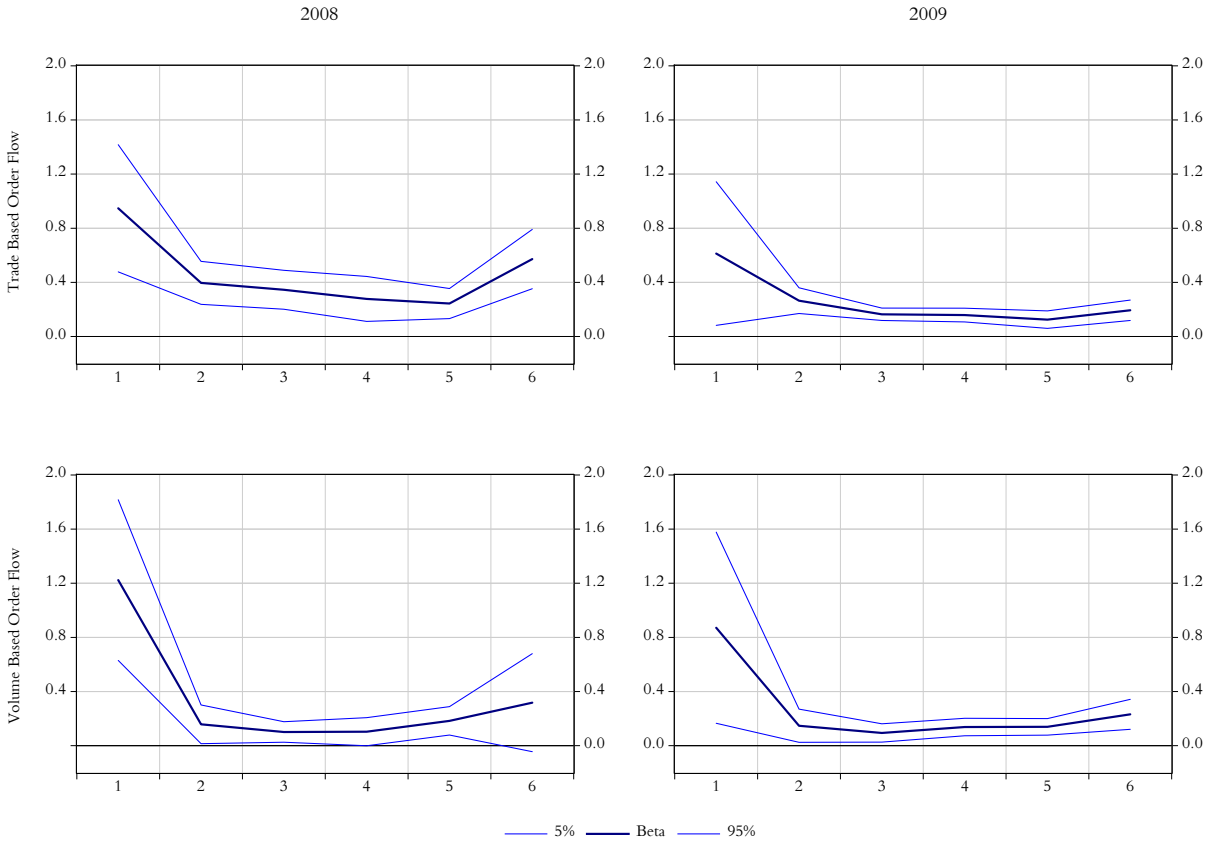
The figure shows the estimation results of the regressions of exchange rate returns (CLP per USD) on order flow leaded and lagged up to 8 periods, separately. The regressions are estimated by OLS at 15 minutes frequency using Newey-West standard errors. The coefficients (blue bars, left vertical axis) show the changes of the exchange rate returns in basis points of net purchases (trade based order flow, top charts) and 1 million USD purchased (volume based order flow, bottom charts), at each time of the day. The confidence interval (red lines, left vertical axis) corresponds to the coefficient estimates plus (top line) and minus (bottom line) two times the standard deviations. Adjusted R^2 (right vertical axis) are plotted as black markers. The sample period ranges from 1/7/2008 to 31/7/2008 (labeled '2008'), and 1/6/2009 to 20/7/2009 (labeled '2009')

Figure 2.2: Non-linear Relationship Between Exchange Rate Returns and Order Flows



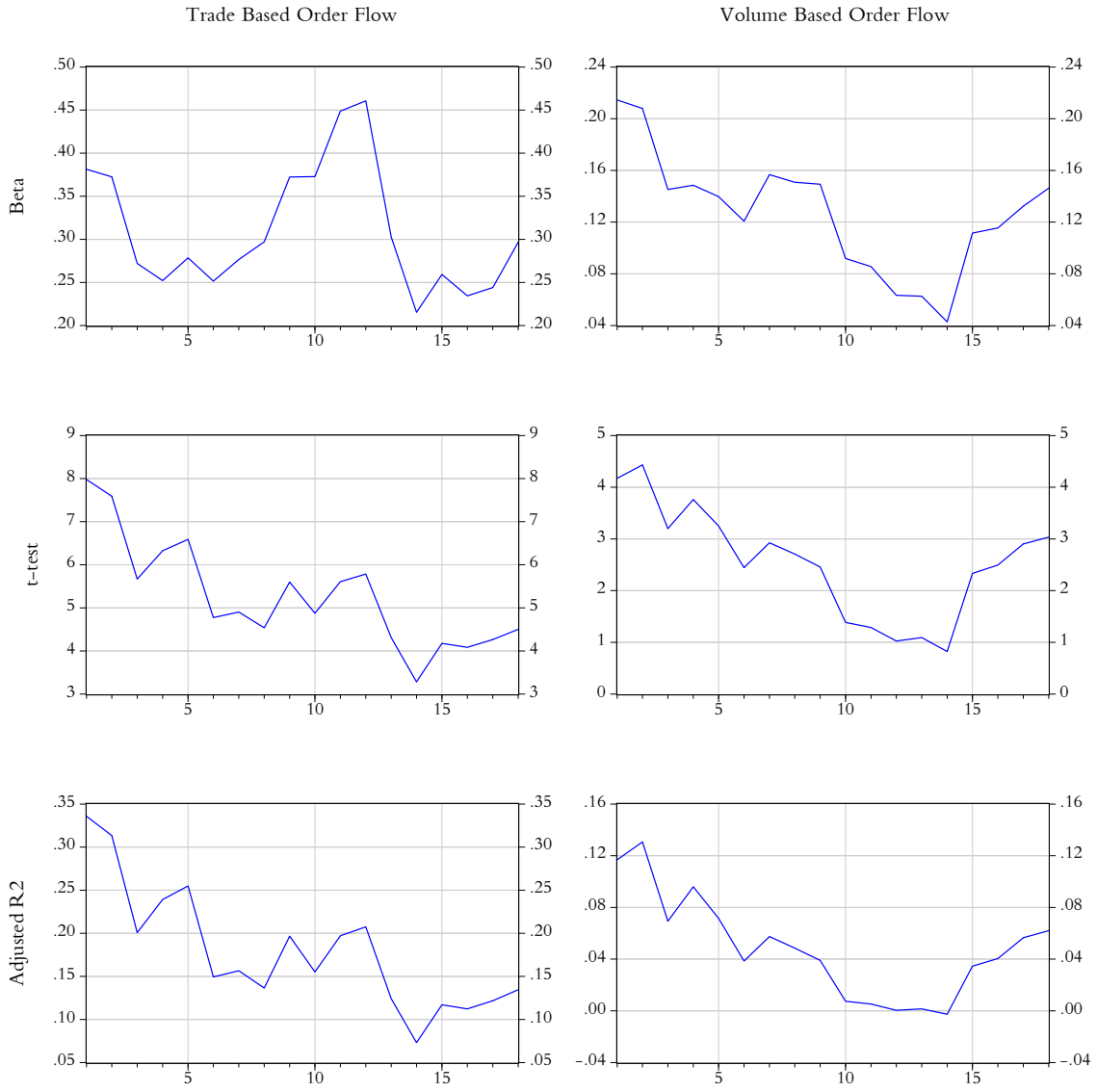
This figure shows a non-parametric estimation of the relationship between exchange rate returns and order flows. The blue circles are the flow and return pairs, the red line is the kernel fit found using Nadaraya-Watson estimator. The top panel shows data for June 2008, bottom panel shows data for June-July 2009.

Figure 2.3: Time-of-the-day Effects



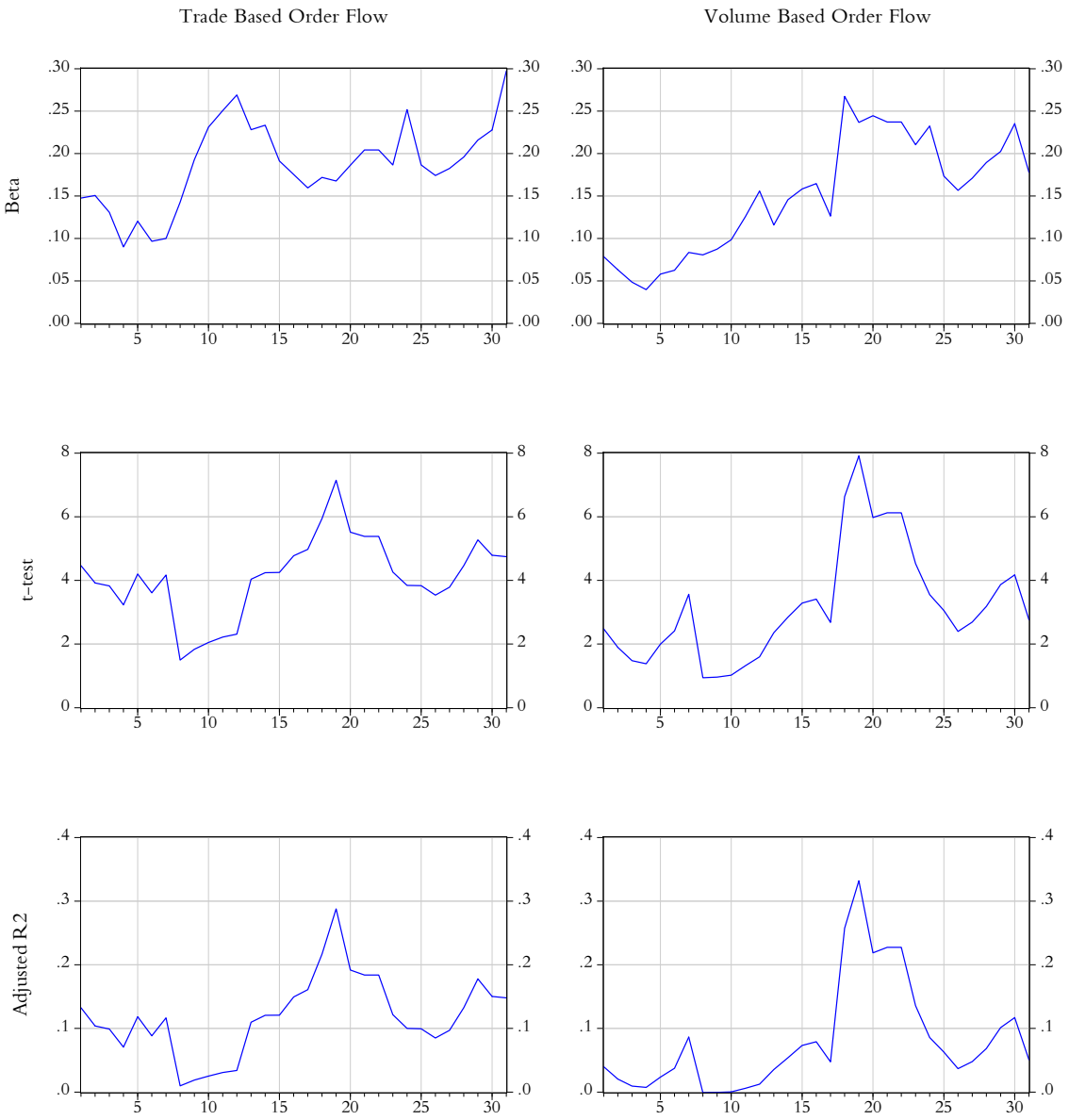
The figure shows the estimation results of the contemporaneous relationships between the exchange rate returns (CLP per USD) and order flow measures interacting with time-of-the-day dummies. The regressions are estimated by OLS at 15 minutes frequency. The coefficients show the changes of the exchange rate returns in basis points of net purchases (trade based order flow, top charts) and 1 million USD purchased (volume based order flow, bottom charts), at each time of the day. Newey-West standard errors in parenthesis. *** indicates statistical significance at 1% level, ** at 5%, and * at 10%. The sample period ranges from 1/7/2008 to 31/7/2008 (labeled '2008'), and 1/6/2009 to 20/7/2009 (labeled '2009').

Figure 2.4: Rolling Window Estimations for 2008



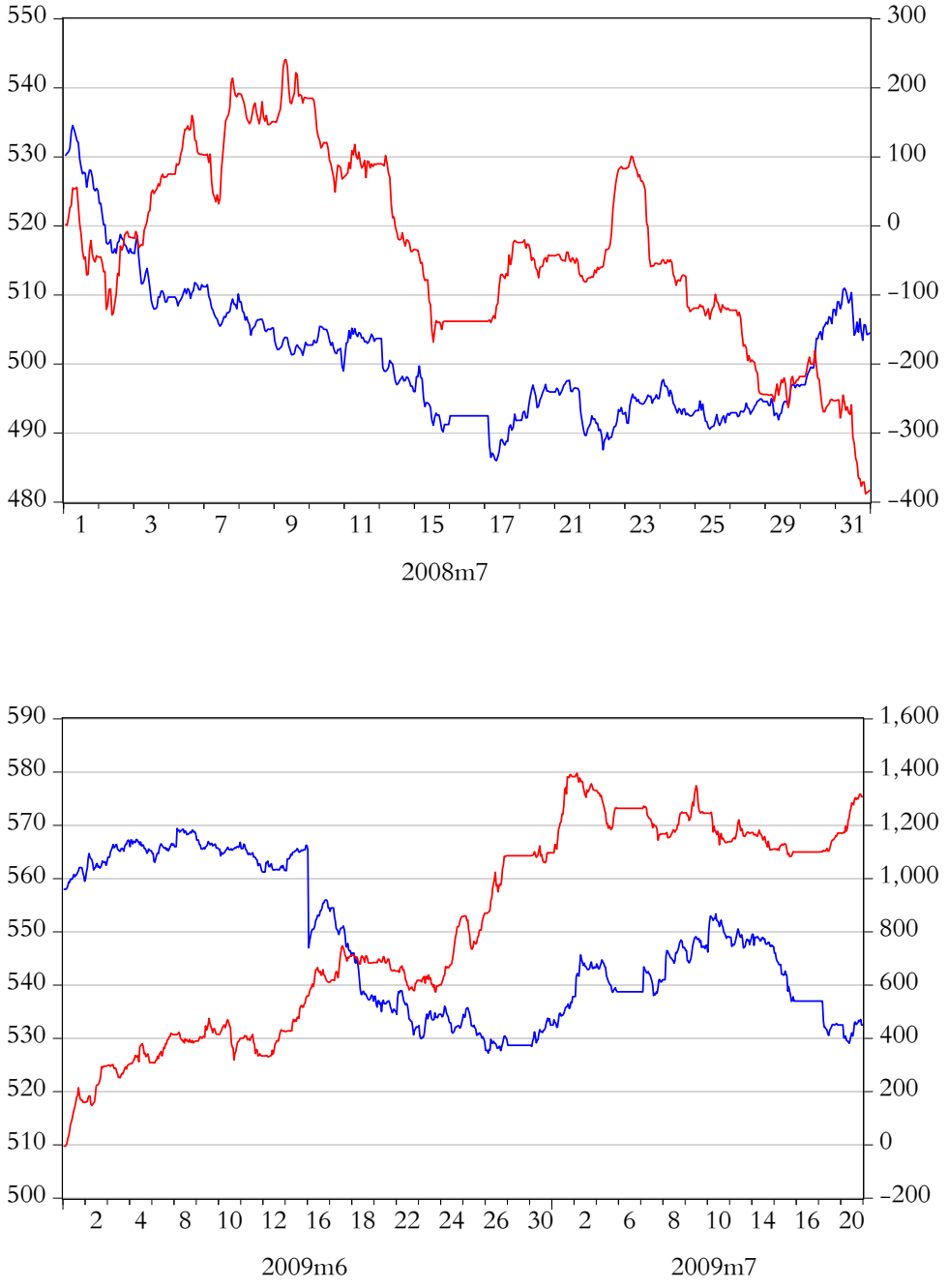
The figure shows the estimation results of the contemporaneous relationships between the exchange rate returns (CLP per USD) and order flow measures for different 5-days subsamples. The rolling window regressions are estimated by OLS at 15 minutes frequency. The coefficients show the changes of the exchange rate returns in basis points of net purchases (trade based order flow, left hand side charts) and 1 million USD purchased (volume based order flow, right hand side charts), for different weeks across time. Newey-West standard errors in parenthesis. *** indicates statistical significance at 1% level, ** at 5%, and * at 10%. The sample period ranges from 1/7/2008 to 31/7/2008.

Figure 2.5: Rolling Window Estimations for 2009



The figure shows the estimation results of the contemporaneous relationships between the exchange rate returns (CLP per USD) and order flow measures for different 5-days sub-samples. The rolling window regressions are estimated by OLS at 15 minutes frequency. The coefficients show the changes of the exchange rate returns in basis points of net purchases (trade based order flow, left hand side charts) and 1 million USD purchased (volume based order flow, right hand side charts), for different weeks across time. Newey-West standard errors in parenthesis. *** indicates statistical significance at 1% level, ** at 5%, and * at 10%. The sample period ranges from 1/6/2009 to 20/7/2009.

Figure 2.6: Exchange Rate and Cumulative Order Flow



The figure shows the spot exchange rate, measured as CLP per USD, and cumulative trade based order flow. Spot exchange rates (blue lines) are on the left vertical axis, cumulative trade based order flow (red lines) are on the right vertical axis. The sample period ranges from 1/7/2008 to 31/7/2008 (labeled '2008m7'), and 1/6/2009 to 20/7/2009 (labeled '2009m6-2009m7').

Table 2.1: Trading Intensity

	Nbr of Trades		Durations	
	2008	2009	2008	2009
8 to 9	3.47	2.78	7.39	7.45
9 to 10	18.76	16.63	1.91	2.14
10 to 11	23.27	26.20	1.04	0.66
11 to 12	22.95	23.45	0.99	0.82
12 to 13	22.28	20.67	1.22	0.87
13 to 14	8.33	9.17	5.23	2.27
14 to 15	0.62	0.68	11.79	13.31
15 to 16	0.17	0.19	22.82	20.04
16 to 17	0.09	0.20	16.73	20.60
17 to 18	0.05	0.04	12.83	19.05

The table shows trades and duration frequencies of the Chilean FX market based on SSE data. It considers all intraday transactions. Column 1 shows hour ranges from opening to closing hours of the SSE trading platform. Columns 2 and 3 show the percentages of total transactions made within these ranges. Columns 4 and 5 show the average duration of transactions made within these ranges. The sample period ranges from 1/7/2008 to 31/7/2008 (labeled '2008'), and 1/6/2009 to 20/7/2009 (labeled '2009').

Table 2.2: Descriptive Statistics

	2008							
	Durations		Order Flows		Returns		Volume	
Mean	55.41		-0.04		-0.03		1.10	
Median	4.00		-1.00		0.00		1.00	
Maximum	3036.00		1.00		26.45		40.00	
Minimum	0.00		-1.00		-39.86		0.10	
Std. Dev.	159.21		1.00		2.31		2.00	
Skewness	8.46		0.08		-0.63		11.05	
Kurtosis	109.55		1.01		34.42		174.04	
JB p-value	0.00		0.00		0.00		0.00	
AR(1)	0.29	***	0.63	***	-0.014	*	0.18	***
Observations	8641		8641		8641		8641	
	2009							
	Durations		Order Flows		Returns		Volume	
Mean	50.42		0.08		-0.01		0.84	
Median	5.00		1.00		0.00		0.50	
Maximum	3380.00		1.00		37.72		50.00	
Minimum	0.00		-1.00		-144.45		0.01	
Std. Dev.	163.06		1.00		1.99		1.71	
Skewness	9.87		-0.17		-23.93		14.78	
Kurtosis	136.60		1.03		1839.82		312.63	
JB p-value	0.00		0.00		0.00		0.00	
AR(1)	0.23	***	0.66	***	-0.05	***	0.22	***
Observations	15443		15443		15443		15443	

The table shows the descriptive statistics of the information recorded for each transaction in the SSE platform. The data are aggregated to 15 minutes frequency and consider only transactions within the most intensive trading hours, i.e. between 8am and 2pm. *Durations* correspond to the time passed between transactions, measured in seconds. *Order Flows* are measured as the number of buys minus the number of sells. *Returns* are the CLP/USD log returns in basis points (i.e. multiplied by 10,000), and *Volume* are expressed in millions of USD. *JB p-value* is the probability for the null hypothesis of the Jarque-Bera test for normality. AR(1) is the first order autocorrelation. *** indicates statistical significance at 1% level, ** at 5%, and * at 10%. The sample period ranges from 1/7/2008 to 31/7/2008 (labeled '2008'), and 1/6/2009 to 20/7/2009 (labeled '2009').

Table 2.3: Correlations

				Tick statistics				
2008	Δs_t	OF_t	VOF_t	OF_t^{IB}	VOF_t^{IB}	OF_t^{NB}	VOF_t^{NB}	Dur
Δs_t	1.00							
OF_t	0.34	1.00						
VOF_t	0.18	0.48	1.00					
OF_t^{IB}	0.26	0.88	0.41	1.00				
VOF_t^{IB}	0.18	0.56	0.64	0.63	1.00			
OF_t^{NB}	0.23	0.46	0.15	0.00	0.00	1.00		
VOF_t^{NB}	0.20	0.37	0.18	0.00	0.00	0.82		
Dur	-0.08	0.03	**0.01**	0.04	0.03	**-0.01**	**0.00**	1.00
2009	Δs_t	OF_t	VOF_t	OF_t^{IB}	VOF_t^{IB}	OF_t^{NB}	VOF_t^{NB}	Dur
Δs_t	1.00							
OF_t	0.13	1.00						
VOF_t	0.04	0.44	1.00					
OF_t^{IB}	0.11	0.85	0.38	1.00				
VOF_t^{IB}	0.06	0.53	0.60	0.62	1.00			
OF_t^{NB}	0.07	0.52	0.31	0.00	0.00	1.00		
VOF_t^{NB}	0.06	0.43	0.18	0.00	0.00	0.80	1.00	
Dur	-0.03	**-0.01**	0.00	**-0.01**	**-0.01**	**0.00**	**0.00**	1.00
				15 minutes statistics				
2008	Δs_t	OF_t	VOF_t	OF_t^{IB}	VOF_t^{IB}	OF_t^{NB}	VOF_t^{NB}	Dur
Δs_t	1.00							
OF_t	0.46	1.00						
VOF_t	0.24	0.60	1.00					
OF_t^{IB}	0.40	0.97	0.55	1.00				
VOF_t^{IB}	0.28	0.76	0.71	0.79	1.00			
OF_t^{NB}	0.46	0.68	0.36	0.51	0.37	1.00		
VOF_t^{NB}	0.09	0.13	0.32	0.08	0.08	0.27	1.00	
Dur	**-0.07**	**0.03**	**-0.02**	**0.04**	**0.04**	0.02	**-0.02**	1.00
2009	Δs_t	OF_t	VOF_t	OF_t^{IB}	VOF_t^{IB}	OF_t^{NB}	VOF_t^{NB}	Dur
Δs_t	1.00							
OF_t	0.29	1.00						
VOF_t	0.22	0.67	1.00					
OF_t^{IB}	0.26	0.96	0.62	1.00				
VOF_t^{IB}	0.25	0.83	0.73	0.86	1.00			
OF_t^{NB}	0.26	0.73	0.45	0.53	0.44	1.00		
VOF_t^{NB}	**0.03**	0.20	0.40	0.13	0.07	0.33	1.00	
Dur	**-0.02**	**-0.03**	**0.01**	**-0.03**	**-0.04**	**-0.01**	**0.02**	1.00

The table shows pairwise correlations for intraday data of the CLP/USD log returns in basis points (Δs_t in Chilean pesos per US dollars), total, interbank and non-bank trade based order flows (OF_t, OF_t^{IB}, and OF_t^{NB}, respectively), total, interbank and non-bank volume based order flows (VOF_t, VOF_t^{IB}, and VOF_t^{NB}, respectively), and durations (Dur_t, calculated as seconds passed between transactions). In bold, correlations that are not significantly different from zero. The sample period ranges from 1/7/2008 to 31/7/2008 (labeled '2008'), and 1/6/2009 to 20/7/2009 (labeled '2009').

Table 2.4: Exchange Rate and Order Flow: Basic Relationship

$$\Delta s_t = \alpha_1 + \beta_1 x_t + \varepsilon_{1,t}$$

	Tick data		*15 min data*	
OF_t	2008	2009	2008	2009
β	0.78	0.26	0.34	0.18
Stand. Err.	(0.03)***	(0.02)***	(0.04)***	(0.02)***
Adj.R^2	0.11	0.02	0.21	0.08

	Tick data		*15 min data*	
VOF_t	2008	2009	2008	2009
β	0.18	0.04	0.14	0.14
Stand. Err.	(0.02)***	(0.01)***	(0.03)***	(0.02)***
Adj.R^2	0.03	0.00	0.05	0.05

The table shows the estimations of the contemporaneous relationships between the exchange rate returns (CLP per USD) and order flow measures. The regressions are estimated by OLS at tick and 15 minute frequency, according to Equation (2.1). The coefficients show the changes of the exchange rate returns (Δs_t) of net purchases (trade based order flow) and 1 million USD purchased (volume based order flow). Newey-West standard errors in parenthesis. *** indicates statistical significance at 1% level, ** at 5%, and * at 10%. The sample period ranges from 1/7/2008 to 31/7/2008 (labeled '2008'), and 1/6/2009 to 20/7/2009 (labeled '2009').

Table 2.5: Exchange Rate, Order Flow and Macroeconomic Fundamentals

	2008									
	OF_t					VOF_t				
	I	*II*	*III*	*IV*	*V*	*I*	*II*	*III*	*IV*	*V*
x_t	0.34	0.34	0.34	0.34	0.34	0.15	0.15	0.15	0.15	0.15
	(0.04)***	(0.04)***	(0.04)***	(0.04)***	(0.04)***	(0.03)***	(0.03)***	(0.03)***	(0.04)***	(0.03)***
$(i-i^*)_{t-1}$	0.01			0.01		0.01			0.01	
	(0.02)			(0.02)		(0.02)			(0.02)	
$\Delta(i-i^*)_t$		0.02			0.02		0.08			0.08
		(0.09)			(0.09)		(0.11)			(0.11)
Δcop_t			0.51	0.52	0.51			0.45	0.47	0.44
			(1.28)	(1.28)	(1.27)			(1.41)	(1.28)	(1.4)
Adj.R^2	0.21	0.21	0.21	0.21	0.21	0.05	0.05	0.05	0.05	0.05
	2009									
	OF_t					VOF_t				
	I	*II*	*III*	*IV*	*V*	*I*	*II*	*III*	*IV*	*V*
x_t	0.18	0.18	0.18	0.18	0.18	0.14	0.14	0.14	0.14	0.14
	(0.02)***	(0.02)***	(0.02)***	(0.02)***	(0.02)***	(0.02)***	(0.02)***	(0.02)***	(0.02)***	(0.02)***
$(i-i^*)_{t-1}$	0.00			0.00		0.01			0.01	
	(0.02)			(0.02)		(0.02)			(0.02)	
$\Delta(i-i^*)_t$		-0.05			-0.09		-0.02			-0.06
		(0.25)			(0.25)		(0.25)			(0.25)
Δcop_t			-1.08	-1.08	-1.12			-1.14	-1.14	-1.17
			(0.37)***	(0.37)***	(0.39)***			(0.39)***	(0.39)***	(0.40)***
Adj.R^2	0.08	0.08	0.09	0.08	0.09	0.05	0.05	0.05	0.05	0.05

The table shows the estimations of the contemporaneous relationships between the exchange rate returns (CLP per USD) and order flow measures and macroeconomic fundamentals. The regressions are estimated by OLS at 15 minute frequency, augmenting Equation (2.1) as to consider as additional explanatory variables the lag and first differences of interest rate differential. The coefficients on order flow show the changes of the exchange rate returns (Δs_t) of net purchases (trade based order flow) and 1 million USD purchased (volume based order flow). Newey-West standard errors in parenthesis. *** indicates statistical significance at 1% level, ** at 5%, and * at 10%. The sample period ranges from 1/7/2008 to 31/7/2008 (labeled '2008'), and 1/6/2009 to 20/7/2009 (labeled '2009').

Table 2.6: Time-of-the-day Effect

$$\Delta s_t = \alpha + \sum_{i=1}^{10} \beta_i I_t^{h=i} x_t + \varepsilon_t$$

	2008		2009	
	OF_t	VOF_t	OF_t	VOF_t
β_1	1.45 ***	0.54 ***	0.62 ***	0.46 **
β_2	0.76 ***	0.16 ***	0.54 ***	0.09 ***
β_3	0.73 ***	0.12 ***	0.39 ***	0.10 ***
β_4	0.62 ***	0.15 ***	0.39 ***	0.11 ***
β_5	0.77 ***	0.32 ***	0.42 ***	0.17 ***
β_6	0.94 ***	0.55 ***	0.56 ***	0.43 ***
β_7	1.43	1.09	0.91	0.30
β_8	2.86 **	3.77 **	1.82 **	1.54 ***
β_9	4.98 *	9.56	1.42	1.82 ***
β_{10}	2.75 **	5.59 **	8.19 ***	8.15 ***
Adj.R^2	0.12	0.04	0.06	0.02

The table shows the estimations of the contemporaneous relationships between the exchange rate returns (CLP per USD) and order flow measures interacting with time-of-the-day dummies, as in Equation (2.3). The regressions are estimated by OLS at tick frequency. The coefficients show the changes of the exchange rate returns in basis points of net purchases (trade based order flow) and 1 million USD purchased (volume based order flow), at each time of the day. Newey-West standard errors in parenthesis. *** indicates statistical significance at 1% level, ** at 5%, and * at 10%. The sample period ranges from 1/7/2008 to 31/7/2008 (labeled '2008'), and 1/6/2009 to 20/7/2009 (labeled '2009').

Table 2.7: Granger Causality Tests

	2008	2009
Δs_t does not Granger cause OF_t	5.09***	4.44***
OF_t does not Granger cause Δs_t	0.12	1.29
Δs_t does not Granger cause OF_t^{IB}	3.31**	2.59**
OF_t^{IB} does not Granger cause Δs_t	0.05	1.41
OF_t^{IB} does not Granger Cause OF_t^{CB}	0.4	0.61
OF_t^{CB} does not Granger Cause OF_t^{IB}	1.68	2.68**
OF_t^{NB} does not Granger Cause OF_t^{IB}	0.34	1.19
OF_t^{IB} does not Granger Cause OF_t^{NB}	0.06	2.77**

The table shows the results of F-statistics of testing causality *a la* Granger between exchange rate returns, all customers trade based order flow (OF_t), IB trade based order flow (OF_t^{IB}), NB trade based order flow (OF_t^{NB}), and CBC trade based order flow (OF_t^{CB}), at 15 minute frequency. First column states the hypothesis tested. Lag length chosen according to the Schwarz information criteria. *** indicates statistical significance at 1% level, ** at 5%, and * at 10%. The sample period ranges from 1/7/2008 to 31/7/2008 (labeled '2008'), and 1/6/2009 to 20/7/2009 (labeled '2009').

Table 2.8: Trade Based Order Flow and Exchange Rate Returns

	2008			
$Constant$	-0.107	-0.274	-0.167	-0.303
	(0.323)	(0.331)	(0.330)	(0.325)
OF_t	0.343	0.914	1.011	0.833
	(0.040)***	(0.138)***	(0.160)***	(0.181)***
$OF_t * OF_t^{IB}$		-0.693	-0.809	-0.726
		(0.156)***	(0.184)***	(0.191)***
$OF_t * OF_t^{CB}$			-0.837	-0.776
			(0.259)***	(0.278)***
$OF_t * Dur$				0.183
				(0.072)***
Adj.R^2	0.21	0.24	0.25	0.27
Observations	575			
	2009			
$Constant$	-0.447	-0.423	-0.381	-0.457
	(0.256)*	(0.258)	(0.259)	(0.236)**
OF_t	0.181	0.349	0.327	0.227
	(0.017)***	(0.055)***	(0.054)***	(0.070)***
$OF_t * OF_t^{IB}$		-0.217	-0.189	-0.145
		(0.069)***	(0.069)***	(0.068)**
$OF_t * OF_t^{CB}$			-0.413	-0.408
			(0.224)*	(0.225)*
$OF_t * Dur$				0.130
				(0.074)*
Adj.R^2	0.08	0.09	0.09	0.10
Observations	900			

The table shows the estimations at 15 minute frequency of the contemporaneous relationships between the exchange rate returns (CLP per USD) and trade based order flow as in Equation (2.4). The regressions are estimated by OLS. The coefficients show the changes of the exchange rate returns (Δs_t) in basis points of net purchases (trade based order flow). Newey-West standard errors in parenthesis. *** indicates statistical significance at 1% level, ** at 5%, and * at 10%. The sample period ranges from 1/7/2008 to 31/7/2008 (labeled '2008'), and 1/6/2009 to 20/7/2009 (labeled '2009').

Table 2.9: Unit Root Tests

	2008				2009			
	DF-GLS		Aug.DF		DF-GLS		Aug.DF	
Exogenous:	Constant	Constant and Linear trend	Constant	None	Constant	Constant and Linear trend	Constant	None
Variable:								
s_t	-0.042	-0.451	-3.122**	-1.137	-0.17	-1.387	-0.916	-0.941
Δs_t	-24.30***	-24.32***	-24.31***	-24.29***	-31.03***	-31.04***	-31.03***	-31.03***
OF_t	-19.43***	-19.53***	-19.46***	-19.42***	-13.27***	-13.36***	-13.48***	-13.25***
Cummulative OF_t	0.228	-1.036	0.002	0.267	1.279	-1.413	-1.73	1.338
VOF_t	-21.90***	-21.93***	-22.02***	-21.86***	-27.23***	-27.22***	-27.22***	-27.24***
Cummulative VOF_t	0.999	-0.737	-2.468	1.115	-1.15	-1.254	-1.176	-1.147

The table shows the t-statistics of Elliott-Rothenberg-Stock DF-GLS and Augmented Dickey-Fuller tests for the null hypothesis of unit root, for CLP/USD rate level and returns (s_t and Δs_t, respectively), and single and cumulative trade and volume base order flow series (OF, *Cummulative* OF_t, VOF and *Cummulative* VOF_t, respectively). Columns 2, 4, 6 and 8 allow for an exogenous constant. Columns 3 and 7 allow for exogenous constant and linear trend. Columns 5 and 9 do not account for exogenous variables. Lags selection according to Schwarz criterion. *** indicates statistical significance at 1% level, ** at 5%, and * at 10% according to MacKinnon (1996) one-sided p-values for Augmented Dickey-Fuller tests, and according to Elliott-Rothenberg-Stock (1996) for Elliott-Rothenberg-Stock DF-GLS tests. The sample period ranges from 1/7/2008 to 31/7/2008 (labeled '2008'), and 1/6/2009 to 20/7/2009 (labeled '2009').

Table 2.10: Johansen Cointegration Tests

	2008		2009	
	OF_t	VOF_t	OF_t	VOF_t
Trace	27.71**	22.76***	22.10**	18.60**
Max-Eigen	19.08*	15.99**	20.32***	10.93

The table shows the results of Johansen unrestricted cointegration rank (trace and maximum eigenvalue) tests, for CLP/USD rate and cumulative trade and volume base order flow series (OF and VOF, respectively). The null hypothesis of no-cointegration is evaluated. Columns 2 to 5 show the trace and maximum eigenvalue (Max-Eigen) statistics for testing the hypothesis of no cointegrating relationships for 15 minutes frequency data. All tests allow for an intercept and a trend. Lags selection according to Schwarz criterion. Results that allow only for a drift, linear trend, quadratic trends, or no intercept or trend, are not substantially different, and are available upon request. *** indicates statistical significance at 1% level, ** at 5%, and * at 10% according to MacKinnon-Haug-Michelis (1999) p-values. The sample period ranges from 1/7/2008 to 31/7/2008 (labeled '2008'), and 1/6/2009 to 20/7/2009 (labeled '2009').

Chapter 3

Official Intervention in the Chilean Foreign Exchange Market

3.1 Introduction

What are the effects of official intervention in foreign exchange (FX) markets? This question has motivated researchers and policy makers for many years generating a wide range of literature on the topic, mainly for advanced economies. However, in the last decade FX intervention had become more popular amongst developing economies compared to the developed world, particularly after the latest global financial crisis, when FX intervention has been one of the main policy responses of emerging market economies (EMEs) (Ishii, Canales-Kriljenko, Guimarães, and Karacadag, 2006; Menkhoff, 2012). Intervention in the FX market occurs for different reasons, such as to stabilise a misaligned exchange rate, calm stressed markets, or accumulate international reserves (Ishii *et al.*, 2006).[1] Therefore, a comprehensive examination of the effects of FX intervention on all aspects of FX markets is necessary in order to assess whether this policy response has improved the market's condition beyond having moved the target towards the desired direction.

The literature in this field usually focuses on understanding through which chan-

[1] In other words, FX intervention can be seen as an alternative or complementary policy tool against inflation in periods of turmoil. An example of this situation would be when misalignments of the exchange rate require changes in interest rates that are not consistent with output gap and inflationary pressures.

nel sterilised FX intervention[2] is most effective. According to the literature, these channels are: portfolio balance, signaling or expectations, co-ordination, and order flow or microstructure channels (see, e.g., Sarno and Taylor, 2001; Archer, 2005). The portfolio balance channel suggests that the sterilisation operations alter the composition of the portfolios of the agents in the economy. The signalling or expectations channel suggests that agents change their exchange rate expectations responding to communication of policy decisions. This channel is seen as effective when intervention announcements are followed by unusual daily changes in the exchange rate. The co-ordination channel suggests that monetary authorities' communications that are co-ordinated with market views help moving the target in a desired direction. The order flow or microstructure channel suggests that interventions alter the order flow dynamics in the domestic FX market when the monetary authority places its own orders as part of the intervention programme. Neely (2008) surveys a heterogeneous sample of 22 central banks in order to capture their beliefs on the effects of FX intervention. In his study, most central banks usually agree that intervention affects exchange rates through co-ordination and signaling channels.[3]

Typically, the effectiveness of an intervention in the FX market is measured by its effect on the level or volatility of the exchange rate. For instance, an intervention consisting of selling (purchasing) foreign currency would expect the domestic currency to appreciate (depreciate) with respect to the foreign currency sold (purchased). Moreover, the intervention can be carried out in order to accelerate, moderate or reverse an appreciation or depreciation trend. With respect to the volatility, usually a reduction is expected with the intervention (see, e.g., Payne and Vitale, 2003; Dominguez, 2006; Dominguez and Panthaki, 2007; Fratzscher, 2005, 2006,

[2]In most cases, policy makers that choose to intervene in the FX market opt for sterilised intervention. Sterilised intervention occurs when the monetary authority complements orders in the FX market with operations involving other assets, in order to offset the effects of changes in official foreign asset holdings on the domestic monetary base.

[3]These beliefs are supported by the literature for advanced economies. For instance, Beine, Bos, and Laurent (2007) find evidence supporting the signalling channel, and Reitz and Taylor (2008) provide evidence in favour of the coordination channel.

2008; Fatum, 2008; Neely, 2011).

In addition, evidence suggesting that FX intervention can increase volatility in the short run and affect other currencies has been found.[4] Furthermore, the literature suggests that oral interventions in advanced economies are more effective than actual interventions, and that intervention effectiveness increases when there is co-ordination amongst central banks, or in periods of high volatility and market uncertainty (see, e.g., Payne and Vitale, 2003; Dominguez, 2006: Dominguez and Panthaki, 2007; Fratzscher, 2008). There is also evidence on the effects of interventions on trading dynamics. Dominguez and Panthaki (2007) find that FX intervention impacts the trading frequency of intraday operations. Fatum and Pedersen (2009) and Fatum, Pedersen, and Sørensen (2013) find that unannounced interventions have an effect on the market perception, thus affecting exchange rate spreads. Marsh (2011) finds that the relationship between the exchange rate and order flow varies during intervention periods.

Emerging markets are interesting cases of study. Usually, their currency markets are smaller than those of advanced economies. Therefore, central bank interventions could be more effective (for instance, through the portfolio channel) compared to the effects that actions of monetary authorities in advanced economies could have on their currency markets. However, most of the papers available analyse the impact of intervention on FX markets using daily data for advanced economies, who intervene on a regular basis, or whose data is publicly available. For developing countries, interventions occur more sporadically, hence research on the effects of intervention on their FX market is rare. This gap in the literature may be due to both data availability issues and the scarcity of intervention events.[5] Overall, the evidence

[4] In his survey, Neely (2008) indicates that central banks mostly agree that intervention affects currencies other than the one in which it is conducted, and it is effective on reducing (or at least not increasing) its volatility and restoring liquidity. Beine *et al.* (2007) also show that intervention tends to primarily raise volatility, whilst Nikkinen and Vähämaa (2009) notes that intervention ultimately increases the correlation between the domestic currency with foreign currencies other than the one purchased.

[5] Recent theoretical papers that study the intervention strategies of EMEs focus on modelling these

found for EMEs is mixed. On the one hand, in most of the cases announcements have an impact on exchange rate returns. On the other hand, actual interventions could in some cases move the exchange rate levels, reduce its short-term volatility and spreads, and change the price impact of private order flows. However, in other cases a reversal or slowing down of the appreciation trend is not obtained and increases in volatilities are observed.

In this chapter, we investigate the effects of official interventions in the Chilean FX market at intraday frequency. Chile is a case of interest given that it has more than a decade of experience in intervention on FX markets. Since the adoption of a flexible exchange rate regime, the Chilean monetary authority kept its right to intervene in the FX market. However, it had not actively participated nor intervened in the market for several years until the early signs of the last global financial crisis. When it did intervene, in 2008 and 2011, these policy responses were previously announced as precautionary actions of international reserve accumulation.[6] Chile is an inflation-targeting small open economy, whose real sector strength relies heavily on commodity trade (copper), and official intervention is discretional yet pre-announced. There is not much work focussing on the effects of intervention on the Chilean FX market during and posterior to the financial crisis at a microstructural level.[7] Given the lack of research available for Chile and the novelty of our data, we believe that this study contributes to the literature on official intervention with new evidence that provides some directions for other EMEs.

For our analysis, we continue to explore our novel dataset that records all spot US

economies assuming that their unconventional monetary policy responses are driven by exchange rate rules (see, e.g., Parrado, 2004; Ho, 2004; Galí and Monacelli, 2005; Kumhof, 2010; Benigno and Fornaro, 2012; Benes, Berg, Portillo, and Vavra, 2013). However, given the heterogeneous nature of the intervention mechanisms observed in the developing world, such theoretical models lack applicability. Unfortunately, comprehensive empirical work on FX intervention of EMEs has been limited. The most common country cases studied are: Brazil, Colombia, Czech Republic, Mexico, Russia, and Turkey. We expose a more comprehensive literature review on intervention in EMEs in Section 2.

[6] In addition, the intervention in 2011, was the largest in terms of duration in the Chilean history.

[7] The existing studies for Chile are by Morandé and Tapia (2002), Gregorio and Tokman (2004), Tapia and Tokman (2004) and Schmidt-Hebbel (2006). These studies provide a description of the effectiveness of interventions and announcements up to 2004, using daily data.

dollar (USD) transactions in the Chilean FX market during two subperiods within 2008 and 2009 respectively. Our intraday data report price, volume and type of each transaction, and the exact time of transaction. The characteristics of this dataset allows us to analyse the impact of intervention from different perspectives: first, we evaluate the effect of central bank order flow on exchange rate returns through linear regression analysis;[8] then we carry out an event study where we incorporate leads and lags of intervention into the order flow regressions in order to examine time delay/anticipation of the effect of intervention on intraday exchange rate returns. Lastly, we examine the effectiveness of intervention in 2008 and the effects of central bank trades in 2009, according to the different success criteria for exchange rate movements and order flow changes. We find that the impact of central bank order flows on the intraday returns of the spot rate is significant but small in comparison with the effects of the order flows of other agent types. Central bank order flows also have an indirect impact in the private order flow dynamics, which corroborates intervention effectiveness through microstructure channel. Furthermore, our event study on an intraday basis shows that the effect of the participation of the central bank in the market is incorporated two hours prior to its occurrence when precautionary intervention takes place. Finally, the rates of intervention success indicate that intervention is successful in moderating exchange rate and order flow trends.

The remainder of this chapter is organised as follows. Section 2 offers a detailed literature review on official intervention in EMEs and describes the Chilean FX market and official intervention. Section 3 describes the data employed. Section 4 provides the empirical results from the daily and intraday analyses. Section 5 concludes.

[8]Expanding the work done in chapter 2 of this thesis.

3.2 Official Intervention in Emerging Economies

3.2.1 Literature Review

Literature on the intraday effects of intervention in the FX market of EMEs is rare. This could be due to data limitations, low frequency of intervention events observed, or even the heterogeneity of intervention motives, objectives and mechanisms. Lately, predominance of intervention activity in developing countries has motivated comparison across countries. Adler and Tovar (2011) study sterilised intervention effectiveness in a group of Latin American and Asian countries. Given that not all the countries under analysis used the same intervention mechanisms, their estimation strategies incorporate a reaction function for intervention in those cases when such a policy was not announced. In addition, as not all countries would pursue the same objective[9] their study would evaluate regressions of both first and second moments of the exchange rates on a set of domestic and external macroeconomic variables and intervention indicators. They find that interventions have had an impact on the second moments of exchange rates, and that on average intervention effectiveness depends on the degree of capital account openness.

A broader analysis of unconventional policy responses is found in Calani, Cowan, and García (2011). They investigate the monetary and non-monetary policy measures implemented by a set of 9 inflation targeting countries during the 2008-09 financial crisis. Their estimation strategy involves the evaluation of the individual impact of these measures on three areas: nominal exchange rates, on-shore interest rates, and deposit rates. According to the authors intervention was one of the three major responses to the crisis of the analysed countries. The evidence of intervention effectiveness is mixed. For countries such as Chile and Colombia either announcements or implementation of such policy show a significant impact on the

[9]This is to say that intervention could either aim to move the exchange rates to certain levels or decreasing its volatility.

nominal exchange rates; Brazil, Mexico and South Korea show no such impact. In some cases, inconclusive results are related to ambiguity of the expected impact, or inability to differentiate whether the impact is also due to other unconventional policies applied during the same period.

Amongst the papers that focus on individual country cases, the most common cases studied are Brazil, Colombia, Czech Republic, Mexico, Russia, and Turkey. Kohlscheen (2012) and Wu (2012) contribute to the literature of intervention in EMEs analysing the Brazilian case. Both studies examine the case from a microstructure perspective, using different estimation strategies. Kohlscheen (2012) uses simple linear regressions to evaluate the effects of intervention through examining the changes in the relationships between order flows and exchange rates. He finds that the link between order flow and exchange rate weakens on days where the Central Bank of Brazil intervenes, an effect that is stronger when the size of intervention is large. Wu (2012) develops a theoretical model to describe the Brazilian FX market and estimates a structural VAR, focusing on the effect of unexpected overnight positions shocks on the exchange rate dynamics. He finds evidence that the Central Bank of Brazil tends to lean against the wind, and to provide liquidity, concluding that the management of Brazilian exchange rates has been a contributor to the resilience of this country.

The Colombian case is analysed in Kamil (2008). The paper suggests that the motives behind the discretionary FX interventions in Colombia are not consistent across time. In periods when the central bank aimed to lean against the wind, slowing or even reversing an exchange rate trend, the effects of intervention were more significant than in those periods when the monetary authority aimed to correct deviations of the exchange rate from its target.

The case of the Czech Republic is recently addressed by Disyatat and Galati

(2007) and Scalia (2008).[10] These two papers differ in the data and methodology used. Whilst Disyatat and Galati (2007) employ daily data and a two stage IV estimation strategy, Scalia (2008) uses intraday data to evaluate the impact of intervention with a microstructure approach. The results of Scalia (2008) show that intervention has a highly significant effect on exchange rates through order flows. This is not fully captured by Disyatat and Galati (2007), whose findings suggest statistically weak effects of intervention on exchange rates.

The results for Mexico by Karacadag and Guimarães (2004) also show that the effects of sales intervention are significant, tending to increase short and long-term volatility, but varies across time. Unlike the Mexican case, Melvin *et al.* (2009) show that, for the Russian case, automated intervention has a positive effect on volatility in the first few minutes after intervention, but overall reduces daily volatility.

Studies for the Turkish case are found in Karacadag and Guimarães (2004) and Tuna (2011). Karacadag and Guimarães (2004) evaluate the effects of interventions carried out over the period 2001-2003. Amongst their results, they note that sales interventions seem to reduce volatility in the short-term, and tend to increase volatility on the long-term. Tuna (2011) expands the period analysed to include interventions in 2005. She finds no evidence of intervention impact on the exchange rate level, as in Karacadag and Guimarães (2004). She also finds that the probability of intervention is affected by increases in exchange rate volatility when analysing sale and purchase interventions separately, supporting the leaning against the wind idea.

In summary, the evidence for EMEs is not conclusive. On the one hand, intervention mechanisms and tools vary from country to country. Some countries are found to lean against the wind, whilst others have a strong rule-based policy. On the other hand, intervention motives also differ, leading to mixed conclusions on

[10] In the early 2000s, Holub (2004) provided a comprehensive description and statistical analysis of the Czech case under inflation targeting.

whether intervention is effective, due to the ambiguity of the results regarding the effects on exchange rate levels and volatilities. Furthermore, data availability issues limit the research at higher frequency levels in some cases, leaving the question open as to whether intervention affects market behaviour on an intraday basis, and if the latter is relevant.

3.2.2 The Chilean Case

The exchange rate in Chile was fixed until 1984, when a bands regime was adopted. The Central Bank of Chile (CBC) would intervene in cases when an overreaction of the exchange rate would be considered to be a threat for the economy. However, even under intervention, the exchange rates did not remain within its bands, hence this regime became less credible. With the depreciation pressures brought on by the Asian crisis, the CBC applied spot non-sterilised intervention in June 1998, narrowing its range of flotation. In September 1999 the monetary authority abandoned the bands, leading to flexible exchange rates. This has been the regime up to this date. Currently, the CBC has the right to intervene in the FX market if it considers that there is a persistent misalignment of the exchange rate identified or judged as an overreaction that could be damaging for the economy (Morandé and Tapia, 2002; Schmidt-Hebbel, 2006).

Since the flexible exchange rate regime was adopted, the CBC has intervened on very few occasions: between August and December 2001, October 2002 and February 2003, April and September 2008, and during the whole of 2011. In these occasions, the CBC used 3 different instruments to carry out its interventions: the spot exchange rate, bonds of the CBC denominated in dollars for different maturities, and announcements.[11]

As explained by Gregorio and Tokman (2004), in 2001 and 2002 the exchange rate depreciation was excessive compared to the expected rate given the evolution of

[11] Announcements are considered here as instruments of the signalling channel.

its fundamentals. In 2001 the CBC decided to intervene in the FX market in a period of financial turmoil in Argentina and the Chilean peso (CLP) depreciating from 550 to 650 pesos per USD (around 18%) in 6 months. The programme of sterilised intervention in 2001 consisted of sales of USDs in the spot market. Only 40% of the total amount announced was actually sold,[12] and this represented close to 5% of the total stock of international reserves in that period. The intervention consisted of 15 events throughout the four months defined. In 2002 the CBC announced a potential intervention in the Chilean FX market whilst uncertainty surrounded the Brazilian economy. The programme announced was similar to that of 2001, aiming to be completed within 4 months, after observing a 7% depreciation of the local currency over the month previous to the intervention. The CBC finally did not carry out the intervention programme announced, it only issued debt denominated in USDs, thus international reserves remained unchanged. In this intervention, an appreciation of 2.3% of the exchange rate was observed on the day of the announcement.

Between 2003 and 2007, Chilean economy was in good conditions: monetary and credit aggregates were growing at a steady rate, domestic stock index and currency became stronger, real sector was expanding, and inflation rate stayed close to its target.[13] However, in 2008 the CBC announced a programme of international reserves accumulation, aiming to strengthen the international liquidity position of the Chilean economy given the growing uncertainty brought by the increasing detriment of international conditions.[14] The objective of this reserve accumulation programme was to acquire a total of 8 billion USDs, through purchasing 50 million USDs on a daily basis. The daily purchases of USDs would be accompanied by a programme of sales of CBC bonds denominated in USD at different maturities. The programme, sched-

[12]The total amount announced to be sold was 2 billion USDs. Only 803 million USDs were actually sold.

[13]According to several issues of the Monetary Policy Reports published by the CBC throughout the last decade.

[14]Interestingly, the CBC did not explicitly use the word "intervention" in this announcement.

uled initially to be completed by December of that year, was stopped in September coinciding with Lehman Brothers' collapse. This time, around 72% of the 8 billion of USDs announced were actually purchased.

Between March and July 2009, the CBC initiated a two-stage programme of sales of USDs owned by the Chilean Government. The fiscal authority aimed to finance its fiscal stimulus plan with these resources. On this occasion the CBC acted as an intermediary between the Government and the market, i.e. a fiscal agent. This programme is not considered an official intervention given that the currency traded was not property of the monetary authority, thus there were no expected effects on the exchange rates through the signalling channel. However, we include this event into our analysis since it could have had an effect on the exchange rates similar to the portfolio channel. This programme was fully accomplished with 3 billion USDs auctioned in its first stage through 50 million USDs being sold on a daily basis. The second stage started one week after the first stage finished and it aimed to auction on other 4 billion USDs through daily sales of 40 million USDs each.

In the first days of 2011 another reserve accumulation programme was announced for 12 billion USDs. Its objective was two-fold: first, to strengthen the Chilean international liquidity position, bringing it to levels that were similar to comparable economies; second, it was believed that "the intervention would soften the effects of the exchange rate adjustment on the economy" (CBC, 2011a). The intervention consisted of daily auctions of 50 million USDs, over the 240 trading days of 2011. Throughout this period, not including the last quarter, the quantity demanded by commercial banks was three times the CBC USD supply and the nominal exchange rate moved around 470 CLPs per USD. The depreciation and higher volatility of the CLP observed in the last quarter of 2011 was due to external conditions and coherent to the trends of other commodity exporters and emerging economies (see, e.g., CBC, 2011b). Compared to the first 3 quarters of the year, in the last quarter

the average of the domestic currency was nearly 8% higher, whilst the quantity of USDs auctioned by the CBC decreased on average by 20 million.

When comparing the interventions in the FX market during the last 5 years, we observe that there were some differences with regards to the time of the day at which the CBC would intervene.[15] In 2008 the CBC explicitly announced the specific time of the day at which it would initialise the USD auctions in the market. A few days later, another announcement communicated that the intervention would be done within a range of hours. Within this range, generally the auction would be initiated under appropriate conditions (price, volatility, news arrival, etc.), monitored by the operators of the CBC's money desk. However, in 2009 the time at which the auction would be initiated would be subject to non-fundamental factors.[16]

As mentioned above, there are no studies that examine the effects of the USD purchase and sale programmes after 2003 in Chile, either at daily or intraday frequency. However, there are several reasons why analysing the impact of these intervention events on the Chilean market is highly interesting. First, Chile is an emerging market that operates under inflation target and flexible exchange rate regimes. In addition, the CLP can be said to be a commodity currency due to the strong influence of the copper price in determining the exchange rate. Contrary to other comparable countries, despite the CBC having the right to intervene in the Chilean spot market, it only intervened on a few occasions after adopting flexible exchange rates. Moreover, its interventions were pre-announced in order to meet transparency requirements.

[15] Note that intraday data for 2011 is not available to us. Therefore, we are unable to provide specific details with regards to the time at which intervention took place in that year. Informal discussions with the operators of the money desk at the CBC would indicate that the auctions in 2011 took place between 9 am and 1 pm, or when the trading activity of the market was observed to be more intense.

[16] For instance, the client (i.e. Chilean Government) requiring one of its representatives be present to monitor and approve the auction process.

3.2.3 Institutional Environment of the Chilean FX Market

The Chilean FX market is a relatively young market. It has been very dynamic in the last 30 years, yet there are no studies that describe its main characteristics, such as who the traders are, trading venues available, or limitations of the trading process. Whilst in Chapter 2 we give a general description of this market, in this section, we give further details about this market, focusing on its institutional environment.[17]

The institutional environment of the Chilean FX market has changed dramatically along side the increase in its trading activity. In the 1980s, all transactions were dealt through telephone, mainly for hedging since the exchange rate was fixed at the time. Electronic systems appeared as alternative venues for trading only in the 1990s, reducing in great manner telephone usage as means for trading. An example of one of the first electronic platforms to be launched in the 1990s is the SSE. This platform grew rapidly, becoming the main venue for currency trading in that decade. The EE as a trading platform was launched in 1989 and was the first institution in Latin America to implement an electronic system that allowed fixed income instrument transactions in real time. Although this important innovation helped decrease the costs of updating relevant information for trading decisions (as the trader no longer needed to go to a physical place to get informed), USD transactions only became possible through the EE in 2003.

The surge of the EE as a competitor of the SSE for USD transactions in early 2000s coincides with the transition from fixed to flexible exchange rate regimes in Chile. As explained in Section 2.3.1 of this thesis, the EE market share increased substantially since it started USD transactions, reaching its peak in 2008. During the financial crisis, SSE and EE shared similar portions of the spot market. After

[17] Given that there is no existing literature that describes the Chilean FX market and its institutional environment, in this section the sources of information used are the websites of the trading platforms available in this market, i.e. the Santiago Stock Exchange (SSE, www.bolsadesantiago.com) and the Electronic Exchange (EE, www.bolchile.cl). Additionally, we gathered information through informal conversations with money desk analysts of the CBC.

that, the EE market share started increasing once again. Nowadays, over 95% of the USD transactions are carried out through the EE.

Regarding the agents who trade in the Chilean FX market, there has been not as many changes as those observed for the trading venues. The Chilean FX market has basically had two types of agents; banks and broker-dealers.[18] Traditionally, banks would trade in the SSE and the EE, whereas broker-dealers would close their deals mainly using the EE. The CBC can also become a trader for a short period of time, whenever it decides to intervene in the FX market or act as a fiscal agent. The pre-Lehman FX intervention of the CBC throughout 2008 was carried out in the SSE platform. On that occasion, more than 80% of the transactions were made between banks in normal trading hours. During intervention minutes, only banks were authorised to participate in the auctions carried out by the CBC. As the EE gained more participation of the total market trades, the CBC also moved to the EE platform to conduct the auctions for the intervention in 2011. Although broker-dealers were also present during interventions, banks were still the main participants in the CBC auctions.

Having two platforms could potentially open arbitrage opportunities. To examine whether these opportunities took place, it is worth observing what the price differences between the SSE and the EE occurred in the periods when they co-existed as equally preferred trading platforms. As explained in Chapter 2, the price levels registered in these platforms have not shown major differences between 2003 and 2008. The exception was seen during the 2008 intervention period when the daily average price in the SSE was predominantly lower than that observed in the EE. However, at the same period of time, the intraday movements did not show price corrections in the EE once the intervention in the SSE finished. Moreover, broker dealers usually would not trade in the SSE. Added to that, it is possible that even if

[18] Broker-dealers are agents who trade on behalf of their investment institutional clients but also their own positions.

there were arbitrage opportunities, the unfavourable external conditions around the financial crisis provided no incentives for selling the acquired USD at a higher price due to the liquidity constraints agents faced. In parallel, around those same years, the EE also faced domestic market problems: for a short period of time, agents other than those who trade in the FX market (possibly institutional investors) had access to EE monitors. This fact possibly allowed for a decreasing on the information asymmetry between traders and their clients, thus pushing away traders who could potentially see their profits decrease whilst trading in the EE. In other words, there could also be a possibility that participants of the EE market decreased during that time due to idiosyncratic factors. That said, the lack of more detailed information on the agents of the EE market limits us to further examine this phenomenon.

3.3 Data

In this chapter, we employ a data set at intraday frequency that consists of all USD spot transactions measured in CLPs covering July 2008 and June-July 2009, recording exact time, price, volume, trade sign, and market type of each transaction. Trade sign indicates whether the respective amount of USD (volume) was purchased or sold. This data is extracted from the Santiago Stock Exchange (SSE) data system.[19] One of the advantages of having sign and volume of trade is that this information allows us to construct different measures of order flows with which the relationship between exchange rates and order flow can be studied. Market type indicates whether the transaction was made between dealers, i.e. interbank (IB), or whether it included at least one non-dealer participant, so that it will correspond to a non-bank trade (NB).[20] In addition, our data also identifies CBC transactions.[21]

[19] Data collection from the SSE system is usually limited, partly due to privacy policies, and partly due to the strictness of the procedure involved in the data collection itself. In particular, we collected these short span data on a daily basis directly from the money desk of the CBC to which access was granted to us for a limited period of time, and for research purposes only.

[20] One drawback of our data set is that identification of whether a NB trade was made between a bank and a non-bank participant, or between two non-bank participants, is not possible.

[21] Noteworthy to mention that the only participant identified in our data is the CBC. Information about the other banks and institutions is not available to us as this type of information is proprietary

The CBC trades currencies only with banks.

3.4 Impact of FX Intervention in Chile

In this section we present results of the empirical exercises carried out based on different approaches, for the Chilean FX market at intraday frequency, using the dataset previously detailed.

3.4.1 Intraday Results

As mentioned in Section 3.3, the intraday data used in this study covers June 2008, and June-July 2009. According to our data, in 2008 the daily turnover was on average 431 million USDs. Excluding the CBC trades, 52% of the trades were sales. Overall, 84% of the negotiations were IB. During this period, the CBC's auctions were adjudicated to four banks on average. The auctions were adjudicated to a greater number of banks usually in the first and last days of the month, and on the same day of the monetary policy meeting. In 2009, the daily turnover was on average 410 million USDs. Excluding the CBC, 55% were purchases. On those days when the CBC did not sell USDs, the volume traded was on average higher. The CBC auctions of USD sales were adjudicated to 4 banks on average each day. On two occasions, the auctioned USDs were distributed amongst a larger number of banks (above 6) not coincident with the monetary policy meeting. On 4 occasions, the amount auctioned would be adjudicated to a single bank.

Order Flows and Intervention

In chapter 2, we examined the effects of order flow of different market agents on intraday exchange rate returns (see Table 2.8). The estimations with and without the CBC's order flows showed that net buying pressure for the USD was associated with appreciation of the USDs with respect to the CLP. The results also suggest that the order flows of the CBC have significant effects on exchange rate returns in

and confidential.

2008 and 2009 (although in 2009 these effects are significant only at 7%).

Comparing the results for the two specifications for each year, we notice that when including central bank order flows, the effect of interbank order flows on exchange rate intraday returns decreases in 2008. Although different in magnitude, this result provides evidence for the order flow channel and is similar to the one of Kohlscheen (2012) for the case of Brazil.[22]

An event study for the intraday data can provide additional information regarding the degree to which agents could anticipate the CBC's interventions, and the duration of the potential intervention effects.

Event Study

Our event study follows Payne and Vitale (2003) and Dominguez and Panthaki (2007), and consists of estimating:

$$\Delta s_t = \alpha + \sum_{i=q}^{-q} \beta_i I_{t+i} + X'\delta + \varepsilon_t \tag{3.1}$$

where Δs_t are the exchange rate intraday returns, I_{t+i} is the intervention indicator variable which corresponds to the interaction between total order flows and central bank order flow, and $X'\delta$ represents other relevant variables, that in our case are the other order flow interactions and lags of the exchange rate returns, as in Equation (2.4) of the previous chapter. Table 3.2 includes the results of these regressions at 15 minutes frequency for 2008 and 2009. We choose $q = 8$ for the intervention indicator in order to examine the effects within a range of 2 hours around the intervention.

From our results, there seems to be a significant impact of actual interventions in 2008 according to the Wald test of joint significance of the leads and lags of the intervention variable. In 2009, the participation of the CBC in the FX market appears not to significantly affect the exchange rates. The results for individual

[22] In his paper, Kohlscheen (2012) indicates that a damping effect on prices occurs when the participation of the central bank in the market induces changes in the pricing process.

leads and lags show that there is a significant impact of the 1^{st}, 4^{th} and 5^{th} lags for the 2008 sample, suggesting that the effect of central bank orders remain over an hour. The results for 2009 indicate that the response to the central bank orders is more immediate, and they do not last long.[23]

Strictly speaking, the contemporaneous effect not being significant in all the specifications does not mean that there was no contemporaneous or first lag effect on the returns. This could be due to the nature of the intervention process in Chile. As explained in Section 3.2, the auctions lasted 3 minutes. Given that we aggregated the data to 15 minutes frequency, it could happen that intervention events were in the first, the last, or somewhere in the middle of the 15 minutes interval of which they belonged. Additionally, from the data we know that during the 3 minutes that intervention would take place, neither IB nor NB trades were recorded. On the one hand, this is because the IB agents were the ones competing to sell USDs to the CBC. On the other hand, as the NB were not able to participate in the auction, it is reasonable to think that they waited until the auctions concluded to react. The negative lagged coefficient could indicate that after the intervention, the agents adjust their expectations downwards. Overall, 2 hours previous to the intervention the spot rate returns would show a decrease and within the 2 hours after the intervention occurred, any further adjustments downwards in the exchange rate would be compensated.

Thinking of 2008 as a year of higher volatility in global FX markets, and assuming that the criterion for measuring the effectiveness of 2008 intervention is its ability to reverse the appreciation trend of the CLP, these results would be comparable with Fratzscher (2008) who states that in periods of higher market uncertainty, the

[23] For 2008, the 7^{th} lead is also found to be significant, which would suggest that the intervention was expected with almost 2 hours in advance. This could be intuitive given that from April to June, the market could have learnt to predict the times at which the CBC would intervene. However, the fact that the other leads are not significant weakens this hypothesis. The strongly significant first lead found for 2009 would suggest that the agents would anticipate the CBC entrance to the market. It could have been the case that the agents learnt to anticipate the CBC's behaviour from the 2008 intervention.

success of intervention tends to increase. That could be a reason to explain why the 2009 "with the wind" operations of the CBC showed weaker results, in contrast with Fratzscher (2005).

To summarise, the results of this event study help to understand intraday market behaviour providing evidence of the existence of intraday effects of intervention on exchange rates in Chile. However, the fact that these effects vary depending on the sample analysed adds uncertainty about whether these results usually vary across time, or whether they are related to the nature of the CBC trades. Such questions cannot be answered through linear regression analysis. Therefore, we proceed to examine the success rates of interventions.

Measuring Intervention Success

Although the CBC promotes and practices a transparency policy in terms of communicating its policy decisions, this only means that the general public will learn about how the CBC will operate, and the primary objectives of its actions. However, the objectives with regards to the particular policy instrument used may vary. That is, through reserve accumulation the authority could be seeking a reversal or moderation of any appreciation/depreciation trend observed, or aiming to affect the dynamics of its quantities demanded and supplied, i.e. the dynamics of FX order flows. In fact, accumulation of international reserves could be either to create a cushion under the uncertainty of future worsening of the economic conditions of the global economy, or just a way of implicitly promoting economic growth through exports.

Given that the particular objectives behind the intervention in the FX market may vary, here we evaluate the effectiveness of the interventions in Chile using two sets of success criteria, on the response of exchange rate and order flow as in Fratzscher (2005) and Marsh (2011), respectively.

Fratzscher (2005) proposes four criteria to evaluate the success of the intervention through examining the changes in the nominal exchange rate around the intervention events. These criteria are known as the *event*, *direction*, *reversal* and *smoothing* criteria, and are explained bellow:

- The *event* criterion states that during the intervention event the direction of the exchange rate change is consistent with the direction of the intervention itself. That means that if the intervention consists of buying foreign currency, the nominal exchange rate (measured as domestic versus foreign currency) increases during the event.

- The *direction* criterion evaluates whether after the intervention event the nominal exchange rate moved in the same direction as the intervention.

- The *reversal* criterion states that the success of the intervention depends on whether the nominal exchange rate trend reverses after the intervention takes place.

- The *smoothing* criterion evaluates whether the nominal exchange rate trend 'slows down' after the intervention event.

Marsh (2011) brings these success criteria to a microstructure view in order to evaluate the effects of FX intervention on order flows. He defines nine success criteria of which five are related to the performance of order flows, and four are related to the value of sales and purchases, that is, order flows and exchange rate combined. Marsh's criteria are defined as follows. In terms of the order flows performance:

- **net flow out of the domestic currency**: an intervention that aims to weaken the domestic currency would be successful if net purchases of foreign currency are observed contemporaneously with the intervention event;

- **reversing the direction of the net flow**: an intervention that aims to weaken the domestic currency would be successful if it changes the order flow direction – i.e. if it was into the domestic currency before the intervention, it goes out of the currency after the intervention;

- **accentuating/moderating the net flow**: an intervention that aims to weaken the domestic currency is leaning with the wind, it would be considered successful if order flow that is out of the domestic currency is accentuated; if such intervention is leaning against the wind, it would be considered successful if it moderates the order flow that is out of the domestic currency;

- **general success criterion for net flows**: an intervention aiming to weaken the domestic currency would be successful if order flows are also out of the domestic currency or, if not, at least less into the domestic currency than they were.

In terms of order flows and prices:

- **increasing in the domestic currency sales**: an intervention consisting of buying foreign currency is successful if the value of the domestic currency sales increases;

- **decreasing in the domestic currency purchases**: an intervention consisting of buying foreign currency is successful if the value of the domestic currency purchases decreases;

- **success criterion for gross flow**: an intervention consisting of buying foreign currency is successful if the value of domestic currency sales increases and the value of domestic currency purchases decreases; and

- **success criterion for flow proportions**: an intervention consisting of buying foreign currency is successful if the proportion of domestic currency sales

increases compared to the period before the intervention.

Table 3.3 summarises the results of applying these criteria to our intraday data on order flow, aggregated to daily frequency, for a preliminary overview. Note that our intraday data for 2008 only contains information for 22 trading days, and in all these days the CBC intervened in the FX market. Also note that we only count with 33 trading days for 2009, and the CBC traded on 29 of these days. Recalling that in 2009 the direction of the CBC trades was opposite to the trades in 2008, in order to analyse the impact of CBC trades of 2009 we consider the inverse of the criteria explained above. The table shows that in 2008 only 36% of the daily average exchange rates followed the direction of the intervention on the same day and the day after the intervention events. However, 50% of the cases showed a smoothing on the trend. In terms of reversal criteria, the proportion of the total number of cases is 23% considering price, and 33% when examining the order flow performance. Nevertheless, a higher proportion of successes is observed when considering the increase/decrease in CLP sales/purchases as criteria for intervention success: proportionally to the total of the day, more than 50% of the intervention events would have succeeded.

The problem with the analysis of success rates with data aggregated at daily frequency is that it does not allow us to evaluate whether the success rates are statistically significant. In the particular case of Chile, where interventions are carried out on a daily basis and for a long period of time, the statistical significance of intervention events can be obtained through examining the data at intraday frequency. Therefore, we increase the frequency of our intraday data to 15 minutes intervals. Tables 3.4 to 3.6 summarise the results. The first row of each criterion shows the number of cases that meet the success criterion (*successes*). Rows two and three show the correspondents percentage of the total observations at which intervention 'succeeded' according to each criteria, conditional to the sample and to the population sizes (*conditional %* and *unconditional %*, respectively). Row four shows

the p-value of observing the number of successes given the sample size, population size and the unconditional success rate, using hypergeometric function, as in Marsh (2011). The columns *pre-event* and *post-event* correspond to the averages of the results of computing each success criterion at 1 to 8 leads and lags separately, in order to identify whether the intervention had anticipated or delayed effects. The population size, which corresponds to the total number of transactions observed in each period, is 501 in 2008, and 786 in 2009. The sample size corresponds to the number of times the CBC operated in the market, and that is 22 times in 2008 and 29 in 2009. Significant comparisons between the conditional and the unconditional success rates are defined as when the p-value is lower than 0.05 or higher than 0.95.

According to Tables 3.4 to 3.6, actual interventions in 2008 appear to have had little effect on exchange rate or order flow. The only significant result at 5% significance is a moderation effect on order flow within the 15 minutes interval at which interventions took place, with a conditional success rate (22.7%) much higher than the expected (13%). If we considered a 10% confidence level, the actual interventions in 2008 would have also had effects on the value of order flows. Interestingly, the effects of USD sale programme in 2009 appears to have had a stronger effect. For example, the reversal on order flow dynamics appears to have taken place at a much higher rate (27.6%) than the expected (17.7%). In addition, the decrease in the value of CLP sales amongst market agents is around 33% more frequent than usual. The USD sales by the CBC on behalf of the Chilean Government not only decreased in value of CLP sales in absolute terms, but also increased the value of CLP purchases from 21.4% to nearly 45% of the cases. As a proportion of the value of buys and sales combined, the decrease in value of CLP sales slows its frequency from 40.7% to 13.8%.

Overall, our results suggest that if the objective of the CBC was to moderate the FX order flow, actual interventions in 2008 were successful. However, the par-

ticipation of the CBC in the market has effects *per se* on decreasing the value of sales. If trades in 2009 would have been part of an intervention programme, then leaning with the wind would have been more effective than leaning against the wind reversing the order flow direction and changing its value.

3.5 Conclusion

According to the literature, the effects of official FX intervention on exchange rates are mixed. A great portion of the research available focuses on the effects of interventions of advanced economies, mainly due to data availability issues and the fact that in the last decade this practice has been observed to be more common amongst developing countries. Our study seeks to provide new evidence that can help filling this gap. Emerging markets are interesting because, given the smaller size of their currency markets relative to advanced economies, their official FX interventions could be more effective, for instance through the portfolio channel, than the same policy carried out in an advanced economy. In this sense, Chile is an interesting case. Taking advantage of our novel dataset, we propose a comprehensive analysis of the effects and success of official intervention in the Chilean FX market.

In our analysis we explore the latest techniques on microstructure data to evaluate the intraday effects of intervention on the Chilean FX market. Our intraday data had not been previously available to scholars, therefore its sole statistical analysis is an important contribution to the literature. This data set records all spot USD transactions on the main trading platform of Chilean FX market, for two samples; one from 2008 and another from 2009. What is interesting in our data is that in 2008 the CBC intervened in the FX market aiming to accumulate reserves to prevent future worsening of the global economy conditions. In 2009, however, the CBC traded in the market as a fiscal agent, and sold USDs from the Chilean government.

To evaluate the effects of intervention on the intraday exchange rate returns we

firstly employ a standard event study. The results indicate that in 2008 the effect of intervention on the market price returns was felt 2 hours after the intervention occurred, whereas in 2009 effects of central bank trades on exchange rate were incorporated within the next 15 minutes on average. The anticipation of 2008's events could be due to acquired knowledge of the traders since the intervention programme started that year in April. Overall, our results provide evidence in favour of the microstructure channel of intervention as the inclusion of central bank orders has an impact on intraday returns and indirectly changes the pricing process of the private market.

We then analyse the intervention success rates in terms of exchange rate movements and order flows. This sort of analysis helps us evaluate the nature of the impact on these variables, i.e. reversals, moderation or accentuation of trends in exchange rates and order flows observed previous to the intervention. In terms of changes in success rates, official intervention appears to have only a moderation effect on the order flow dynamics on the days of intervention. The effects of the USD sales in 2009 appears to have had a stronger effect on the reversal of order flow dynamics and on changes in the value of sales and purchases of CLP in the market. This could imply that CBC trades have an effect on private order flows *per se*, which usually is not considered as an input to the policy decision process.

Table 3.1: Intervention Dates and Exchange Rate Variations

	2008	**2009**	**2011**
Announcement Actual Interventions or CBC participation	Apr 11^{th} Apr 14^{th} - Aug 29^{th}	Mar 19^{th} *stage 1:* Mar 27^{th} - Jun 22^{nd} *stage 2:* Jul 1^{st} - Nov 20^{th}	Jan 3^{rd} Jan 5^{th} - Dec 16^{th}
30 days prior announcement *(a)*	-5.21	-4.60	-2.61
First days post announcement *(b)*	3.34	-1.26, -2.78	-0.42, 4.02
30 days post announcement *(c)*	5.16	-0.72, 2.75	-3.46
Throughout the programme	15.11	-6.75, -6.31	6.62

The table shows the dates of oral (announcements) and actual interventions or participation of the CBC in the FX market in 2008, 2009 and 2011, in the top panel, and percentage changes of the spot exchange rate is the bottom panel. A negative value indicates appreciation of the domestic currency (CLP) against the foreign currency (USD). Since the announcements were published at the end of each corresponding day, *(a)* corresponds to the percentage change between the exchange rate level on the day of the announcement with respect to the exchange rate level on the 30^{th} day prior the announcement. Given that in 2009 and 2011 actual operations started 6 and 2 days after the announcement respectively, *(b)* shows both the exchange rate return the day after the announcement and the percentage changes between the first actual intervention day and the announcement day. As the purchase programme of the Government USDs in 2009 was carried out in 2 stages, in column 3 the 30 days posterior exchange rates variations *(c)* correspond to the percentage changes 30 days after the first day of each stage.

Table 3.2: Trade Based Order Flow, Exchange Rate Returns and Intervention

$$\Delta s_t = \alpha + \sum_{i=q}^{-q} \beta_i I_{t+i} + X'\delta + \varepsilon_t$$

	2008		2009	
$Constant$	-0.233	(0.495)	-0.685	(0.385)***
I_{t-8}	0.027	(0.210)	-0.229	(0.322)
I_{t-7}	0.391	(0.277)	-0.193	(0.192)
I_{t-6}	-0.049	(0.339)	0.118	(0.121)
I_{t-5}	-0.529	(0.268)**	0.051	(0.213)
I_{t-4}	0.888	(0.387)**	-0.100	(0.249)
I_{t-3}	0.121	(0.442)	-0.342	(0.239)
I_{t-2}	-0.583	(0.444)	-0.011	(0.170)
I_{t-1}	-0.803	(0.481)***	-0.126	(0.217)
I_t	-1.340	(0.311)*	-0.652	(0.252)*
I_{t+1}	-0.570	(0.297)***	0.409	(0.244)***
I_{t+2}	-0.802	(0.334)**	-0.128	(0.372)
I_{t+3}	-0.130	(0.340)	0.235	(0.346)
I_{t+4}	0.009	(0.347)	-0.258	(0.255)
I_{t+5}	-0.778	(0.508)	0.159	(0.471)
I_{t+6}	-0.043	(0.436)	0.048	(0.216)
I_{t+7}	-0.742	(0.342)**	-0.306	(0.295)
I_{t+8}	0.031	(0.375)	-0.217	(0.531)
Δs_{t-1}	-0.016	(0.042)	-0.034	(0.034)
Δs_{t-2}	-0.010	(0.049)	0.010	(0.022)
OF_t	0.909	(0.201)*	0.223	(0.071)*
$OF_t * OF_t^{IB}$	-0.821	(0.210)*	-0.147	(0.071)**
$OF_t * Dur_t$	0.003	(0.001)**	0.002	(0.001)***
Adj.R^2	0.31		0.09	
$H_0 : \sum \beta_i = 0$	4.21 **		1.10	

The table shows the OLS estimations at 15 minute frequency as in Equation (3.1), of the contemporaneous relationships between the exchange rate returns measured as CLPs per USDs, and trade based order flow. The coefficients show the changes of the exchange rate returns (Δs_t) in basis points of net purchases (trade based order flow). Newey-West standard errors in parenthesis. *** indicates statistical significance at 1% level, ** at 5%, and * at 10%. The sample period ranges from 1/7/2008 to 31/7/2008 (labeled '2008'), and 1/6/2009 to 20/7/2009 (labeled '2009').

Table 3.3: Intervention Success Evaluation, Daily Observations

	2008	2009
Price based criteria		
event	36.36	48.28
direction	36.36	48.28
reversal	22.73	24.14
smoothing	50.00	34.48
Order flow based criteria		
out of/in the CLP	45.45	48.28
reversal	33.33	21.43
accentuation	9.52	21.43
moderation	9.52	10.71
general criterion	42.86	42.86
Order flow and price based criteria		
increase sales/buys	47.62	42.86
decrease buys/sales	47.62	50.00
success gross	33.33	17.86
success proportions	52.38	50.00

The table shows the percentage of the total observations at which intervention 'succeeded' according to the criteria of Fratzscher (2005) and Marsh (2011), using daily data on trade based order flow and nominal exchange rate CLPs versus USDs. The sample period ranges from 1/7/2008 to 31/7/2008 (labeled '2008'), and 1/6/2009 to 20/7/2009 (labeled '2009').

Table 3.4: Intervention Success Evaluation, Intraday Observations

		2008			2009		
		pre-event	event	post-event	pre-event	event	post-event
Price based criteria							
event and direction	successes	68	11	84	91	17	105
	conditional %	38.64	50.00	47.73	39.22	58.62	45.26
	unconditional %	37.85	48.30	37.23	36.40	46.18	36.37
	p-value	0.54	0.65	0.85	0.65	0.94	0.88
reversal	successes	38	6	39	43	5	49
	conditional %	21.59	27.27	22.16	18.53	17.24	21.12
	unconditional %	18.54	21.36	16.54	17.22	20.23	16.33
	p-value	0.62	0.83	0.72	0.62	0.45	0.82
smoothing	successes	57	8	61	73	11	78
	conditional %	32.39	36.36	34.66	31.47	37.93	33.62
	unconditional %	28.79	37.33	28.92	28.80	35.88	27.78
	p-value	0.72	0.56	0.72	0.69	0.67	0.74

The table shows the number of cases that meet each success criteria (*successes*), the correspondents percentage of the total observations at which intervention 'succeeded' according to each criteria, conditional to the sample and the population sizes (*conditional %* and *unconditional %*, respectively), and the p-value of observing the number of successes given the sample size, population size and the unconditional success rate, using hypergeometric function, as in Marsh (2011). The results showed in this table correspond to these calculations using intraday data on trade based order flow and nominal exchange rate CLP/USD. A window of 8 leads/lags is used to cover the pre and post-event evaluations. The population size is 501 observations in 2008, and 786 in 2009. The sample size is 22 in 2008 and 29 in 2009. The sample period ranges from 1/7/2008 to 31/7/2008 (labeled '2008'), and 1/6/2009 to 20/7/2009 (labeled '2009').

Table 3.5: Intervention Success Evaluation, Intraday Observations *(cont.)*

		2008			2009		
		pre-event	event	post-event	pre-event	event	post-event
Order flow based criteria							
out of/in the CLP	successes	68	9	81	64	12	101
	conditional %	38.64	40.91	46.02	27.59	41.38	43.53
	unconditional %	36.25	47.31	36.13	31.00	40.97	32.59
	p-value	0.61	0.35	0.88	0.43	0.60	0.89
reversal	successes	29	5	33	35	8	44
	conditional %	16.48	22.73	18.75	15.09	27.59	18.97
	unconditional %	14.20	17.96	14.57	14.23	17.68	14.54
	p-value	0.62	0.81	0.80	0.61	0.95	0.77
accentuation	successes	14	2	20	14	1	26
	conditional %	7.95	9.09	11.36	6.03	3.45	11.21
	unconditional %	8.26	9.98	7.83	6.66	8.02	6.98
	p-value	0.45	0.62	0.76	0.41	0.31	0.87
moderation	successes	22	5	28	35	7	38
	conditional %	12.50	22.73	15.91	15.09	24.14	16.38
	unconditional %	12.05	12.97	15.37	14.84	16.41	17.18
	p-value	0.50	0.95	0.55	0.57	0.91	0.42
general criterion	successes	52	8	54	58	10	75
	conditional %	29.55	36.36	30.68	25.00	34.48	32.33
	unconditional %	26.80	34.53	25.32	24.57	32.06	24.54
	p-value	0.63	0.67	0.70	0.58	0.69	0.86

The table shows the number of cases that meet each success criteria (*successes*), the correspondents percentage of the total observations at which intervention 'succeeded' according to each criteria, conditional to the sample and the population sizes (*conditional %* and *unconditional %*, respectively), and the p-value of observing the number of successes given the sample size, population size and the unconditional success rate, using hypergeometric function, as in Marsh (2011). The results showed in this table correspond to these calculations using intraday data on trade based order flow and nominal exchange rate CLP/USD. A window of 8 leads/lags is used to cover the pre and post-event evaluations. The population size is 501 observations in 2008, and 786 in 2009. The sample size is 22 in 2008 and 29 in 2009. The sample period ranges from 1/7/2008 to 31/7/2008 (labeled '2008'), and 1/6/2009 to 20/7/2009 (labeled '2009').

Table 3.6: Intervention Success Evaluation, Intraday Observations *(cont.)*

		2008			2009		
		pre-event	event	post-event	pre-event	event	post-event
Order flow and price based criteria							
increase sales/buys	successes	77	14	85	76	13	119
	conditional %	43.75	63.64	48.30	32.76	44.83	51.29
	unconditional %	40.54	50.30	37.60	37.07	44.66	43.19
	p-value	0.61	0.93	0.84	0.32	0.59	0.78
decrease buys/sales	successes	61	8	93	98	23	104
	conditional %	34.66	36.36	52.84	42.24	79.31	44.83
	unconditional %	34.01	40.32	38.95	38.47	46.06	34.61
	p-value	0.52	0.44	0.90	0.70	1.00	0.91
success gross	successes	33	5	48	39	13	60
	conditional %	18.75	22.73	27.27	16.81	44.83	25.86
	unconditional %	17.27	21.36	17.61	17.76	21.37	18.05
	p-value	0.68	0.68	0.93	0.40	1.00	0.87
success proportions	successes		12			4	
	conditional %		54.55			13.79	
	unconditional %		44.71			40.71	
	p-value		0.88			0.00	

The table shows the number of cases that meet each success criteria (*successes*), the correspondents percentage of the total observations at which intervention 'succeeded' according to each criteria, conditional to the sample and the population sizes (*conditional %* and *unconditional %*, respectively), and the p-value of observing the number of successes given the sample size, population size and the unconditional success rate, using hypergeometric function, as in Marsh (2011). The results showed in this table correspond to these calculations using intraday data on trade based order flow and nominal exchange rate CLP/USD. A window of 8 leads/lags is used to cover the pre and post-event evaluations. The population size is 501 observations in 2008, and 786 in 2009. The sample size is 22 in 2008 and 29 in 2009. The sample period ranges from 1/7/2008 to 31/7/2008 (labeled '2008'), and 1/6/2009 to 20/7/2009 (labeled '2009').

Concluding Remarks

An important challenge to policymakers across the world is the design of effective policies that deal with movements in international portfolio flows. These policies are better informed if we can empirically disentangle the relative importance of push factors that are external to the economies receiving the flows and pull factors that are internal. The first chapter of this thesis contributes to the debate on what drives international portfolio flows by estimating a dynamic latent factor model using more than 20 years of monthly international bond and equity flows from the US to 55 other countries. The advantage of this model is that it provides a flexible way for assessing the relative importance of the contribution of push and pull factors to the variation in international bond and equity flows.

We find that the push factor dominates the pull factor by explaining more than 80% of the variance of international portfolio flows. This holds for the vast majority of countries, all geographic regions and for both bond and equity flows. The strength of the push factor is even more pronounced for equity flows than bond flows, and for developing countries than advanced economies. However, the pull factor tends to be higher for the G8, the G20 and the BRICS countries. It is even higher for countries involved in the foreign exchange carry trade, than it is for countries with very low or very high interest rates. Notably, over the crisis period, the role of the push factor diminishes as on average the contribution of the pull factor to the variance of flows effectively doubles. Furthermore, the dynamics of push and pull factors can be explained to some extent by US and foreign macroeconomic indicators respectively.

The empirical evidence reported in the first chapter essentially confirms the public perception that forces related to financial globalization are the primary determinants of international portfolio flows. Therefore, countries exposure to global (rather than domestic) risks appear to be more important in informing the domestic policy response to time-varying international portfolio flows. This suggests that compared to domestic macroeconomic policies, capital controls may be a more effective policy tool for countries aiming to stimulate economic growth partly by managing the consequences of international portfolio flows. Indeed, the new institutional view of the IMF announced in November 2012 recognizes that this may be the case. Although we do not explicitly provide direct evidence on the effectiveness of capital controls, our empirical findings contribute to this debate and lend support to the new institutional view of the IMF on capital controls.

Within the economic context of the last decade, knowledge on EMEs have become more valuable, as these countries have experienced increasing participation in the global economy, shown resilience during the global crisis, and in some cases become strongly financially developed. Understanding how FX markets work in these countries and what have been the effects of official FX intervention used as responses to the latest global crisis, are other two key aspects that can contribute to further policy design.

In the second chapter of this thesis we present new evidence on the microstructure of exchange rates in emerging markets. We employ a novel dataset that, to the best of our knowledge, has never been analysed before. With this data we are able to examine the features of all spot USD transactions recorded in the Chilean FX intraday market over four weeks in mid 2008 and six weeks in mid 2009. We evaluate the impact of order flow on exchange rate returns and analyse the behaviour of such relationship throughout the day and across time. We also evaluate the differences amongst the impact of dealers, non-dealers and central bank order flow on exchange

rates.

Our findings suggest the existence of a statistically significant relationship between CLP/USD rate and its order flow. Furthermore, the domestic currency tends to depreciate with USD buying pressures, regardless of who initiates the trade. Trade based order flow has higher explanatory power than volume based order flow, as suggested by Sager and Taylor (2006) for customer flows. The impact concentrates in the most intensive trading hours, which is consistent with the liquidity provided during the day. The order flow impact is also changing across time, both in magnitude and significance. Differences in the results between the samples could be related to the fact that the economic conditions at which the market operated in 2008 were different than in 2009. Interesting to note that in 2009 the period when the impact of order flow was highest is around the week were the CBC did not trade in the market.

Unlike evidence found for some EMEs, our findings do not support bi-causality between order flow and exchange rate. However, we find weak evidence suggesting order flow leadership from central bank to dealer, and from dealer to non-dealer trades in 2009. According to our results, the interbank order flow effects are no more than one quarter of the total order flow effect, and trading intensity has also minor impact during the first trading hours. Our findings also suggest that the official intervention in 2008 had an effect on damping the price effect of interbank order flow, whereas the direct effects of the CBC order flow on exchange rates seem to be stronger in 2009. Regarding the existence of a long run relationship between exchange rate and cumulative order flow, Johansen's test rejects the hypothesis of no cointegration. Our VECM estimations indicate that between 0.2% and 0.4% of the deviations from the long-run trend return to equilibrium at 15 minute frequency.

Due to the nature of our data, defining who the liquidity providers in this market are is not an easy task. The presence of the CBC in the market impacts the order

flow dynamics in the short run: the interbank order flow effect decreases during official intervention periods, and contents an important portion of the total order flow effect as a fiscal agent. These conclusions are not conditional on the volume traded by the CBC. Overall, our analysis provides directions on future analysis of FX intraday markets in EMEs. As our results imply that the Chilean FX market works differently from some EMEs, future investigation should consider the evaluation of possible extensions to Evans and Lyons' model applicable to small FX markets.

According to the literature, the effects of official FX intervention on exchange rates are mixed. A great portion of the research available focuses on the effects of interventions of advanced economies, mainly due to data availability issues and the fact that in the last decade this practice has been observed to be more common amongst developing countries. In the third chapter of this thesis we seek to provide new evidence that can help to fill this gap. Emerging markets are interesting because, given the smaller size of their currency markets relative to advanced economies, their official FX interventions could be more effective, for instance through the portfolio channel, than the same policy carried out in an advanced economy. In this sense, Chile is an interesting case. Taking advantage of our novel dataset, we propose a comprehensive analysis of the effects and success of official intervention in the Chilean FX market.

In our analysis we explore the latest techniques on microstructure data to evaluate the intraday effects of intervention on the Chilean FX market. Our intraday data had not been previously available to scholars, therefore its sole statistical analysis is a great contribution to the literature. This data set records all spot USD transactions on the main trading platform of Chilean FX market, for two samples; one from 2008 and another from 2009. What is interesting in our data is that in 2008 the CBC intervened in the FX market aiming to accumulate reserves to prevent future worsening of the global economy conditions. In 2009, however, the CBC traded in

the market as a fiscal agent, and sold USDs from the Chilean government.

To evaluate the effects of intervention on the intraday exchange rate returns we firstly employ a standard event study. The results indicate that in 2008 the effect of intervention on the market price returns was felt 2 hours after the intervention occurred, whereas in 2009 effects of central bank trades on exchange rate were incorporated within the 15 minutes on average. The intervention events in 2008 were anticipated almost two hours before, on average. The latter could be due to acquired knowledge of the traders since the intervention programme started that year in April. Overall, our results provide evidence in favour of the microstructure channel of intervention as the inclusion of central bank orders has an impact on intraday returns and indirectly changes the pricing process of the private market.

We then analyse the intervention success rates in terms of exchange rate movements and order flows. This sort of analysis helps us evaluate the nature of the impact on these variables, i.e. reversals, moderation or accentuation of trends in exchange rates and order flows observed previous to the intervention. In terms of changes in success rates, official intervention appears to have only a moderation effect on the order flow dynamics on the days of intervention. The effects of the USD sales in 2009 appears to have had a stronger effect on the reversal of order flow dynamics and on changes in the value of sales and purchases of CLP in the market. This could imply that CBC trades have an effect on private order flows *per se*, which usually is not considered as an input to the policy decision process.

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