MICROSTRUCTURE MARKETS, STRATEGY AND EXCHANGE RATE DETERMINATION

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A Thesis Submitted in Partial Fulfilment of the Requirements of Bournemouth University for the Degree of Doctor of Philosophy

June, 2015

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Acknowledgements

In writing this thesis on exchange rates, I have been privileged to receive the supervision and support of Dr. Allan Douglas Webster. I am grateful for his weekly dose of advice, guidance with my research issues, support, and also good sense of humour.

Chapter 3 and 4 were also reviewed and commented on by Dr. Fabian Homberg and Dr. Davide Secchi, I am pleased to extend greetings to them.

I am also happy to acknowledge the generous assistance provided during my doctorate by many members of the staff at Bournemouth University.

My entire gratitude to my family in Colombia; they have supported me with no conditions during my research in the UK and they helped me to carry on from very difficult times.

On this exciting journey, I had the opportunity to meet my wife Ellie, and soon we will receive our first daughter. I need to mention that they fill me up with a deep motivation to finish my work.

This is how I know that God exists; there is intelligence in every particle of nature, and the miracle of existence is absolutely astonishing. But most importantly, God has showed me that he/she is good through the kindness of all the persons mentioned above. ‘I thank my God in all remembrance of you’ (Phi 1: 3).

Microstructure Markets, Strategy and Exchange Rate Determination

By Camilo Calderon-Morales

Abstract

The main contribution of this empirical research is to demonstrate that agents' strategies are important in the exchange rate determination. This research shows that strategic objectives are heterogeneous particularly when they are related to the expectations with respect to volatility. Trading strategies contribute to solving the empirical problem of explaining exchange rates. In this connection, the main research question addresses how far strategies are important in the exchange rates determination. The concept of strategy includes a) the strategic objectives, b) the trading strategies and c) the strategic content (agents preferred variables).

This research departs from the Microstructure Markets Models used by Evans (2002, 2010). Unlike the literature, this empirical research includes a survey approach, combined with recently developed techniques in panel time series estimation, such as the Pooled mean-group (Pesaran and Smith 1995, Pesaran and Shin 1999, and Pesaran 2004), and especially the panel second step least squares with time-invariant variables (Panel 2SLS) (Atkinson 2014). The strategic objectives are extracted from the economic literature. Trading strategy characteristics are taken from the strategic management literature, and the strategic content (variables) from the microstructure literature. Among the findings are that: (a) strategic objectives comprise more than the traditional objective 'profiting from investments'; (b) the effect of planning and learning strategies on the exchange rates is both important and statistically significant; and (c) market homogeneity is related to the strategic information used by market agents.

Key words: Microstructure Markets, Exchange rates determination, Management Strategy, Heterogeneous behaviour.

CHAPTER 1. INTRODUCTION

This study considers the underlying relationship between the microstructure market models of exchange rate determination and the strategies of agents' trading in the foreign exchange markets. In this chapter the following aspects are defined and discussed:

a) The objectives of this research
b) The specific key research questions
c) The background to the foreign exchange markets
d) An outline of the thesis

This empirical investigation aims to explain the exchange rates (ER) determination. It focuses on defined strategy features (i.e. strategic objectives, trade management, and strategic content). In this connection, choosing the economic model is a key aim of this research, in order to highlight the importance of the mentioned strategy economic heterogeneity. The Microstructure Markets Model (MMM) is chosen because it permits the testing of the strategy findings empirically.

Moreover, within this research, the MMM assumptions are the subject of scrutiny related to the role of the market agents and their subjacent strategic behaviour. It is not possible to depart from habitual macroeconomic models because they assume a representative household who have a similar strategic objective, trading strategies, and strategy content. On the other hand, MMM relaxes the assumption of homogeneous behaviour. This allows investigation of the strategic heterogeneity of the market agents. This is the major reason why this research on strategy is highly supported in the microstructure markets models.

Briefly, the next paragraphs focus on historical developments (including macroeconomic models) and the main economic problem, before pointing out the importance of individual and organisational strategy assumptions. The latter are associated with the approach of the Microstructure Markets Models (MMM) discussed throughout this research, and the theoretical platform used to analyse the strategic phenomenon.

1.1. Exchange rates: Main research problem

Without a doubt, the main problem within the field is the poor empirical results from consistent macroeconomic models to explain and forecast the nominal ER. This casts doubts on the success from alternative models such as MMM. This research contributes to solve this problem by using a strategic approach. In referenced papers, Meese and Rogoff (1983a and 1983b, p.95) report what the central problem is, and they conclude: "The models do sometimes produce better forecasts than random walk model at longer horizons, but in an unstable fashion", and as a result of these papers Krugman (1993, p.7) has also stated: "…it became difficult to present another set of regression results without embarrassment… the theory of exchange rate determination has never recovered from the empirical debacle of the early 1980s".

The inability to explain the exchange rates with macroeconomic fundamentals known as the "exchange rate disconnect puzzle" was solved partially by Mark (1995) and Chin and Meese (1995). They found that in long horizons the monetary fundamentals outperform the random walk (RW) forecast. However, Kilian (1999, p.507) has questioned these findings: "There was some evidence of exchange rate predictability, but contrary to early studies, no evidence of higher predictability at longer forecast horizons". Moreover, a thoughtful study by Cheung, Chinn and Garcia-

Pascual (2005) tested the performance of the monetary, productivity based, interest rate parity and behavioural models, confirming the negative results of Kilian.

1.2. The Background and contributions made from a macro perspective about the problem

Nonetheless due to the poor explanatory power explained above, there are many economic contributions that can be further addressed. Particularly, these include contributions that are important when explaining how price reacts to information, and those highlighting the relevancy of some economic variables (strategic content). They can be tested in a microeconomic context.

Namely, in 1962-1969, the contribution of the role of trade and capital flows in the equilibrium of the ER by the Mundell-Fleming Model (details found in Mundell 1963 and Boughton 2003). For example, the work of Bathi (2001) has supplied empirical evidence of a strong long-term relation between ER and relative prices, incomes, and interest rates (long term). However, his results have lacked ratification by using the rupee *vis à vis* with the French franc and U.S. dollar.

Some other contributions were successful during shorter periods of time. The original chaos and uncertainty of the Bretton Woods system gave way to the free floating system in 1973. The phenomena undermined the ER explanation power of the Mundell-Fleming Model, and the gap was filled with the Flexible-Price Monetary Model approach. The latter contributed to the postulate of international money stocks and inflationary expectations as principal variables affecting the ER. Nonetheless, Moosa (2007) and Harvey (2006) show evidence of the rejection of the Flexible-Price Monetary Model, and by contrast the significance in favour of a post-Keynesian approach. The Flexible-Price Model performed well in approximately the first 5 years of the flexible exchange rates period. However, other works conducted in the 1980s rejected this monetary model (e.g. Frankel 1983).

A successful and recent macroeconomic strand of macroeconomic literature departs from a variation of the Taylor (1993) rule used for ER determination; Engel and West (2005) provide an explanation of the difficulty of tying ER to fundamentals. The Taylor rule proposes that "the Central Bank adjusts the short-run nominal interest rate in response to changes in inflation, the output gap, and the exchange rate". They prove that ER can be modelled using present value asset pricing models (being near-RW) if two conditions are satisfied: "(a) fundamentals integrates are of order 1 and (b) the discount factor for future fundamental is near 1". The latter condition has been proved empirically by Sarno and Sojli (2009). Finally, Molodsova and Papell (2009, p.179) provide strong evidence at the one-month horizon for 11 of 12 countries: "We find very strong evidence of exchange rate predictability with Taylor rule fundamentals".

Other methodologies use models with expectations on future values of fundamentals releases (e.g. Bacheta and Van Wincoop 2006). Other studies focus on particular economic releases, for example Clarida and Waldman (2007), who concluded that announcements on high inflation lead to the appreciation of the exchange rate. Mark and Sul (2001) and Groen (2005) applied correction models of panels in the long term, and their predictions are evidenced to be superior to RW. Finally, using survey data on ER market expectations, Hauner et al. (2011) explained correlations with inflation and productivity differentials. Accordingly, they support that market expectations are formed under the Balassa-Samuelson effect and the Power Purchasing Power (PPP) theory.

Finally, James, et al. (2012) found strong economic evidence against the RW benchmark. Particularly, empirical ER models based on the uncovered interest parity (UIP), Power Purchase Parity, and the Taylor rule outperform the RW in OOS predictability power. They conclude that conditioning on Macroeconomic Fundamentals reduce OOS economic gains. Moreover, joint-forecasts designed by means of model averaging methods work better than single empirical models.

1.3. Background and contributions from a microeconomic perspective

The ER "disconnect puzzle" (the disconnection of ER to fundamentals) brings about the development and application of the Microstructure Market and behavioural theories to the field of ER. More specifically, the aim to overcome the above mentioned puzzle situates the heterogeneous behaviour (e.g. strategic objectives and the agents risk tolerance) as a central point of the most recent economic developments (e.g. MMM). This last view in coincidence with some of the literature of the strategy field finds the strategic process also to be relevant (micro processes) and the strategic content (types of information). Indeed, these similarities permit this research to affirm that the Microstructure Markets Models is the more appropriate framework to address these strategy subtopics.

Formally, in the selected research framework, that is the Microstructure Market Models (MMM), agents share the same information on the structure of the market. However, they have different information about the current conditions of the economy (informational heterogeneity). In other words, they do not have the same FX future returns expectations and therefore, have a different degree of uncertainty.

What is more, the MMM use explicit trading rules, processes and outcomes of exchanging currencies. These results from the market agent's optimisation problems focusing on micro aspects such as information transmission among participants, the behaviour of market participants, and the notions of order flow, heterogeneous trading volumes, and volatility. In this connection, the strategic behaviour of organisations is addressed and therefore, the specification of the MMM allows the testing of the economic importance of different types of trading management strategies and strategic content. For this important reason, the economic model of choice to answer the research questions is MMM. In connection with the predictability power, a second important reason to choose these models is their ability to outperform RW forecasts OOS in horizons between 1 day and 1 month (Lyons 2001a; Evans and Lyons 2005a).

1.4. Microstructure Markets Assumptions

Opposite to macro models, the assumptions of MMM are:

a) The information is not perfect, but rather asymmetric, implying private information, even if it is not economic (Lyons 2001a, p.26). Market makers can do inferences on private information based on order flow, and the net result between bid volumes and sell volumes.

b) Market participants with common information can interpret ER differently compared to those who are uninformed. The agents are different, many elements impact their behaviour, and their objectives within the FX market can differ as well (i.e. hedging, protect the economy, speculation).

c) The trading process and its structure affect the ER (i.e. characteristics of the currencies and types of traders). There are two instances or “tiers” within the market. Firstly, the ‘customer to dealer’ tier where trading between these two groups takes place. Secondly, the ‘dealer to dealer’ market tier. In practice three forms of market structures operate in combination: a) auction markets, b) single-dealer markets, and, c) multiple dealer market.

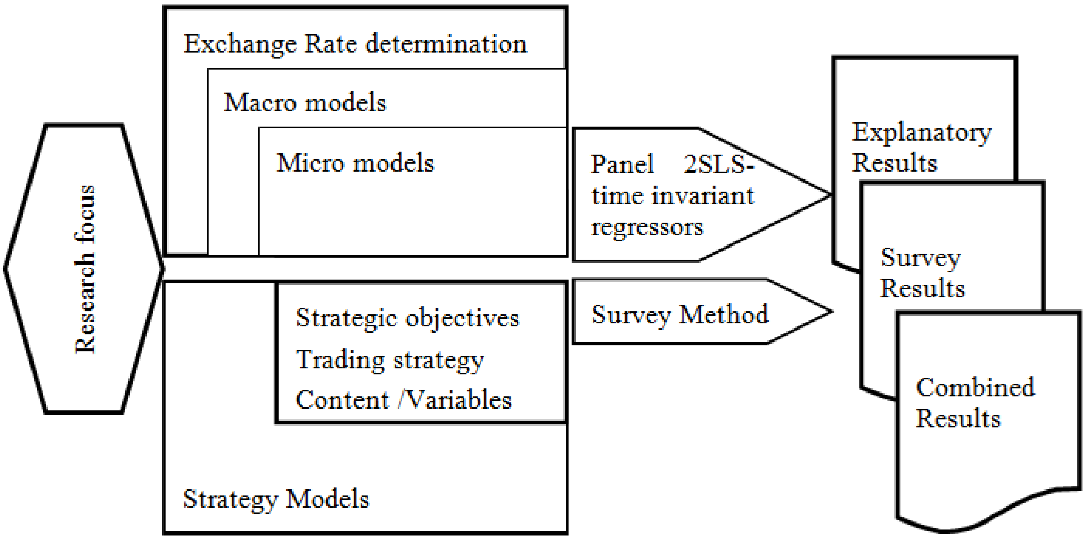
The assumptions of macroeconomic models uphold a homogenous agents' behaviour regarding information, and homogeneous expectations on future returns. These assumptions cast doubts as to the premises of different behaviour upon information, market structure and heterogeneous behaviour that are emphasized in the MMM. The MMM postulations provide the background, and transfer strength to the study of strategy within trading organizations or individuals.

The power of MMM OOS predictability and their assumptions permit the inclusion of variables to model the trading management and the economic strategy, and therefore, this allows one central question throughout this research to be determined: whether trading management strategies are a key factor in the ER determination in the specific context of MMM. In this connection, trading strategy decisions are defined as those: "characterised by a large commitment of resources and deal with issues of substantial importance to the organisation usually with longer rather than just short term impact; they usually involve more than one function and involve significant change" (Bailey et al. 2000).

Succinctly, Figure 1 summarises the key features of this dissertation and presents the overall scheme of this work, and the insights on research completeness and consistency.

Figure 1. Research synopsis

The Figure presents a brief synopsis of the contents of this thesis and its research thoroughness. In detail, this chapter presents an introduction to this empirical investigation and addresses the research focus. Within this section is stated the research objective and the research questions. Moreover, the research rationale comprises the reasons, and the importance of this empirical investigation.



Chapter 2 covers the literature review. The guiding concept through this chapter is 'strategy' in the context of microstructure market models. This chapter provides an account of what has been published on the ER strategy and the microstructure topic by accredited scholars and researchers. The purpose of this chapter is to convey progressively what the main knowledge and ideas on microstructure and strategy behaviour are in the exchange rate determination. It begins with broad to then specific topics, comparing their strengths and weaknesses, which are related to the research objectives. This part contains the scope and relevance of the review, and supplies details of the exchange rate market structure and the concept of order flow. Moreover, it defines the Portfolio Shift Model as a theory of reference for this research, and addresses the topic of economic heterogeneity.

Chapter 3 considers the Survey Research Method the quantitative methods such as logistic regression, factor analysis and the tests of hypotheses (e.g. Wilcoxon-Mann-Whitney and Kruskal-Wallis rank test). The sample includes individual speculators, members of mutual funds, hedge funds, central banks, commercial banks, and governments from different cultures and countries. Furthermore, probabilistic sampling is applied in order to obtain universal conclusions. This chapter also reports the survey pilot results.

Chapter 4 reports descriptive statistics, tests of hypotheses, and ordered Logistic regressions for the most important survey items. Furthermore, within this chapter the reader finds details on the survey sample size, the survey pilot, and the explanation of variables. This part establishes the importance of strategy and whether there are heterogeneity regarding strategic objectives, trading strategies, and strategic content (variables to forecast the exchange rates).

Chapter 5 looks at the Econometric Model Estimation and Data, and discusses the assumptions of the empirical model. Specifically, the empirical specification and estimation of the model comprises macro panel data models where N (the cross-section unit) is small and T (The time series) large. Therefore, in order to pool the data, and to include the instrumental variables and time-invariant variables, the two-step least squares Panel Data Model (2SLS) were selected with weak instruments and time-invariant regressors. In detail, this Chapter explains the secondary data and how the order flows were estimated. There are also explanations on the algorithm to compute the real-time Macroeconomic conditions, and other variables such as the rollover rates.

Chapter 6 on Panel Fixed Effects covers the first stage of the 2SLS panel model strategy explained in chapter 5. The estimation of the first stage uses heterogeneous parameter models to solve the exchange rates co-integration issue. In this connection, coefficients represent averages across groups, computed as unweighted means. After comparing with other estimators, the choice of model is the Pooled Mean-group by the fixed effects model. The chapter documents the model estimation procedure. In addition, in this chapter, the reader will find details on the data, cointegration, unit roots, and other dynamic equation models.

In Chapter 7, there are the combined results, which cover the econometric model estimation including the trading management strategies. The chapter begins with the calculation of the control variables and the trading management variables. It reports the results using panel second step least squares regression. This modern econometric technique is suitable for time-invariant or low-variant cross-sectional variables, which permits the addition in the model of variables and findings from the survey method.

Finally, Chapter 8 summarizes the most important findings, results and conclusions, together with recommendations, limitations and references for future research in the field.

1.5. Objective

The objective is to assess how far the strategies of agents are important in exchange rate determination.

In this connection, this research addresses:

a) The trading objectives of diverse categories of agents (e.g. dealers, customers, banks, central banks, commercial banks, speculators, etc.).
b) The trading management strategies (i.e. command, planning, incremental, political, cultural, enforced choice).

c) The economic or financial variables (e.g. order flow, fundamentals, and other market assets).

Moreover, this empirical investigation reviews the relation of these dimensions with the risk tolerance, and explores quantitatively the effects and relations within the MMM.

1.6. Research Questions

The research questions are as follows:

a) What is the significance of trading management strategies on exchange rates?
b) Aside from ‘profit’, how far other strategic objectives are relevant in Forex?
c) What are the most important types of variables for modelling the exchange rates?

1.7. Rationale

In 2013 the average daily turnover in the global FX by instrument is about 5 trillion dollars (Triennial Central Bank Survey 2013), and the figure has been increasing strongly since 2001 when it reached 1.5 trillion dollars as a daily average, which is far more than any other asset in any market. Because of the asset turnover size and its implications over businesses and individuals, the study of ER determination is a key aspect in macro and micro economic models. The flexible ER system, the information technologies, the expansion of firms beyond national frontiers, and the market objective of each market agent (i.e. central banks, governments, mutual funds, brokers, dealers, organisational and individual speculators) bring about their ability to cope with risk exposure with regard to foreign exchange risk given the fluctuations in the currency markets. As a result, this research studies the market agents’ strategy implications within the ER determination; a key economic variable in a globalised context.

Particularly, this empirical investigation studies the different objectives, trading management and economic strategies of market agents to deal with the implicit fluctuation of risk. Following this further, the subheadings below state the reasons and importance of this study.

1.7.1. Macroeconomic policy

Economic authorities might want to act upon the structure, determined strategic objectives or public or private information. Also, the exchange rate determination, under flexible exchange rates, is linked with the interventions in the market by central banks. These are supported on two propositions: a) exchange rate fluctuations can be excessive and b) fluctuations may have unfavourable influences on economic activity.

Much has been written on economic models and the strategy content (variables) to forecast and predict the exchange rates and the associated risk. This research contributes to these studies by considering the importance of strategic objectives, market agents' behaviour and economic authorities such as central banks and governments.

The results of this research contributes by explaining whether the objective, the trading management strategies and the content can increase the precision and ability of these public instances to regulate or deregulate, forecast, adjust the risk tolerance, and act upon ER fluctuations. Also, this study contributes to existing research by providing understanding into how the objective in the market or the type of organisation modifies the strategic behaviour upon ER.

1.7.2. Macroeconomic linkages

Another reason to study the exchange rates fluctuation is the macroeconomic linkage through exchange rates. For example, undesirable changes in exchange rates may cause imported inflation, loss of competitiveness, changes involving resources allocation, debacles in exports, and affectation of the wealth distribution in the different economic sectors. This research provides insights into the relationship between an organisational strategy approach, and micro and macro-variables in the context of MMM.

1.7.3. Microeconomic benefits

Businesses are particularly affected by ER, especially under the globalised environment. The advantage of the financial globalization permits the enhancement of the investment portfolios of different types of agents. Indeed, opportunities in a more connected market bring about risk to hold currencies. This research contributes to the strategy of all market participants, which include among others the private banks, corporations, individual traders, dealers and brokers.

1.7.4. Academic contributions

This study establishes whether there is economic heterogeneity in terms of agents' strategy, and estimates the coefficients of trading management strategies. The notion of economic heterogeneity is very important for this thesis, as it can be used to evaluate distinctive agents' strategies. This research suggests that strategy is an important factor within the Microstructure Models literature.

This research is significant for the literature, as it converges two specific topics: trading strategy management and MMM, and addresses an important part of the organisational "black box" behaviour in which the trading positions are determined by market agents.

Particularly, this empirical investigation contributes to the Portfolio shift model in explaining whether the strategic behaviour is heterogeneous or homogeneous within the two tiers of the FX market. Finally, this research could be considered a first step to extend the predictive MMM and actual information assumptions.

CHAPTER 2. REVIEW OF LITERATURE

This study is focused on the literature on MMM for exchange rates determination. Particularly, this study deals with an explanation on the economic problem of exchange rates. Indeed, the literature on exchange rates is largely in agreement concerning the poor explanatory power of traditional macroeconomic models. This problem is even more noticeable at high time frequencies.

The focus of this literature review is on the role of strategy in Microstructure Market Models (MMM). Specifically, the discussion focuses on three key aspects. These are (a) strategic objectives; (b) the mixture of different trading management strategies employed (strategy process); and (c) the economic and/or financial strategies (strategic content) adopted by the market agents in the determination of exchange rates. The literature and concepts that are under consideration for this research topic are presented in the Figure 2.

Figure 2. Literature review outline

This figure shows a synopsis of the literature reviewed on MMM. The first column illustrates the guiding concepts on strategy. The second column summarises the essential topics needed for this study. The third column reports on the relevant topics that are directly related to this empirical investigation. The fourth column presents some other topics which are also important in terms of research awareness.

	Essential references	Relevant references	Other relevant topics
Strategic ObJectives	Heterogeneity Type of market agents	Informed and uninformed trade	Dealer behaviour, arbitrage, banks, institutional investors, intervention, regions, speculation, carry trade, Microstructure Models.
Trading Strategy Process	Order flow process Order flow and news	Customer order flow, order flow and regions, order flow and events, ordeer flow and market activity, price discovery,	Algorithms, transaction costs, dealer quotes, direct and indirect transactions, transitory and permanent shocks, vehicle currencies, forward premium, price clustering, price cascades, transaction costs.
Strategic content	Order flow variable Order flow fundamentals Order flow and news varibles Risk and volatility Unit roots	Order flow and technical analysis Volume and volatility Garch, volatility and returns	Algorithmic trading, option hedging, algorithm efficiency,change in market structure, currency and equity markets, GMM and spreads, indicative transaction data, liquidity risk, linear and non linear models, neural networks, regime, support and resistance, volume spikes, financial crisis.

The above topics of this research will be discussed in the sections below. As a preamble to this discussion, the next section will cover the scope and relevance of this literature review.

2.1. The scope and relevance of the review

The literature review will first focus on past surveys, as well as the books on the Microstructure Market Models (MMM) such as, Sarno and Taylor (2001), Lyons (2001b), Vitale (2004), Osler (2006 and 2009), Moosa and Bhatti (2010), Evans (2011), Rime (2012), and King et al. (2012b). Thoroughly, this empirical investigation reviewed within the Forex Market Microstructure literature a total of 242 papers from 59 different journals. The most representative in terms of these publications comprises of:

a) The Journal of International Money and Finance (44 publications)

b) The Journal of International Economics (20 publications)

c) The International Journal of Finance and Economics (19 publications)

d) The Journal of Banking and Finance (13 publications)

e) The Journal of Finance (10 publications)

f) The remaining Journals have from 1 to 8 publications.

A total of 107 working papers on MMM were considered during the literature review process. The most important research institutions from which working papers were drawn were:

a) National Bureau of Economic Research (12),

b) Cass Business School (8),

c) Bank of Canada (6),

d) Georgetown University (5), and

e) Brandeis University (5).

The remaining working papers are disseminated over 49 institutions, which are mostly from Universities and Central Banks. Likewise, the literature reviewed also account for 8 books, 3 PhD dissertations, and 19 chapters and articles.

In the studies reviewed an important focus is on the "heterogeneity" (behaviour, expectations and structure). One key reason for this focus is that "strategy" is a concept embedded throughout the existing research in the topic of exchange rate determination. In other words:

"There is vast literature disputing the validity of the representative agent hypothesis, rejecting it in favour of heterogeneity on the grounds that the former is consistent with observed trading behaviour and the existence of speculative markets" (Moosa and Shamsuddin 2003, p49).

The most valuable studies for this research are those that have analysed the behaviour of the market agents from various different approaches (e.g. types of agents, type of countries, timing, response to fundamental, technical indicators or order flow, etc.). However, the literature typically does not show evidence of studies focusing on the agents as strategists, nor does it directly examine the trading management strategy. This is the research gap that has been identified, and therefore, the focus of this empirical investigation.

This research acknowledges the work of Sarno and Taylor (2001). Particularly in Chapter 3, they discuss the previous literature related to survey data on market participants' expectations. Sarno and Taylor point out that the research strategy used in much of the microstructure literature employs the direct measures of agents' expectations. In other words, the survey method is applied by financial-services companies to unveil the market participants' expectations (ibid. p.11). The research method in this study is therefore supported by previous literature. The research of Sarno and Taylor is also relevant for this study as they review literature on the market makers' behaviour.

The work of Lyons (2001b) has been frequently cited in empirical research. This study also highlights the importance of this work for policy recommendations from MMM. His work has contributed to pinpoint the rationale and justification of this study. Briefly, Lyons addresses the following topics:

a) order flow (the net buyer and seller-initiated orders)
b) data gathering
c) central bank Intervention
d) emerging banking design
e) international currencies reserves
f) transaction tax policy

This study also takes note of the literature review of Vitale (2004). In his work, Vitale compiles an important set of contributions from 17 empirical studies on MMM. Nonetheless, his review did not use a conceptual delimitation. His work simply classifies previous literature by reference, source of data, currencies addressed, and the main statistical results.

In accordance with this study, Osler's (2006) findings show that agents' heterogeneity in trading is fundamental, "As financial economists have long noted, there can be a 'no trade' equilibrium if supply and demand curves are common knowledge and all agents are rational speculators". Her review divided the literature into macroeconomic lessons. In common to this thesis, she focuses on financial and commercial traders (also called noise or liquidity traders). However, this thesis acts as a contrast to her work by presenting findings that show that the financial and non-financial agents have homogeneous trading strategies.

This empirical research follows closely the findings of Fan and Lyons (2003) related to heterogeneity. They investigate more sources of economic heterogeneity (as shown here). Their work comprises the economic behaviour of non-financial corporations, and leveraged and unleveraged financial institutions. Similarly, this thesis also focuses on trading strategy approaches.

The findings of Fan and Lyons show that aggregated customer order flow (10% to 15% of market total) is best approximated by a random walk. They have also found that the aggregate order flow tracks ER at long horizons (e.g. annual). This thesis confirms their findings of heterogeneous behaviour when the customer order flow is disaggregated. Importantly, they found that extreme ER fluctuations are positively correlated with high frequency order flows from financial institutions, and that low frequency trends are correlated with order flows from non-financial corporations. In the same fashion, this thesis contributes by researching the type of financial institutions that generate the highest ER fluctuations, and shows what types of organisations generate the lowest ER fluctuations.

In summary, the works of Lyons (2001b), Vitale (2004), and Osler (2006 and 2009) are useful as a starting point for this literature review. However, the central attributes to divide the literature is distinct from the 'heterogeneity' or 'agents strategy'. In a nutshell, they contribute to this literature review by reporting:

a) The concept of agents' strategy included into the concept of economic heterogeneity.

b) The importance of heterogeneity to explain the ER volatility.

c) Empirical evidence on agents' heterogeneity and the importance of financial agents at high time frequencies.

d) The predictive implications and recommended public policies.

Especially valuable to this research is Evans (2011) who explains the Microstructure in sequential developments. This is particularly useful to doctoral students at whom his book is particularly targeted at. His review divides the field into rational expectations models, sequential trade models, currency-trading models, order flow and macro-economy models, and an order flow with macro-data releases. This study chooses an "order flow with data releases models" because:

a) It combines the micro and macro data in a scheme that is closer to what a practitioner does in reality.

b) The evidence suggests good predictive and forecasting power.

c) It permits the inclusion of time-invariant variables (trading strategies).

Finally, the work of King et al. (2012a) reviews historically the origins of FX MMM, the impact of the concept of order flow, the liquidity provision, the price discovery, and the problems derived from empirical models. It also suggests the potential explanations for ER 'puzzles'. Their research is important for this study, as they review the many efforts that exist to explain the economic heterogeneity of trading strategies from key agents (ibid. p.7). This study analyses trading strategies from:

a) Hedge funds, exporters and importers (King et al. citing Osler 2009)

b) Asset managers (King et al. citing Taylor and Farstrup 2006 and Osler 2012)

c) Retail traders (King et al. citing Heimer and Simon 2011)

d) Dealers (King et al. citing Lyons, 1998; Bjønnes and Rime 2005 and Osler et al. 2012)

Moreover, on their section related to private information, King et al. (2010) report the abundant literature on agents' beliefs and economic heterogeneity. This thesis finds strong support in the research of King et al. by assuming that strategy is another element of the economic heterogeneity.

The next section briefly analyses and discusses stylized facts on ER market structures. Perhaps, the most important concept of MMM is order flow. Therefore, the notion, linkages and main findings related to 'order flow' are explained in the next section. Order flow is also an important strategy content and price discovery variable for the market agents. Therefore, the next section informs the most important controversies and discussions on this topic.

2.2. Stylized Facts on Exchange-Rates' Market Structure

One early study on stylized facts is the work of Dominique et al (1997), who examines the intra-daily market microstructure characteristics and agents' heterogeneity. He covers many market characteristics such as the distribution of the returns of prices, the process of price formation, and the heterogeneous structure of the market. They propose, as research challenges, the definition of risk and efficiency, and the modelling of the learning process. These challenges will be addressed to some extent in this empirical investigation by analysing the learning strategy and the evaluation of certain volatility measures. Their stylized facts are very important for this research because they suggest implications for model building as follows:

a) The FX Market has two prevailing segments, the interbank 'tier' and the retail 'tier' (Evans 2011, Cap 6).

b) Dealers can operate directly or indirectly within the market (Rime 2003 and Evans 2011 Cap 6).

c) Dealers have incomplete information about the market, liquidity and transaction prices (Sager and Taylor 2006; and Evans 2011, Cap 6).

d) The dealers' main constraints are duration and size of their currency holdings. Overnight positions are usually zero (Evans 2011; and King et al. 2012a and 2012b).

e) The dealers' most important source of private information are the customer orders generated through the retail market, therefore, a competitive advantage is to increase the number of customers and to provide worldwide operations (Evans 2011, Cap 6).

f) Customer orders are generated by allocative, speculative and risk-management factors (Evans 2011, Cap 6).

g) Feedback orders are a function of historical prices (Evans 2011, Cap 6).

This section revises mostly the academic sources of stylised facts on the market structure. Contributing to this study is the comprehensive study of Sager and Taylor (2006), and the work of Rime (2003) who both focus on how trading takes place. Essential for this research are the studies of King et al. (2012a and 2012b). They thoroughly summarise the most recent changes of the market structure using a good array of literature sources.

Other important sources included in this section are the BIS surveys showing the most recent statistics, and the work of Barker (2007) who examines innovations on dealing technologies, the mix of market participants, the growing use of automated trading and the costs of the FX market. The above literature review enables the research for this thesis to determine the structure of the FX market, and to include a mix of market and agents, their strategic objectives, their trading management, and their preferred variables for trading.

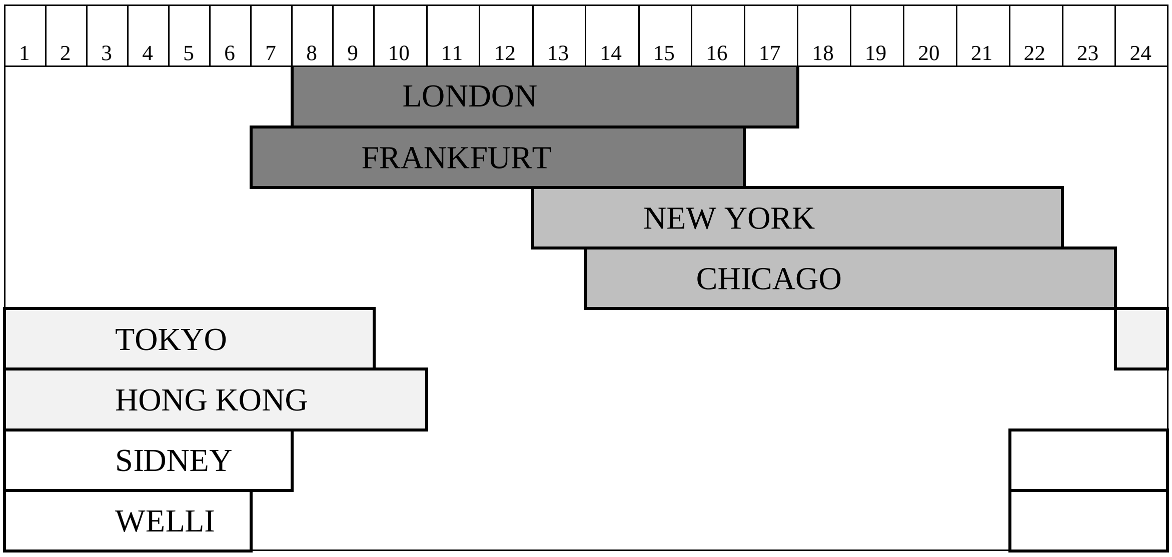
Beginning with the geographic location, the actual structure of the FX market is a result of recent developments in information technologies (IT) and historical events. Important historical events include the establishment of the interbank market and the retail market structure in 1960s, together with the lack of a single physical location.

Traditionally, London has had the major portion of the market (30%), followed by New York (20%), and Asia (Hong Kong, Tokyo, and Singapore). The FX market is an over the counter (OTC) market. This means transactions are conducted directly between two parties, therefore, agents assume the credit risks and the probability of default of the counterparty.

From all the available currencies in the market, just a few currencies dominate in terms of market participation. The U.S. dollar (USD) is by far the anchor currency (or reserve currency) commonly used in international trade. The USD transactions are between 80% and 90% from 2001 to 2007 in the Forex market. From the BIS survey (Triennial Central Bank Survey 2013), the most transacted currencies during 2013, 2010 and 2007 were in the following order: USD, Euro (EUR), yen (JPY), pound sterling (GBP), Swiss Franc (CHF) and Canadian dollar (CAD).

The opening times that are set for the most important markets are key factors for the trading strategies. The most liquid currencies are transacted 5 days a week (from Sunday 10 PM GMT to Friday 10 PM GMT), over 24 hours. The volume of the market is bigger when two or more important financial centres are open at the same time (where there are overlaps). The most important overlapping financial centres are Tokyo and London; London and New York (Chicago is also important); and New York and Sydney. These overlaps are important to enable the research of this thesis to model the ER. Figure 3 shows the opening times (GMT) for the most important financial centres in terms of its transactions volume.

Figure 3. Financial centres opening times (GMT)



2.2.1. Interdealer market or interbank market

Both names (the interdealer and interbank) indicate the same market. As outlined before, the agents are inevitably part of one or two instances or 'tiers'. The first tier includes participants with direct access to the interdealer market. These participants are commonly referred to as the 'big players' (dealers, brokers and big banks), and they trade with each other. The second tier refers to transactions between customers in the market and also the 'big players' who have direct access to the interdealer market. Therefore, the MMM literature usually is divided into studies using the customer order flow data (private dealer datasets with the transactions of its customers), and studies using interdealer transactions datasets (data from the electronic platform, namely EBS and Reuters). This research uses a customer dataset that is specified in the methodology section.

The concept of direct trading refers to transactions between two dealers from different banks; more commonly through Reuters Dealing 2000-1 platform which provides records of the transactions (direct trading can also take place via phone and telex). For further details, Rime (2003) explains a real transaction ticket of a dealer receiving a quote request from the D2000-1. This example shows a spread (0.0002) or two "pips" in the trading slang. This is a key notion as often dealers reduce their quotes on spreads to induce other dealers to trade. Interestingly, sometimes dealers use the system to exchange their views of the market. Some of the key aspects are remarkable:

a) The details of direct trading are just known by the two dealers in the transaction; the Reuters system does not report the transaction to any other party.
b) It is absolutely feasible that two transactions can take place at the same time, and that the exchanges have different transaction prices (e.g. one dealer buys EUR/USD at 1.37148; the other dealer at 1.37145).
c) There are two types of dealers, the initiating dealer and the quoting dealer. Both provide information; the former informs a decision to buy or sell given a quote, and the latter provides information on spreads (bids and asks quotes).

Importantly, the FX indirect trading take place by brokers on Reuters D2000-2 and EBS. The framework operates through limit orders to purchase (or sale) a determined quantity up (or down) to a maximum (or minimum) price. The market operates using orders (either buying or selling) at the best price available. In this framework, the broker matches limit orders with market orders, prioritizing the transactions between the best limit orders and current market orders. Market orders are matched sequentially with the best limit order, and if necessary, it is used for the next best limit order. The broker verifies the credit contract of the counterparties to guarantee the exchange on the settlement date.

Indirect trading through brokers can be a proxy of the market as a whole, with the Reuters and EBS systems providing information on the best market limits and the direction of a trade, but the identity of the counterparties is kept confidential. In contrast, brokers disclose a segment of the entire set of limit orders submitted to the system. Therefore, the dealers’ capacity to drain out the flow of limit orders in the market is limited.

Lyons and Moore (2009) studied the competition between direct and indirect trading. They have found that when transactions are modelled to convey information, that ER prices uncover different information depending on the type of transactions (direct or indirect). They argue that 'missing markets' take place when there is insufficient symmetric information, instead of insufficient transactions.

Dealers can change the composition of their currency holdings by following these three procedures:

a) They can increase or decrease their price quotes to provoke transactions in the direction of their interest.
b) They can induce the trade direction through Reuters D2000-1 by adjusting the quotes to initiating dealers. The success of this strategy depends on the whole set of quotes in the market.
c) Dealers can trade through a broker; however, they will need to compete with the limit orders of other dealers. The closer the limit order to the best limit order (bid or ask), the higher probability to change the composition of their portfolio.

2.2.2. The retail market.

This research also examines the strategy of the market agents without direct access to the market. They are often termed in the literature as ‘customers’ because they need to make the transactions through an agent with direct access to the interbank market. Their strategy is important in the retail market (the market created by a dealer with their customers), because in prior research papers customer order flows have been found to be highly significant to forecast and explain the exchange rates.

Customers comprise a heterogeneous group; they include central banks, corporations, funds, individual speculators, etc. Typically, the customers are the trade initiators and dealers are the ask quotes and bid quote providers. The prices provided by dealers to customers include a profit for the bank (spread). The provided prices are assumed to be indicative of the real price of the market because they are exposed to competition from other bank quotes. Indeed, ‘ask’ and ‘bid’ quotes might have a larger spread than the quotes at the interbank market, but the mid-point is a very good indicative of the market price.

The Reuters FXFX information service provides customers with real-time information on bank prices. This source of data was one of the first to be used by researchers. Other sources such as FX Connect, FXAll, and Currenex has been positioning in the market in the recent years, and has increased the competition among banks by allowing customers to observe the quotes of several banks. The system has shortened the differences between the interdealer market and the retail market to the extent that some banks offer to their customers the possibility to trade directly on the broker systems.

The Electronic Crossing Networks (ECNs) are another type of trading systems. In this framework, ECNs match customer orders at the prices gathered at the interbank market, but in reality the ECNs operate as the counterparty of the trades or market orders. However, ECNs are not representative in their volume; they simply add more competitiveness to the market quotes.

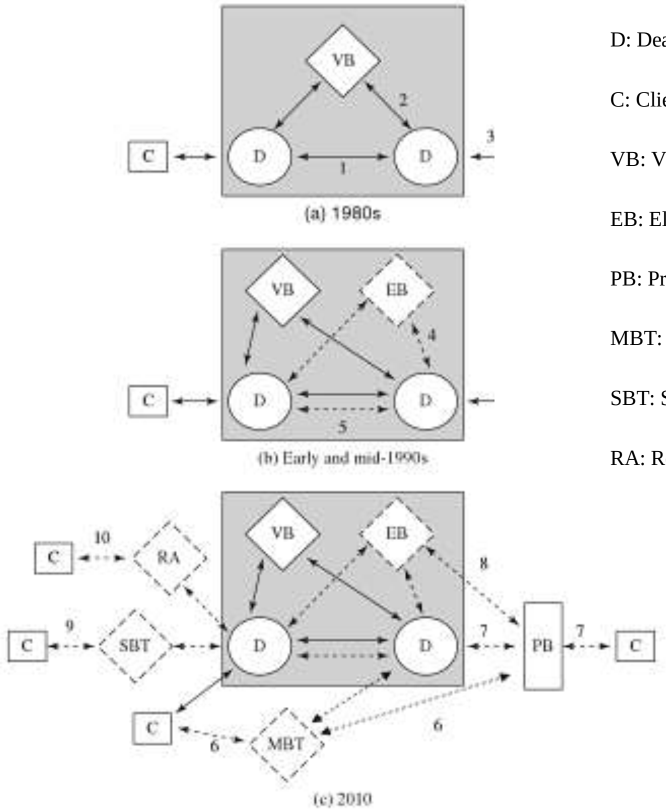
The customer transactions are an important source of information for the dealers. Many large banks share their customers' transactions information with their subsidiaries abroad. The customer demand for currencies provides key insider information for banks, and they exploit it to maximize the profits of their trading strategies. Not surprisingly, this information is highly confidential, and therefore, is hardly accessible for empirical investigations.

The customer orders are categorized by Evans (2011) in terms of their price dependency. Namely, feedback orders are those generated as a response to the market's spot prices (e.g. to stop loss orders and those more complex generated by chart strategies and based on historical prices); and non-feedback orders that are driven by different historical price factors.

To illustrate the market framework, the Figure 4 (King et al. 2012b) presents the structure of the market and the relationships between agents. Moreover, it portrays the transformation of the market structure from the 1980s to 2010. These characteristics and many others can be a subject of further research as a source of time-invariant variables. In the 1980s, electronic platforms replaced the telephone. During the early and mid-1990s, the market participants established new methods to take advantage of the new technologies. In the figure 4, the numbered arrows represent the channels for transactions. Solid lines represent voice transactions (by telephone), and the dotted lines characterise the electronic execution methods.

Figure 4. The Evolution of the FX market structure (King et al. 2012a)

The figure illustrates the evolution of the structure of the market. The quantity of relations and the type of organizations has notably increased since the 1980s. The increased complexity in terms of agents, and the possible convergence of other agents into the FX interdealer market, opens up the necessity to consider the heterogeneity and expectations in terms of strategic approaches, given the objective in the market and the type of agent.



D: Dealer

C: Client

VB: Voice broker

EB: Electronic broker

PB: Prime broker

MBT: Multibank trading system

SBT: Single-bank trading system

RA: Retail aggregator

In the figure above, the interdealer market is drawn with a grey square. This exclusive segment is comprised of dealers, voice dealers and electronic dealers. They trade and offer liquidity to exchange currencies. The remaining traders operate indirectly through an agent with direct access to the interdealer market. In 2010, the type of agents is more diverse. There are individual clients (C); retail aggregators (RA) providing liquidity, spreads, and the internalisation of transactions; single bank trading systems (SBT) or small banks without direct access to the interdealer market; multibank trading systems (MBT) or alliances of small banks to negotiate the currencies within their clients; and prime brokers (PM), which provides a centralized securities clearing facility.

2.2.3. Customer profiling

The recent developments in electronic trading are important for this research because they recognise those new directions and organisational behaviours inside the market structure. Among the most interesting changes are firstly the aggressive behaviour of large banks to internalise trade and to profile their customers. In their role as academics, large banks will categorize their clients, and market orders from different agents increase explanatory and predictive power. This aspect is important to the research in this thesis as it uses control groups to analyse trading strategies.

Interestingly, there is a strand of research that is focusing on the dealers and brokers strategy of the internalisation of customer trades. Internalisation provides the possibility for dealers to hold positions from diverse clients, in order to internally match the opposite market positions. This intermediation activity is supported by a predictive algorithm, i.e. automated reasoning through a set of ordered mathematical or statistical procedures.

Another strategy addressed in the literature is customer profiling or the ability to associate customer trades with subsequent or non-subsequent movements in ER.

Associated with customer profiling, another source of research is the rapid growth in prime brokerage. This phenomenon is close to 30% of the spot transactions in London (Triennial Bank Survey 2013), which is up from 15% in 2008.

Having described the market structure and many important features, the next section discusses and analyses the heterogeneity assumption and its link with the concept of strategy.

2.3. Heterogeneity and strategy

Inspired by Frechette and Weaver (2001), this study in parallel with Moosa and Shamsuddin (2003, p.50-51) shares the same concept of heterogeneity: "… financial economists have been inclined to use the notion of heterogeneity as an alternative to the representative agent model because the former is more consistent with behaviour in speculative markets. Most of the previous studies defined heterogeneity in terms of expectation formation mechanisms or expectation bias, with limited classifications. In this study, heterogeneity is defined with respect to trading strategies, introducing a broader and more comprehensive classification than before" (ibid,p.8). Similarly, this thesis uses as the classification category 'trading strategy', dividing this category into strategic objectives, trading management, and strategy content.

The empirical evidence from the research survey-data is based on exchange rate expectations. This approach commonly assumes 'heterogeneity' shaped through bounded rationality, with most of the time it is dividing the agents between fundamentalists and technical analysts. This research, however, will cover the heterogeneity in terms of objectives which I believe is more imperative and less risky in terms of modelling based on agents' assumptions. The paragraphs below reviews previous research studying 'heterogeneity' in the context of the ER. Afterwards, this study discusses recent literature on economic heterogeneity.

In common with this thesis, the following literature used the survey method to respond to important economic questions. One early effort, which was an analysis conducted on ER expectations by Ito (1990) over bi-weekly data gathered by the Japan Centre for International Finance, finds strong evidence of agents' heterogeneity and a lagged expectation formation. In the same year, Allen and Taylor (1990) researched the predominance of the ER technical analysis in London. Also using the survey method, they came across evidence which is relative to the prevalence in short horizons of the technical analysis. Indeed, the technical analysis was used among 90% of the agents reported in short horizons. At longer periods (1 year or more) pure fundamental analysts were 30% and 85% which affirmed that the fundamentals were more influential. Moreover, supporting Allen and Taylor (1990), Taylor and Allen (1992) also report heterogeneous expectations among chartists. Furthermore, Allen and Taylor find evidence for the chartists' expectations being adaptive, regressive, extrapolative, and with bandwagon prospects. Taylor and Allen (1992) confirm these evidences with a research based on a questionnaire from the Bank of England.

This study uses a different characterisation of the market agents, and in the same fashion it can be shown that Cavaglia et al. (1998) used a survey method based on exchange rate expectations, and they supported the evidence that rejected the rational expectations and the efficient use of available information by market agents. Also, using questionnaires, Menkhoff (1998) characterizes two types of agents; arbitrageurs who have fully rational expectations, and noise traders, who are subject to systematic bias. In addition, Menkhoff also observed that even fundamentalists are apparently subject to some kind of bounded rationality.

Very importantly, for this empirical research, previous literature has found that trading strategies and agents' views are ER determinants. In a much cited work Cheung and Chinn (2001) also evidenced the agents' heterogeneous trading styles, their opinions on other market participants, and their perspectives on the ER determinants. Many works followed the previous efforts which had already been made with the intention of understanding the agents' heterogeneity (e.g. Lui and Mole (1998); Cheung and Chinn (2001); Cheung, Chinn and Marsh (2004); Gehring and Menkhoff (2004);

Menkoff (2001); and Menkhoff and Schmidt (2005)). Importantly, Gehrig and Menkhoff found that dealers believe that currency flows determines the ER. Indeed, Osler (2006) confirms this perspective and evidences the dealers' use of this approach to forecast the ER.

As commented before, the evidence shows that the rational expectations economic models, based on a representative agent, are unsuccessful in empirically explaining the exchange rates. The notion of ER disconnect puzzle is derived from the fact that ER appears to be disconnected from observable news and fundamentals. As a reaction to this puzzle, three approaches to model the ER has surfaced. First, the REDUX framework of dynamic utility optimization of a representative agent (Obstfeld and Rogoff 1995 and 1996) emphasises the microeconomic foundations of the ER determination.

Second, a variety of models highlighting the heterogeneity among agents emerged. They were probably initiated by the work of Frankel and Froot (1987), and refined within the financial asset pricing framework. However, the flaw of this approach is noted on the empirical evaluation which has been modelled mostly through simulation (e.g. Brock and Hommes 1997, 1998; Lux, 1998; Lux and Marchesi, 2000; Chiarella and He, 2002; De Grauwe and Grimaldi 2005 and 2006). Nonetheless, a small number of studies fully examine and estimate the heterogeneous agents' model with switching mechanisms (i.e. Boswijk et al. 2007; De Jong et al. 2009a, b; and Frijns et al. 2010). Exceptionally and remarkably, De Jong et al. (2009a) estimate the GBP during the European Monetary System crisis and the Asian crisis using the commented approach.

Thirdly, the approach chosen in this thesis, and the portfolio shift model explained before (Evans and Lyons 2002a and 2002b), has stressed the importance of the agent heterogeneity, especially in the process of the aggregation of dispersed information which determines the order flow. Interestingly, they also find that the volumes explanatory power is an indication of heterogeneity in terms of different information among agents and/or different information processing.

This empirical research uses the Evans and Lyons modelling approaches presented above. Of course, the contribution to the field is the examination of other sources of heterogeneity (and homogeneity) relative to a) objectives; b) trading management process; and c) information diversity. The latter (public and private information) is one of the most studied sources of heterogeneity in the field, Frankel et al. (1995); Lyons (2001a); Sarno and Taylor (2001); Evans and Lyons (2005c, 2006); Bacchetta and van Wincoop (2006); Evans (2011) have proposed micro models based on private heterogeneous information and order flow as the main indication favouring heterogeneity.

This study continues with a rigorous characterization of the key strategic objectives of the agents and the most important economic assumptions. For example, King et al. (2012a) consider that hedge funds are motivated by profits; they use a costly forecasting system with costly information, and are limited by their individuals risk aversion as in the macro models, but are also influenced by firm risk exposure and funds size. They might be the agents that best correspond to the representative rational investor assumption. In contrast, Osler (2009) depicts the objective of exporters and importers as the simple need for currency as an instrument of exchange. Therefore, they might want to purchase more of a currency when it has depreciated and less if it has appreciated. Their trades are not forecast-based (Goodhart 1988; Bodnar et al. 1998), and they are rational as speculation is avoided given the high cost of controlling and monitoring the risk. The Characterizations above are found in traditional or standard macroeconomic models.

In contrast and outside of the standard macro modelling, Taylor and Farstrup (2006) affirm that international asset managers do not forecast future exchange rates in a traditional fashion, given the correspondence between random walk and ER determination. Osler et al. (2011) pointed out that these asset managers seem to be unresponsive to transaction costs. Unexpectedly, Heimer and Simon (2011) found that retail traders lose money as a group, even though they condition their trades on the ER forecast.

Contrary to standard macro models and the selected model in this thesis, MMM has assigned a lot of attention on the dealers. They profit from liquidity provision and speculative positions. Their risk tolerance is limited by positions and ‘stop losses. They tend to have zero inventories at the end of the day due to the volatility of the market (King et al 2012b, p8). The interdealer trading takes place by direct or indirect limit-orders, within a framework provided by an electronic broker (e.g. EBS or Thomson Reuters in Lyons 1995).

The best bid and ask quotes are provided by the trading platforms. The customer quotes are linked to the interdealer quotes, and the latter are pressured by the dealers’ preference for zero inventories. Accordingly, Ding (2007) has studied the differences between dealer quotes at the inter-dealer market, and customer FX markets with different market structures. He found that customer spreads are wider, rather than inter-dealer spreads, due to a lack of transparency. The discrepancy between customer and interdealer spreads decrease with the increase of order sizes. Mid-quotes tend to be the same in the two markets.

The above agents' heterogeneity in terms of economic objectives is a research gap considered during this study. Specifically, this empirical work examines the main objectives of the market agents. This also comprises a characterization of the behaviour of market agents from both the interbank market and the retail market. In addition, the intrinsic agents' risks are also subject to examination and characterization.

As presented before, many survey researches follow the difficulty of tying the ER to the fundamentals. Together with those documented insights, this research develops a survey to critically analyse the innate strategic objectives, the risk aversion, and the possible main restrictions of:

a) Commercial Banks
b) Investment Banks
c) Security Houses
d) Branches or subsidiaries with a sale desk
e) Market makers
f) Speculative organizations
g) Individual speculators
h) Central banks
i) Governments
j) Mutual
k) Pension and Hedge Funds
l) Currency Funds
m) Money Market Funds

n) Building Societies

o) Leasing Companies

p) Insurance Companies, and

q) Corporations or its financial subsidiaries

This thesis also enquires about the access to the interbank market (direct access or indirect access).

There is also a research gap in the literature consistent with the strategic objectives of market agents. The current literature focuses on what extent the trading organisations are pure 'return profit-orientated', and at what extent they share diverse strategic objectives that might be innate or inherent to certain types of market agents. In other words, this empirical investigation researches the strategic objectives preferences extracted from the literature within a survey sample (i.e. profiting; intermediating; protection against volatility; protection against low or high prices; protection against inflation, and exporting, importing, or the simple need of currencies).

The relevance of researching the central points, as mentioned above, is backed up by the recognized literature related to ER heterogeneity. For this reason, and in addition to the literature previously mentioned, the following section covers the essential references on the relationship between the economic heterogeneity and agents' objectives.

2.3.1. Essential References – Heterogeneity and Agents' Objective

Certainly, an essential reference for the extensive literature covering the Forex microstructure market models is the work of Evans (2010). This work inspired this empirical investigation to study all the Forex agents at high frequency dynamics and the developments in macroeconomics. As shown in this research, Evans' theoretical model of ER determination is based on microstructure and traditional models. Interestingly, he explains how diffused microeconomic information is aggregated and passed on to dealers by means of transaction flows. Moreover, he supplies empirical evidence supporting the existence of the link between macroeconomics and order flow. Following his pioneering and influential research, this research also estimates the price returns based on order flow and macroeconomic variables. His most important findings comprise the following:

a) Developments in macroeconomics account for between 20% and 30% of the variance in excess for price returns. (He studied one and two month horizons.)
b) He showed that the explanatory power is higher than traditional models, including the most recent monetary models with the reaction functions of the central banks.
c) He also makes available a solution to the ER disconnect puzzle or the apparent disconnection between exchange rates and fundamentals.

Another interesting and competing approach to Evans (2010) is the seminal work of Bredon and Vitali (2010). They depart from the analytical framework of Bacchetta and van Wincoop (2006). Using a simple structural model of ER rates determination, they separated the portfolio-balance and the information effects from order flow. In contrast, this study has chosen a different approach as the selected model uses Evans (2010). Indeed the work of Breadon and Vitali estimate the origin of the influence of order flow on exchange rates, which is not precisely the aim in this thesis.

Therefore, this research can be situated among a long list of papers addressing the influential approaches of Martin Evans D.D. The following are relevant for this empirical investigation:

a) Chinn and Moore (2011), following a hybrid microstructure model similar to Evans and Lyons (2006), improve the explanatory power and model stability, particularly, on out-of-sample forecasting.
b) Reitz, Schmidt, and Taylor (2011) find positive evidence of the information aggregation process (applying the model proposed by Evans and Lyons (2002)). They did not find evidence backing up customer order flows as a source of information for speculative strategies.
c) D'Souza (2008) researches the strategy of some market agents (customers and, foreign and local investment businesses). They apply the model of Cao, Evans, and Lyons (2006). However, his work focuses on confirming the dealer liquidity provision assumptions, and pinpoints that customer trades have different qualitative value for the market makers. These latter findings reinforce the justification of this thesis.

The topic of the economic heterogeneous behaviour of the dealers is thoroughly covered and theoretically supported in the paper of Evans (2002). For him, the ER dynamics are based on the FX information structure. Importantly for this research, he finds that:

a) Short-term volatility in ER comes from sampling the heterogeneous trading decisions of dealers. Indeed, this finding supports this research effort to explore the heterogeneous strategic behaviour of the trading agents.
b) Public news lacks any predominance on ER movements over any time horizon.

This thesis studies different types of market agents with direct access or indirect access to the market, financial and non-financial institutions, and the agents by geographical regions. In the same direction, the paper of Gradojevic (2011) studies many customer types. Importantly for comparative reasons, he finds that the direction of causality between the returns of the CAD (Canadian dollar) and order flow depends on the customer type, the time frequency, and the time period.

Similarly and focusing on different types of organisations in the spot market (as in this study), Evans and Lyons (2005) research the topic of macroeconomic news arrivals and their impact over time. They examine the impacts of news on successive trades from hedge funds, mutual funds, and non-financial corporations. They find a connection between news arrivals and the subsequent trading. Such induced trading has lasting effects on prices. Therefore, the Forex market reacts to news with persistent effects.

Even when they do not directly research the strategy heterogeneity as shown here, another very influential effort for this research is found in the paper of Beber, Breedon, and Buraschi (2010). They studied the significance of heterogeneous beliefs within the dynamics of asset prices. Their research is similar to this study in that they created a proxy variable for heterogeneity. Nonetheless, they measured the differences in beliefs rather than a proxy for differences in strategies. The following lists their findings:

a) They have shown that generated proxy has a remarkable effect on the volatility of currency options, greater than the volatility of macroeconomic events.
b) They show that differences in belief influence the shape of the implied volatility, risk-premiums volatility, and future currency returns. This finding reinforces the use of volatility later on in the combined results chapter.

Another study using a proxy for heterogeneity is the work of Wang (2003). He focuses on the foreign currency futures markets of GBP (British Pound), CAD

(Canadian Dollar), DEM (German Mark), JPY (Japanese Yen), and CHF (Swiss Franc). In his research the trading activity is used as a sentiment measure. Importantly he finds that:

a) Speculator (hedger) attitude is positively (negatively) related to future returns.

b) On average, Hedgers are defeated by speculators in the futures markets.

These studies using proxy variables and order flow are highly important for this research to support the research focus, procedures, methodology, and trading agents targeted.

2.3.2. Directly Relevant Literature – Specific Types of Agents and ER

In addition to the aforementioned literature, there is a vast literature related to informed and uninformed trading. This set of literature is directly relevant because information differences are a very important assumption for agents' heterogeneity literature. Different levels of information inspire the hypotheses on heterogeneous strategy in this study. In other words, this study hypothesises that trading strategies depend on the level of information. In this connection, the paragraphs below highlight specific literature and relevant findings related to uninformed and informed trading.

This discussion begins with a paper that has been much commented upon. Ito, Lyons, and Melvin (1998) find evidence on private information in the FX market after the Tokyo lunch hour. Interestingly, they find that after the Tokyo lunch, the variance doubles due to private information (the number of public news did not change). In opposition to this previous evidence, Andersen, Bollerslev and Das (2001) find no apparent alterations outside of the Tokyo lunch period. They attribute the previous misleading results to the breakable finite-sample space inference of standard variance-ratio techniques and a single outlier. This discussion is important because the concept of ‘private information’ is strongly linked to the ‘Political’ one trading strategies examined in this empirical investigation. The concept of ‘public information’ is linked to other trading strategies addressed in this study (i.e. command, planning, incremental, cultural, and enforced choice).

Of course, there are different levels of information. For this reason, the literature also uses the terms ‘superior informed traders’ and ‘inferior informed traders’. These groups are logically related to ‘private’ and ‘public’ information respectively. Important examples of this sort of literature include:

a) Covrig and Melvin (2002), using the JPYUSD, examine the concept of ‘public information’. They term ‘normal periods’ as times when public information has a high correlation with quotes. In the same spirit, Covrig and Melvin (2005) compare two different periods, one with high informed trader clustering, the other without informed trader clustering.
b) Ito and Hashimoto (2006) put their research focus on Tokyo, London and New York market participants.
c) Bjønnes, Rime and Solheim (2005) who specially evidenced that non-financial customers are passive traders.
d) Onur (2008) investigates asymmetric information (in a similar fashion, Payne 2003) for ‘well-informed’ investors and not ‘well informed’ investors.
e) McGroarty, Gwilym, and Thomas (2009) and Stephen Thomas who use order flow and trading volume as a proxy for private information.

Trading strategies might be a response to different levels of information. For this reason, the findings from the literature above (public and private information) are important for this empirical investigation. The literature provides the following findings:

a) Japanese quotes command the remaining market at periods when the informed traders are active. At other periods, quotes go through two-way causality (Covrig and Melvin 2002). The input of Japanese quotes to the JPYUSD price discovery relative to foreign quotes is from 5% to 12% points greater when the informed agents are in action than when agents are not. According to Covrig and Melvin (2005), JPYUSD quotes do adjust three times faster to full-information in the presence of informed traders. Therefore, there is evidence of the importance of private information.

b) Using also JPYUSD, Ito and Hashimoto (2006) find evidence on the U-shape of the intraday performance (transactions and currency changes) for Tokyo and London agents. However, they did not find the same evidence for New York agents. In other words, transactions and price changes do not upsurge towards the end of the New York business times, even on Fridays. Volatility of price returns share a similar U-Shape with intraday activities, and volatility and spreads are negatively correlated. They also find a negative relation between the number of transactions and the size of the bid–ask spread, particularly during opening times from big financial centres. They also find that transactions concentrate at time overlaps from big financial centres. This might be explained by the heterogeneous expectations among agents from other geographical regions.

c) The asymmetric information explains around 60% of average spreads. On the other hand, 40% of all permanent price variation is explained by information related to transactions (Payne 2003). Payne finds strong evidence on time effects in the information carried by trades, which is related to the supply of liquidity. He finds that when liquidity supply is high (low), individual trades generate small (big) permanent effects on quotes.

d) There is a negative (positive) correlation between the aggregated position of non-financial customers (financial customers) and the ER (Bjønnes, Rime and Solheim 2005). Their research shows that alterations in the net position of non-financial customers can be predicted from changes on net positions from financial customers. Therefore, they conclude that non-financial customers have a ‘passive’ role in the market, and their function might be to provide liquidity to the market.

e) Currency demand (Shequel/dollar) is positively (negatively) correlated with well-informed (less well informed) investors Onur (2008).

This literature supports the applied methods in this empirical investigation. These methods are directly relevant to test empirically the levels of information from diverse market agents. This literature is also helpful to set the questionnaire of this study, particularly regarding the questions relative to ‘informed’ and ‘uninformed’ trade. The works presented above used the Tokyo lunch time datasets with detailed information from market participants, diverse trading regions, and order flow as the proxy of private information.

More recently there can be found more directly related literature on the same topic. There is the work of Frommel, Mende, and Menkhoff, (2008) who study the orders flow from banks and customers. There is also Menkhoff and Schmeling (2010a) who research how the information of the market competitors affects the future trading strategies. In addition the research of Menkhoff, Osler, and Schmeling (2010) find evidence that informed trading dominates the limit-order submissions. Finally there is the work of Menkhoff and Schmeling (2010b) who used the six indicators of informed trading to distinguish agents with the greatest price impact.

Also examining the distinctive types of market agents as found in this research, there is Carpenter and Wang (2007) who have studied the identity of market participants as one key element of information and price impact. They pinpoint the following findings:

a) Central banks generate the highest price influence, followed by non-bank financial institutions. Trades by non-financial institutions have the least impact.
b) Dealers with access to the private information show an inclination for direct trading. In other words, dealers tend to decrease their trade transparency. Conversely, indirect trading by mean of brokers generates a lower price influence due to the increased information transparency.
c) The price impact highly depends on organisations with the highest trading volume.
d) Non-bank financial institutions report the greatest tendency for herding practices', followed by interbank dealers.
e) The propensity for herding explains the different price impacts from different market participants (except for central banks).

The work of Frommel, Mende, and Menkhoff (2008) is directly relevant for this thesis as their findings can be compared with the findings of this research. They find that large-sized orders from financial customers and banks are a key factor to explain volatility. Contrary, order flows from commercial customers are less important to explain volatility. In the same way, Menkhoff and Schmeling (2010a) suggest that traders are inclined to fit their orders in the direction of better-informed traders. Therefore, uninformed traders extend the price impact of informed traders. Informed traders integrate their private and publicly available information into currency prices. In this sense, market orders convey more information than limit orders.

This study investigates trading strategies and the link with 'informed' trading. The findings of Menkhoff, Osler, and Schmeling (2010) are directly relevant as they indicate that informed trading is linked to spreads, volatility, momentum and depth. They suggest that limit-order submissions are dominated by informed trading.

Moreover, the findings of Menkhoff, Lukas and Schmeling (2010b) are directly related with a question of this research survey related to the induced trading generated by order flow; they find that more information is conveyed when:

a) There is 'stealth trading'; in other words, when there are medium-sized orders hiding big positions.
b) Large trading volume.
c) Orders come from a financial centre.
d) The orders come from the early trading session.
e) When there are wide spreads.
f) When the order book is thin.

Literature relevant to geographic regions is relevant and common to this thesis. Accordingly, Ding and Hiltrop (2010) and Moore and Payne (2011) study the advantages of dealer information on the interdealer market, for intermediation, and on different geographic regions. Mainly, they use the bid ask spread as a dependent variable.

Importantly Ding and Hiltrop (2010) show the following findings:

a) The EBS lessens spreads importantly.

b) Compared to Reuters, the EBS dominates in the DEM/USD currency.

c) Information advantage brings about wider quotes placement by informed dealers.

d) Geographic differences in liquidity are decreased through the electronic systems. The effects occur immediately and persist in the long-term.

e) They argue that the positive effects of electronic trading tend to dominate, thereby increasing the FX market liquidity.

The findings of Moore and Payne (2011) involve:

a) Dealers that trade habitually, and who direct their efforts to a certain currency pair, are the source of more important market information.

b) Dealers trading in cross-rates are involved in triangular arbitrage and have superior information. Arbitrageurs have the strategic advantage to predict order flows.

c) Well-informed dealers also have larger trading floors.

d) Specialized traders can predict order-flow and omitted variables uncorrelated with order flow.

Finally, this study is directly related to the paper of Phylaktis and Chen (2010). They research the topic of informed traders and information asymmetry in the FX market. They find that the top 10 banks (out of 100) have a monthly average share of over 70%. This share of the market increases to about 80% during US macroeconomic events. The results highly support the private information assumption in the FX market.

2.3.3. Awareness of previous literature on specific types of agents

Several previous papers described below have analysed distinctive exchange rates market agents. It is very important to highlight their findings to bring about thoroughness and research completeness. These researches are also considered to situate the literature contributions of this research. For this reason, this review of literature only presents their main research findings. However, they are not commented upon, given that they are not considered essential or directly related to this research. The following are the most recognised topics and literature.

a) Literature on arbitrage:

Akram, Rime, and Sarno (2008) research arbitrage opportunities in FX, and their specific frequency, price size, duration and economic influence. Moreover, they examined deviations from the covered interest rate parity (CIP), with the following findings:

- Brief violations of CIP (Covered Interest Parity).
- The price size of CIP violations might be economically important.
- The duration of the CIP violations is high enough to permit traders to profit from them, but also short-lived enough to justify why arbitrage has been previously unnoticed at low frequencies.

Akram, Rime, and Sarno (2009) address the topic of one way arbitrage and the strength of the law of one price (LOP). They study the time frequency, price size, and duration of inter-market price differentials for borrowing and lending or 'one-way arbitrage'. They find that the LOP is confirmed in average. However, abundant and economically important violations of the law of one price are identified. The duration is high enough in order to reduce borrowing costs and to gain a profit. The opportunities decay with the increasing volume of the market and surge with volatility.

b) Literature on carry trade:

The MMM literature study the phenomenon of carry trade (benefiting from the interest rates differentials). Brzeszczynski and Melvin (2006) studied the changes in momentum and carry trades of interest differentials. Their findings are the following:

- Fridays have lower activity, and Tuesday's have greater activity than average. Trading is very low before and after London business times.
- At the daily business time for London, the trade activity is higher after a psychological price is broken.

Burnside, Eichenbaum, and Rebelo (2011) research Sharpe ratios and the Forex microstructure markets. This research is interesting for speculators, and it can be a source for future research using trading strategies. The following are the main findings in their study:

- The Sharpe ratio associated with carry trade importantly upsurges even with emerging market currencies.
- Spreads are considerably higher in emerging markets (from two to four times) than in developed countries' currencies.
- If carry trade strategies disregard (uses) bid-ask spreads, they result in negative (positive) Sharpe ratios.
- The yields of the carry trade are fundamentally uncorrelated with returns of the U.S. stock market.

In an interesting work, Christiansen, Ranaldo and Soderlind (2011) address the topic of carry trade performance. They used a model based on asset pricing with factor loadings dependent on ER regimes, instead of constant regimes. They report the following findings:

- The carry trade strategy is riskier in comparison to the stock market. Moreover, during high Forex volatility, the strategy becomes mean reverting.
- The carry trade yields can be explained by a time-varying systematic risk that augments in conditions where the markets are volatile. Partially, this provides an answer to the 'Uncovered Interest Rate parity puzzle'.

c) Central banks

Central banks are examined in this study. One early effort on this MMM literature is the work of Lyons and Rose (1995). They find that Dealers can trade sell orders for a weak currency, and close these positions before the rollover takes place in the afternoon. This is to avoid interest cost. The most important findings of this early work are the following:

- In times of fixed-rate crisis, the tactic commented in the paragraph above is attractive. The tactic protects Dealers against the central bank's interest rate defence.
- On the other hand, buyers from a weak currency are compensated with an intraday profit, when devaluation does not take place. Therefore, it is expected that currencies under attack normally increase its intraday value.

Interestingly, central bank interventions appear to follow sequential stages. In other early work, Peiers (1997) studied the central bank intervention as a trigger for price dominance patterns in FX. Using Granger causality tests to DMKUSD quotes, he shows that the Deutsche Bank intervention dominates as a price guide up to 60 minutes *ex-ante* official Bundesbank release of intervention. The results show that interbank quote adjustments become a two-way Granger-causal. Therefore, Bundesbank intervention actions are exposed in stages: first, the price leader, followed by competitors, and finally all the public.

Interventions by the Bank of Japan are studied by Chang and Taylor (1998) from October 1992 to September 1993. Their main findings comprise:

- JPYUSD volatility significantly changes with different patterns during periods from 1 hour before to 1 hour after the release of the intervention report.
- By means of an ARCH approach, it is demonstrated that intervention has a positive and significant effect on JPYUSD volatility, especially at very high frequencies (5 and 10-minutes). Interventions have the largest impact upon volatility 30 to 45 minutes before the announcement report.

Adding to the researches reviewed above, Fischer and Zurlinden (1999) find that only first interventions on CHF/USD (1984-1994) are crucial; customer transactions and successive interventions lack impact. In the same strand of research, Payne and Vitale (2003) study the SNB interventions (1986 - 1995). Using a dataset with interventions (indicative quotes) and news-wire releases of central bank actions, they confirm that interventions have short run effects on ER returns. Their contributions suggest the following:

- Interventions have greater impact when the SNB moves in the direction of the market prices, and when its actions are accompanied with that of other central banks.
- ER returns change in the 15 minutes intervals before interventions.

Related to the latter paper, Pasquariello (2007) study the effects of official interventions on currency returns before the intervention and after the intervention. He also analysed the market liquidity after interventions to test its effectiveness (CHFUSD from 1996 to 1998). They contribute to the literature by finding that the effectiveness of SNB interventions is linked to their perceived information content, instead of their size, the imperfect substitutability or inventory considerations. Contrary to Payne and Vitale (2003) they suggest that unexpected interventions or interventions against the trend have more important and durable effects on daily returns. The evidence for the SNB suggests that in spite of the intervention effectiveness, SNB interventions induce significant uncertainty, and hence, deteriorate the market liquidity. These generated uncertainties are translated into higher market transaction costs.

Confirming this latter point, Chari (2007) has found evidence on increased volatility and higher spreads, after central bank interventions. He finds that there is a high dispersion of bid–ask spreads placed by individual banks as a result of the reaction to the interventions.

Using a dataset from the Czech National Bank (CNB), Scalia (2008) studied order flow during intervention times (CZKEUR at hourly frequency). In the observed periods, the CNB intervened favouring the price increase of CZK. This research is interesting because it contributes to explaining the CNB order flows impact on the ER. The CNB influence is equivalent to 7.6 basis points per €10 million. The following are further findings on his paper:

- Moreover, there is a persistency effect equal to 80% throughout the day.
- There is an additional effect from intervention news, i.e. they raise order flow influence on price around 3.9 basis points per €10 million.

The most recent paper studying order flow and interventions is Marsh (2011). He studied the order flows during periods of lasting and severe interventions by the

Bank of Japan. He finds limited evidence that corporate customers are net sellers of Yen when an intervention to sell Yen is taken place. Contrary, there is strong evidence on financial customers as net buyers during the same periods. Particularly, they find very strong evidence that the interventions of central banks are a determinant of exchange rates. They indicate that the strong correlation between order flows and ER critically decrease on the days when interventions occurs.

Another identified topic of discussion is the controversy related to the velocity and duration of central bank interventions. In a noteworthy paper, Dominguez's (2003) results suggests that some agents are previously informed on the Fed intervention at least 1 hour *ex-ante* the public announcement. His study indicates that a good timing for interventions is an important factor to obtain largest effects. They suggest that the effects are more important when interventions (Forex trades) take place at times of high trading volume, or when interventions coincide with calendar event releases, or when they are combined with operations from other central banks.

Central bank interventions appear to be an important determinant of trading volume (Chaboud and LeBaron 2001). Using the positive correlation between volume (futures, daily trading), and Forex intervention conducted by the FED (1979 - 1996), they conclude that interventions are an important determinant of trading volume even if the intervention is not publicly reported

Another strand of research focuses on whether 'technical trading rules' can profit in the presence of Central Bank interventions. Interestingly, Neely (2002) suggest that technical analysis can produce high returns before DMK, CHF, and USD interventions. Particularly, for AUD, they suggest that interventions take place before the high returns from technical rules; however, they argue that intervention patterns may not generate the profits, and on the contrary they suggest that is more plausible that intervention responds to ER trends from which trading rules have recently profited.

The estimation of the percentage of secret interventions (non-reported official interventions) is another topic of discussion in the literature. Using news wire reports directed by three important central banks, Beine and Lecourt (2004) find that the proportion of ‘secret’ interventions is lower for collaborative operations. Their findings on secret interventions also suggest the following:

- They show excessive variability over both time and cross-section (i.e. for three major central banks).
- Their analysis suggests that the Bank of Japan not long ago has implemented a secret operations policy.

The latter topic of research is also covered by Gnabo, Laurent, and Lecourt (2009). They particularly studied how transparency (high or low) impacts the ER. Interestingly, they found that a policy on market rumours crucially depends on the content of the speeches provided by the authorities.

Finally, there are other new discussion surges from the paper of Melvin, Menkhoff, and Schmeling (2009). They analysed the application of a crawling ER band on a trading platform. Their most interesting findings suggest the following:

- The limit orders from central banks may coordinate the beliefs of market agents.
- In their sample, intervention increases ER volatility and spread for the following minutes, but overall both decreases at day frequency in comparison with 'normal' days.

- Interbank order flow is lower on intervention days compared to 'normal' days. However, the effect is conditioned to the existence of large reserves and capital control.

d) Dealers

The MMM literature investigates dealers beginning with a paper from Lyons (1995). This research backs up the inventory-control approach and the asymmetric-information approach. Lyons finds that dealers control inventory with their own price. However, dealers also release inventory to the prices generated from other dealers and brokers. Banks objectives, following Ammer and Brunner (1997) are intermediation and volatility products (e.g. options), which generates most of the banks’ earnings. Banks cannot forecast with precision the ER. Therefore, banks’ earnings from trading positions are not that significant. Using data from a particular dealer, Lyons (1998) indicates that the dealer’s profit is on average USD 100,000 per day, and a daily volume around $1 billion. The duration of dealer's positions is 10 min on average. This finding supports the inventory models. It identifies speculative positions over time. However, the intermediation role is much more important.

Using datasets from four interbank dealers, Bjønnes, and Rime (2005) studied the dealer behaviour in the FX spot market (four interbank dealers). Interestingly, Bjønnes, and Rime report the following findings:

- The transaction direction is more important than size; however, they find that the information effect increases with trade size.
- Contrary to Lyons (1995), they find that inventory control is not revealed through dealer quotes. Moreover, they find heterogeneity in terms of trading style from dealers relative to the control their inventories.

Using a specific case (an event study), Carlson and Lo (2006) examine an event related to an increase in German interest rates. They find that the dealers' book of transactions evidences the tendency to target profits immediately in the presence of uncertainty. The speculators' reaction has generated a destabilisation of the market during the following 2 hours.

Another important topic regarding dealers is the impact of the trader's geographic location on price discovery. Relevant for this topic, D'Souza (2008) finds that dealers headquartered in a country whose currency is being traded have superior information. He also proposes the following findings:

- The trades of financial institutions are more informative than non-financial firms.
- Major international financial centres may have a natural advantage.

Danielson and Payne (2011) conducted a comprehensive account of the determination of the electronic FX broking system liquidity. Their review included bid-ask spreads, trading volumes, generation of flow entry rates, and depth variables captured from the limit book. Their primary findings comprise of the following:

- Strong predictability of events related to liquidity supply and demand.
- Low (high) liquidity is linked to liquidity supply (demand).
- During intense periods of trading activity and volatility, the proportion between limit orders and the market order is very high, and the spreads and market depth have a decreasing pattern.
- The transactions from market orders denote higher information than those related to limit orders.

e) Intermediaries

Early research based on Microstructure Markets is focused on ‘intermediaries’ and the linkages with risk, volatility, and transaction costs. Glassman (1987) suggests that market makers estimate the probability of ER variations relying on both short-run and long-run volatility. The long-run by itself is not a complete measure of volatility. Their proxy for trading volume lacks the predictable relation with spread. Transaction costs differ over time and might be responsive to the exchange rate controls.

The comparison between the Reuters spot ER quotes and the futures ER from the Chicago Mercantile Exchange (CME) has been a technique to analyse intermediaries’ strategies. Previous literature finds that quotes from Reuters are inefficient, and can be enhanced by including the information from CME (Martens and Kofman 1998).

Using as a proxy for competition the number of dealers trading in the market, Huang and Masulis (1999) studied the influence of competition on the market spreads (intermediation). They find that bid-ask spreads decline when competition increases, even when the influence of volatility is controlled. The estimated intensity of competition is time-varying, substantially foreseeable, and exhibits a strong seasonal behaviour which is partially influenced by the geographic business activity of the trading day.

Goodhart, Love, Payne, and Rime (2002) examine the fact that USDEUR bid-ask spreads are considerably wider than DEM/USD before the establishment of EUR. They find that large spreads cannot be explicated by any variables in their sample (e.g. volatility, trade intensity). Their findings include the following:

- Spreads have not increased in terms of 'pips'.

- Wider spreads reflect the more marked 'granularity' of quoting in EURUSD rather than DEM/USD.
- The policy of managing quotations at the fifth decimal might increase the market's liquidity.

f) Geographic regions

The topic of order flows effects per geographical regions is researched by Menkhoff and Schmeling (2008).

- There is a permanent price impact when order flow is generated from certain regions (i.e. centres of political and financial decision making).
- Order flows from foreign regions have a short-effect. Contrary, local order flows and information is highly important. Local orders are usually traded by ‘market makers’ and ‘aggressive limit orders’.

Adding to this, the Ranaldo (2009) study has shown why currencies appreciate (depreciate) systematically during foreign (domestic) trading hours. This phenomenon is valid in time and has several ER, and prevails over calendar effects. The following are the most important points of Ranaldo:

- They argue that the phenomenon above is caused primarily due to liquidity and inventory, which are affected by the net tendency of domestic agents to buy the foreign currency, and to operate in their country’s trading hours.
- The pressure on a domestic currency implies a sell-price during domestic working hours.

g) Speculators

The MMM literature on speculators might begin with an early paper on rationalism and speculative economic stabilization and destabilization (Fieleke 1979 and 1981). This early study research shows whether speculation is economically stabilising or destabilising. The main finding of this study is that speculation is conducive to stabilisation and destabilisation depending on the case. Therefore, the rational assumption of household behaviour is not supported by the evidence.

One strand of Market Microstructure literature associates rational speculation and ER volatility (Carlson and Osler (2000). The most remarkable findings of Carlson and Olser comprise the following:

- Informed and rational speculators magnify the effects of interest rate differentials on ER. This, in turn, increases the overall ER volatility.
- There is a structural connection between speculators and volatility. The latter directly affects the ER process, which does not depend on asymmetric information.
- They find that speculation is stabilizing if there are low quantities of speculative actions and destabilizing at elevated intensities of speculation. This is contrary to standard macroeconomic positive theories that states rational speculators must smooth ER.

Using a case of study, Mende and Menkhoff (2006) study the profits and speculation (USDEUR) from a bank in Germany over a four-month period. Their findings include:

- Dealing activity at the bank generates profits; however, customers' speculation does not seem to contribute to their profits.
- Speculative positions are not profitable within a 30 minute horizon.
- Customer trading itself is significant to explain the revenues, not the speculative trading volume or the inventory position.

- The spread analysis shows lack of disposition to speculate.

Another interesting strand of literature focuses on the tendency of speculators to converge at certain prices and times. For example, Moulton (2005) has studied trade-size clustering. He examines investors' trades and exact demand quantities per time. His most relevant findings comprise of the following:

- Customers conduct more odd trades and less round trades; however, the market quantity of trades and the market volume is significantly the same.
- The price influence of order flow increases when customers trade precise quantities.

2.4. Order flow: concept, controversies and discussions

As discussed before, the chosen concept of heterogeneity can also include the agents' objectives, trading strategies, and their decisions based upon economic, financial and other market microstructure variables. As a result of the heterogeneity assumption and the particular elements of the FX market structure, the MMM has been successful in explaining the ER. The MMM approach is perhaps the best framework to analyse the strategy of the market agents. Within MMM, order flow is termed as the initiated net buyer and net seller transactions (net buy and sell transactions over a period of time). In other words, order flow is a measure of net buying or selling pressure or the net temporal demand of a currency. Lyons (1995) provides evidence on how dealers change their quotes based on incoming orders, his results show that $10 million of incoming orders will raise the dealers' quotes by 0.0001 DEM. However, his result cannot be applied to other currencies.

Numerous works confirm the importance of trading flows for explaining the ER dynamics (i.e. Evans 2002, Hau et al. 2002, Payne 2003, Killen et al. 2006, Berger et al.

2008, King et al. 2010, Rime et al. 2010, and Bjønnes et al. 2011). When returns are allowed to depend on order flow, Evans and Lyons (2002a) confirm that there is an explanatory power exceeding 70% in comparison with less than 1% of the interest rate differential.

Order flow is seen in the literature as a communication channel that simplifies aggregation of disseminated relevant information. This information includes agents' heterogeneous interpretations of economic announcements, variations in expectations, and risks to hedging and liquidity demands.

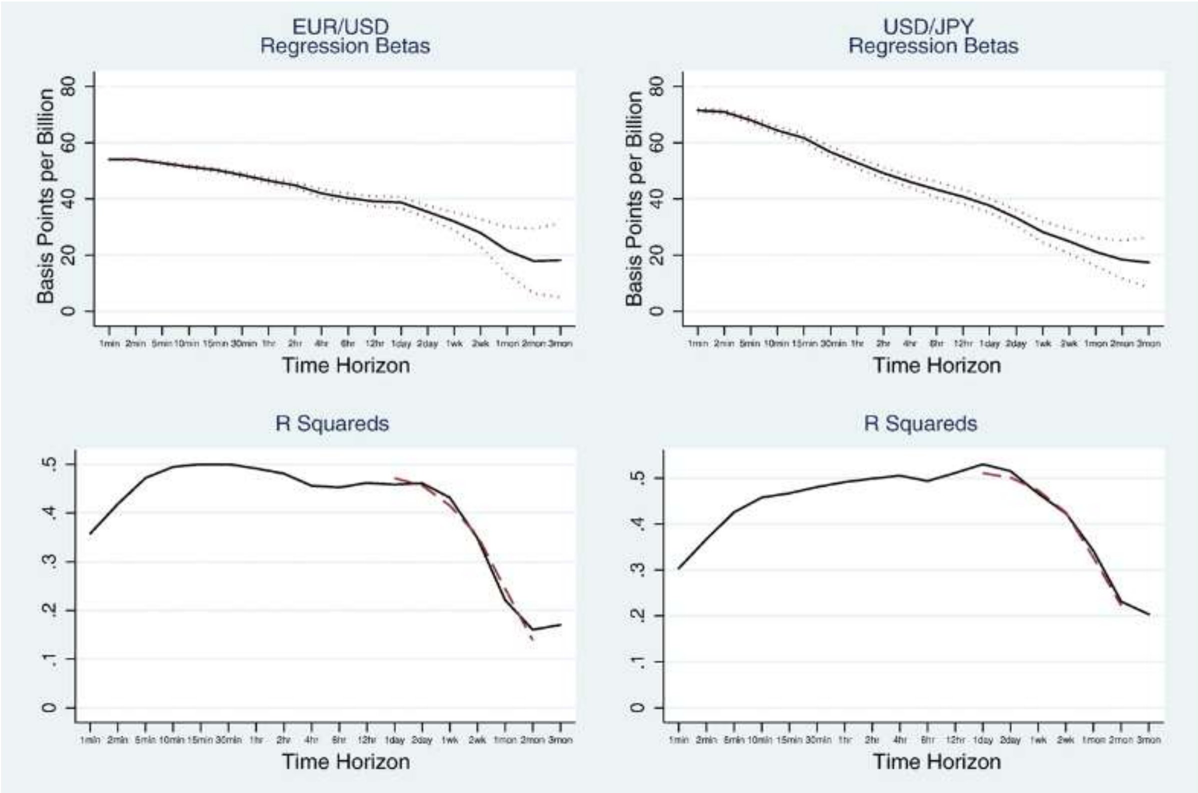
In order to contrast the order flow approach with the traditional macroeconomic models, Osler (2006) suggests that: "…our models should explicitly include currency flows, and it raises the possibility that our models should be built on the equilibrium condition that flow demand equals flow supply".

The evidence also shows a contemporaneous relation between spot changes and order flow in both interdealer and customer flows. Related to ER price returns, the disaggregated customer flows from financial customers generate even greater explanatory power than aggregated order flows from the interbank tier. However, at high time frequencies, disaggregated flows explain a smaller amount of the variation in ER returns than aggregated order flows from the interbank market, but the explanatory power at low frequencies is similar (Cerrato et. al 2011).

The strong relation between spot and order flow across time has been addressed by Chaboud et al. (2008). In the Figure 5, Chaboud et al. confirm a strong causal relation between order flow and ER over time.

Figure 5. Order flow at different time frequencies (Chaboud et al. 2008)

The top panels show the estimated coefficients (the impact on spot prices) at a 95% of confidence. The panels at the bottom describe the correspondent R^2 statistic, the variance explained by the model. Chaboud et al. conclude a strong spot-order flow relation at intraday and daily basis, which weakens at lower time frequencies. Based on the strong supportive evidence on order flow, this study selects the order flow approach as a reference to examine the research questions.



In this order of ideas, this study closely examines the order flow as aggregation mechanism. The information conveyed by order flows includes trading management strategies to process agents' private information, interpretation, expectations, hedging and liquidity shocks. This permits this study to examine the relevance of management strategy, strategic approaches, and strategic variables on the FX market.

The first microstructure perspective of ER determination emphasises the role of order flow in the trading information-structure among FX dealers (i.e. Evans and Lyons, 1999, 2002a). This approach is essential for this research because it divides the agents between dealers (with access to the interbank market), and non-dealers (without access).

Therefore, the approach opens up an opportunity to analyse strategic characteristics of these types of agents, and their respective sub-groups.

This literature review recognizes several discussions and controversies on order flow. Firstly, the discussion on whether order flow conveys information, and its explanatory power to determine diverse ER (e.g., Evans and Lyons 1999, 2002a; Payne 2003; Breedon and Vitale 2010). The empirical results specifically show that the order flow has two channels of transmission:

a) The inventories of FX investors as functions of shifts in expected returns.
b) The information innovations (news), affecting the future market conditions.

These channels of transmission are difficult to observe. Breedon and Vitale (2010) disentangle the liquidity and information effects using a structural model of ER inspired on a working paper prepared in 2003 (i.e. a work published later on by Bachetta and van Wincoop 2006). The procedure has two assumptions:

a) Symmetric information among FX investors.
b) They assume fundamental information is disseminated through order flow and not individual transactions as in Bachetta and van Wincoop.

Their results show that order flows convey primarily agents' portfolio-balance effects (FX agents' inventories) even the in presence of Central Bank interventions. Breedon and Vitale show the evidence of trading strategies given the portfolio-balance innovations conveyed by order flow. In this way, the latter results support this study survey method in measuring the agents' expectations and trading strategies towards different order flows. Methodologically, the results provided by Breedon and Vitale (relative to FX-trader inventories) also encourage this study to use the portfolio shifts model (e.g. Evans and Lyons, 2002a, 2005a).

A second discussion on order flow is the theoretical connections between order flows and other exchange rates variables such as bid-offer spreads, liquidity or volatility (Payne 2003; Moulton, 2005; Breedon and Vitale 2010; Killen et. al. 2006). These types of academic papers are valuable to identify changes in the economic strategy as a result of either market liquidity or volatility.

This study is set on a flexible ER system, where the elasticity of speculation is low and volatility is high due to order flow effects (Killen et al. 2006). Moreover, this empirical investigation will consider the economic strategy under low and high market liquidity, as well as low and high volatility, as according to Payne (2003) order flow is more relevant under high liquidity, and there is higher significance of individual transactions under low liquidity.

A third controversy on order flow is the public features of information, including whether information is published and released at the same time to all markets participants (i.e., Ito and Roley, 1987; Goodhart et al., 1993; Almeida et. al, 1998; Fornari et al., 2002; Andersen et al., 2003; Evans 2002; Evans and Lyons 2002a; Love and Payne 2003). However, this controversy is out of the scope of the research focus. In all cases, even the public and simultaneously released information is conveyed through the order flow mechanism, and not directly to the prices as in the traditional macro-economic models.

Finally, other efforts using order flow cover MMM to test the international financial integration (Evans and Lyons, 2002b). This last strand of literature is reported, but they are out of the scope of this study.

The next section describes the portfolio shifts model, and explains further why this approach has been chosen. The Portfolio Shift model is presented as a mathematical representation of the order flow mechanism.

2.5. Conceptual reference - Portfolio Shifts Model

Apart from the important reasons given above to use order flow in this empirical investigation, the portfolio shifts model (Lyons, 1997 and specifically, Evans and Lyons, 2002a) has been chosen as the primary model framework for this research because:

a) It simply and mathematically represents how the trading activity occurs in the interbank and retail tiers of the market.
b) Its predictive power on the evolution of the spot exchange rate is high.
c) Very importantly, the link between ER dynamics and trading activity permits the study to model the strategic objectives, trading management and economic strategies.
d) The model has been tested in many papers adding other variables. Therefore, it supplies validity and reliability. And it permits an opportunity to attain the proposed research objectives and questions. In the words of King et al. (2012b, p16) "this model (Portfolio Shift) captures so many important aspects of currency markets that it has become the intellectual workhorse of the microstructure field".

The Portfolio Shift (PS) model describes the trading-moments (rounds) that have occurred during a stylized trading day from the diverse types of traders (i.e. dealers, brokers and investors). Briefly, on the first round of the day (in the retail tier of the market), all investors and dealers simultaneously evaluate their current payoff at the FX market and the arrival of public information. Private investors analyse the figures on their profits and the arrival of private information. Private investors decide whether to hedge their portfolios. Meanwhile, dealers place their own quotes (which they are publicly disclosed). Quotes are the two prices at which dealers buy or sell the currency to customers (no matter what the customer order size is). Subsequently, investors place an order (multiple orders at several dealers) and they are written in a dealer's book. Obviously, the dealers implicated in that process can see just what the orders are that are placed to them.

In the second round, brokers and dealers place quotes, this time to trade among themselves at the interbank market (main tier). All dealers and brokers trade with each other. Trading orders have positive (negative) sign when the order is purchase (sell) when initiated by a dealer or broker (or purchases and sales respectively). At the end, the aggregate dealers and brokers order flow is generated. Interdealer order flow aggregates the individual orders of dealers and brokers in this round.

In the third round, the retail market reopens. Customer orders are received and dealers' quotes are defined individually. After investors post their orders, dealers and brokers trade again.

The PS model has two main types of agents (customers and the dealers), and they trade at two different tiers of the market. Further economic heterogeneity can be evidenced by examining how more types of agents manage market information and their expectations upon the generated order flow. This is the innovation and the academic contribution of this research to the theory.

2.5.1. PS Assumptions

a) Investors and dealers are risk-averse and are inclined to maximize expected utility based on their wealth.

b) There is public and private information (heterogeneous information).

c) There are two tiers in the market; these are the interbank tier and the retail tier.

2.5.2. Empirical Approach

The specification of the empirical model of PS follows the daily description in the theoretical model:

$$S_t - S_{t-1} = \lambda(X_t - \mathbb{E}(X_t|CI_t)) + \xi_t \qquad (1)$$

Where:

t: Day (end of the round III in the theoretical model)

S_t: Common and quoted dealers' spot price (measured in foreign currency per USD dollar)

ξ_t: Price impact of common knowledge news

X_t: Aggregate interdealer order flow

$\mathbb{E}(X_t|CI_t)$: Expected interdealer order flow conditioned on dealers' common information (*CI)* at the start of day *t*.

λ : Coefficient that quantifies the impact of order flow and expected order flow on $S_t - S_{t-1}$

The empirical equation model in Evans and Lyons (2002a) has three changes:

1) $S_t - S_{t-1} \equiv lnS_t - lnS_{t-1}$, the quoted prices are substituted by their logarithms.

2) $\mathbb{E}(X_t|CI_t) = 0$

3) $\xi_t \equiv \Delta(R_t - R_t^*) + \zeta_t$, where:

a. R_t : Nominal interest rate per dollar

b. R_t^* : Nominal non-dollar interest rate

c. Therefore, $\mathbf{\Delta}(R_t - R_t^*)$: Nominal interest rate differential

d. ζ_t: Common knowledge news uncorrelated with $\mathbf{\Delta}(R_t - R_t^*)$ and X_t

Then:

$lnS_t - lnS_{t-\mathbf{1}} = \lambda_{\mathbf{1}}X_t + \lambda_{\mathbf{2}}\mathbf{\Delta}(R_t - R_t^*) + \zeta_t$ (2) (Evans and Lyons 2002a)

This research uses the equation (2) using multiple currencies. But contrary to Evans and Lyons (2002b), this study will not use the order flows of other currency pairs in the equation model. The dynamics between currencies are considered by pooling the data and allowing for individual effects. Also, as pointed in the PS model explanation, the dealers quote the spot price based on the customer and dealers order flow in round I and II. This research will analyse and measure the agents' expectations (the non-zero premium) on a market profits given order flow, but also on the given market objective, type of market agent and strategy approach. The equation specification for multiple currencies therefore is the following:

$LnS_t^k - LnS_{t-1}^k = \lambda_{\mathbf{1}}X_t^k + \lambda_{\mathbf{2}}\mathbf{\Delta}(R_t - R_t^k) + \zeta_t^k$ (3)

Where *k* denotes the multiple currencies based dollar.

This study researches the profits expectations given X_t^k and$\mathbf{\Delta}(R_t - R_t^k)$, (Micro and macro models variables respectively) hypothesising that the agent strategic approach plays a role in the process. Also, this empirical investigation follows Evans and Lyons (2009) and Evans' (2010) measure of "real-time estimates of macro variables", that is the updated and estimated value of a macro variable based on current fundamental developments and other information available.

Attributes of real-time estimates are the following:

a) The set of data used to calculate each real estimate is based on common information over a period of time.
b) Even though fundamentals are predominantly released on a quarterly or monthly basis, real estimates vary absorbing the current shocks caused by information (e.g. day by day).

The approach of this study is supported based on the findings of MacDonald et al. (1996), a frequently-cited paper, which addresses the heterogeneous behaviour of the FX traders within the market. Its findings demonstrate that FX forecasters hold heterogeneous expectations. These diverse expectations are caused by the idiosyncratic behavioural characteristics from the types of traders, and by the interpretation of market information. As a result, this research examines this heterogeneous behaviour and hypothesises whether trading strategies translate into meaningful differences to forecast the exchange rates (ER).

2.6. Order Flow Process and Trading Strategy

The following sub-sections cover the market microstructure literature related to the strategic trading process. Adding to the section above, the first section addresses the essential references for this research. They are essential references because they address order flow and public information as a process in which market agents are directly involved. Moreover, they are essential because the aim of this study is related to determine trading management strategies and their explanatory power.

2.6.1. Essential References - Trading Strategies and Order Flow Process

This section on essential references begins with a very interesting work of Carrera (1999), who has researched the market participants and currency attacks. This paper is essential for this research because it studies the agents' strategic behaviour, although the research was narrowed down to currency attacks. Carrera uses an optimization model focusing on several characteristics of the currency attacks: timing, magnitude and probability of success. He finds attack determinants including order flow, inventory management, intra-day price volatility, and the forward intervention-price differential. His work also shows linkages between the currency speculative attacks and the role of central bank reserves.

Extending Carrera's findings to a broader currency context, the greater intensity of public information flow generates unusually high quoting activity and price volatility (Melvin and Yin 2000). Melvin and Yin finds that agents' reactions to information bring about strategies to deal with the ER forecasting. This research expects different reactions to order flow, news announcements, chart indicators and correlated assets from market agents.

These reactions or strategies bring about decisions characterised by a large commitment of resources. Indeed, strategies usually involve one or more versions of functions to estimate the price changes. This is corroborated by the paper of Almeida, Goodhart, and Payne (1998) on ER reactions to public information (they analysed U.S. and Germany). Their dataset comprised high frequency (5 minutes) observations from DEMUSD. Their paper is essential for this thesis, as they show distinctive reactions among traders. Mostly, they found distinctive strategies relative to countries. Other relevant findings from Almeida, Goodhart, and Payne include the following:

a) Significant impact durations of most macroeconomic announcements on the ER change (15 minutes post-announcement). Nonetheless, the significance of these effects declines rapidly when the horizon of the post-event is increased.

b) Moreover, it is evidenced that there are influences of German authorities on the reactions of the ER.
c) Finally, it is corroborated that there are differences between U.S. and German reactions to news in terms of a time pattern.

The evidence above on agents' reactions to news announcements from Almeida, Goodhart, and Payne (1998) and Melvin and Yin (2000) is augmented in a seminal work on order flow conducted by Evans and Lyons (2002) and especially by Evans (2006). He finds that the price influence of order flow varies given the types of interbank market agents. This finding is very important because it generates the question of why order flows from different types of interbank agents have different impacts on the ER prices. To answer this question, researchers have been studying information asymmetry. This empirical research contributes to the field by finding evidence of distinctive trading strategies from market agents. The work conducted by Evans (2006) also finds the following:

a) Order flow from liquidity-motivated agents has ER predictive power.
b) *1/3* of the predictive power (1 month ahead) comes from the order flow's faculty to predict future order flow. These findings arise from interbank agents' heterogeneity, as order flow makes available timely information to market makers on the economy.

Previous research suggests that the speed of orders impact the order submission strategies. Lo and Sapp (2006) use an asymmetric autoregressive conditional duration (ACD) approach to study the impact of order speed over limit and market orders submissions, causing variations in the slope of the limit order book, and changes in price uncertainty (volatility). The work of Lo and Sapp is highly important because it demonstrates the fact that agents act upon the orders from other traders. The survey results of this empirical work are comparable with the findings of Lo and Sapp. Importantly, they found:

a) The previous type of submitted order and the slope of the order book at both sides determine the time difference between arrivals of consecutive orders.
b) The volatility effect is secondary after controlling for the influence of the variations in the slope of the order book. The amount of information enclosed in the submission of orders varies at the opening and closing of the market.

For the reasons above, McGroarty, Gwilym, and Thomas (2009) propose a modified decomposition model adapted to the market characteristics related to order flow. One of the features is price clustering, a new explanatory factor in their research. The concept of price clustering is also supported by the work of Osler (2003). The latter author studied the clustering in the stop-loss and take-profit orders. In this connection she explores explanations for two ‘technical analysis’ predictions:

a) Reverse price direction at support and resistance levels.
b) Trends unusually speed up after prices cross support and resistance levels.

Interestingly, Osler used a proprietary dataset with individual currency stop-loss and take-profit orders. She found that take-profit order clusters are stronger at round numbers, and that stop-loss order clusters are numerous just beyond the round price numbers.

These findings bring the idea that trading strategies are clustered and constrained by the phenomenon of price clustering. In this connection, Liu (2011) examined the hypotheses on price clustering using a proprietary interbank FX dataset. Importantly he finds that:

a) Market uncertainty shows a very important influence on price clustering.
b) Very relevant to the topic of trading strategy in this empirical investigation, that the trading behaviour changes depending on different market conditions. Market times also influence the probability of price clustering.
c) Importantly, they find support for the price resolution hypothesis and the negotiation hypothesis. Contrarily, price clustering in the FX is less explained by the 'attraction' hypothesis.

Related to trading strategies, the concept of price cascades has linkages to 'price clustering'. Price cascades imply that certain prices trigger trading activity and therefore trading strategies. Osler (2006) found evidence that price movements may be explained by stop-loss orders, which speed up and reinforce price movements, termed 'price cascades'. Very importantly, they found that standard structural exchange-rate models are inconsistent with price cascades. The concept of price cascades contributes to the explanation of the 'exchange-rate disconnect' puzzle. Moreover, they found evidence that ER reacts to non-informative order flow.

Order flow is important for the trading management strategy because it has been found to carry information to the market. This aggregation process is presumed to be linked with the agents' trading strategy approaches as they need to explain and forecast the ER. Indeed, with an utilised VAR methodology, Danielsson and Love (2006) have found that at a 1 and 5 minute frequencies feedback that trading causes a significantly larger price. Feedback trading supports the idea of trading strategies related to order flow.

Ding (2009) reports evidence on the intermediation strategy and order flow. Specifically, he has studied the relationship between order sizes and spreads. For this empirical investigation, the profit from intermediation (habitually surrogated by spreads) is a strategic objective, and order flow (the result from the aggregation process) is a strategic variable used to explain and forecast currency prices. Ding finds that the relation between order sizes and spreads are different at the interbank market and at the retail market. Within the interbank market, the spreads are independent of order sizes, and they are correlated with a negative sign with the customer orders.

Of course, the findings of Ding (2009) do not consider the specific trading strategies among intermediaries influenced by order flow. Nonetheless, the order flows from different investor groups have been studied in the work conducted by Dunne, Hau, and Moore (2010). They modelled order flows from the belief variations of the different agents from a dataset comprising of two countries. They calculated the dataset from a daily aggregate order flow for equity trades in the U.S. and France (from 1999 to 2003). Moreover, they found that daily returns in the S&P100 are determined by both ER returns and aggregate order flows at both markets. The model is also carried on for intraday returns. This work is very important because it studied the strategies and expectations given order flow. Also, the work of Dunne, Hau, and Moore is highly influential for this research because it finds a relationship between other markets and exchange rates.

Another strand of literature related to trading strategies is the predictive power of the information content and the determinants of order flow. This research is essential because it puts forward the importance of order flow from a predictive perspective. In this connection, King, Sarno, and Sojli (2010) studied a CADUSD dataset from 1994 to 2005. They find:

a) Within a context of stylized dynamic asset allocation, order flow has a high out-of-sample forecasting power, using market timing to allocate orders and generate economic gains.
b) Order flow is recommended in the literature as a macroeconomic variable, and also, it is determined by 'commodity price' fluctuations.

Mainly, the MMM literature finds that the intraday ER is determined by both economic announcements and order flow (Frommel, Kiss, and Pinter 2011). News impacts in two ways: via direct reactions on ER prices, and also indirectly via order flow. Comparatively, the direct impact of news is ¼, and the indirect impact through order flow is 3/4. Frommel, Kiss, and Pinter find that even when the HUF is pegged to the EUR, the ER denotes similar characteristics described for the most transacted currencies. However, the indirect transmission has more importance than in major currencies. In addition, extending the set of news with statements from central banks considerably improve the explanatory power. Regressions using order flow reduce RMSEs compared to the habitual benchmark random walk (RW) for all ER and frequencies (Danielsson, Luo, and Payne 2012).

The dependence of Forex prices on order flow is evidenced by Danielsson, Luo, and Payne (they use EUR/USD, EUR/GBP, GBP/USD and USD/JPY). In view of the literature reviewed, it is confirmed there is a strong price dependence and order flow explanatory power at different time frequencies.

Lastly, the work of Kitamura (2011) is considered essential because he found that there is a low influence of the order flow when trading becomes more informed. Therefore, competition among informed agents is likely to dominate over the adverse selection problem from uninformed agents. They used the Copula function for the

EUR/USD and JPY/USD currencies in order to measure the state-dependent influence of order flows on returns in the Forex market. They also examined whether this influence is dependent on the number of informed agents. These results are important because it has been found that there is a tendency in the literature to link the level of information of the market agents to the order flows, and therefore, to ER determination. However, this empirical investigation studies, whether apart from information, the way in which market agents deal and learn from information which is a key feature to explain the ER.

To sum up, the works presented above are essential for this empirical research on the trading strategy because:

a) They put forward that reactions from agents to information are important to generate strategies to deal with the forecasting of currency prices.
b) The literature above suggests the involvement of one or more interpretation functions to estimate the price changes.
c) These previous studies demonstrate the fact that agents act upon the orders from other traders.
d) They imply that the order flow aggregation process is presumed to be linked with the agents' trading strategy approaches.
e) They imply that order flows are derived from the strategies of different investor groups.
f) They have probed order flow and information content predictive power to explain and forecast out the sample ER.

g) Apart from the habitual explanation of agents' information levels, this research investigates whether the trading strategies (how the market agents deal with information) is a key feature to explain the ER.

2.6.2. Directly Relevant Literature – Trading Strategies and Order Flow Process

The paragraphs below present the directly relevant literature on the strategic trading process topic. As commented earlier, the empirical findings in the literature are more linked to the agents' levels of information. This section reviews studies on order flow as an aggregating process from different angles related to the trading strategy. Namely, price discovery, heterogeneous customers' orders, informational linkages across countries, environment, news, volatility, limit and stop loss orders, market activity, stock exchange and bond linkages.

The trading strategy is also linked to the price discovery process. There is evidence that there is a dynamic relation between the direct quotes of the JPY/DM and the rate implied by JPY/USD and DM/USD (de Jong, Mahieu, and Schotman 1998). This means that the trading strategy on a certain currency pair affects the quotes of other currencies. In this manner, the price discovery process is presumably linked to the agents' trading strategy process. Effectively, de Jong, Mahieu, and Schotman (1998) use a covariance estimator for irregularly spaced data to deal with practical issues such as computing currencies autocorrelations, cross-correlations, and high frequency data with irregular intervals. They find a lagged adjustment of the cross JPY/DM to fluctuations in the USD indirect rate. Nonetheless, given that the USD rate is particularly 'noisy', a considerable price discovery is brought about by direct trading on the JPY/DM market. Very importantly, the price discovery caused by JPY/DM direct trading occurs mainly during the busiest periods of the day.

The work of Osler, Mende, and Menkhoff (2011) is essential for this research as they focus on price discovery, and the crucial division between customer and interdealer market. They argue that price discovery is not based on the adverse selection problem (i.e. undesired results when dealers and end-users have access to different information) as in standard models. They propose as evidence the fact that spreads are not positively associated to information content. They argue that variation in customers' spreads is explained by three factors: fixed operating costs, market power, and strategic dealing. Osler, Mende, and Menkhoff proposed instead, and have provided preliminary evidence, that the price discovery process is based on liquidity at the two-tier currency markets. Related to strategy, they find that dealers take advantage of their roles as quote providers. Particularly, dealers can offer narrower spreads to informed traders to benefit from private information at a low fee by trading in the interdealer tier.

Other direct relevant literature to 'trading strategies' is those related to market news. There is a strand of literature comparing the quote arrival, as the proxy for trading activity, with market news. Particularly, DeGennaro and Shrieves (1997) studied the influence of market activity and news on the returns volatility for JPY and USD. Specifically, they observe the effects of news *ex-ante*, in course, and *ex-post* news influx, using three categories of news. Interestingly and methodologically relevant to this empirical investigation is that they have isolated the trading activity into a predictable seasonal component and an unexpected component. Interestingly they find:

a) The two components of trading activity and news announcements affect the ER volatility.
b) Private information and news effects are significant determinants of ER volatility.

c) Unexpected quote arrival has a positive influence on ER volatility, and it might be consistent with the assumption that unexpected quote arrival might work as a proxy for informed transactions. This view is strengthened with the regression between trading spreads and the trading unexpected component.

Of course, these findings are relevant because they bring about the question of whether this trading activity (expected and unexpected components) can also be explained by the agents' trading strategy and not just the private information phenomenon.

Another influential paper on the news topic is the work of Evans and Lyons (2002a). They researched the price variation when publicly released information is flowing rapidly. They found that transactions after macroeconomic releases have higher price impact. This is important for trading strategies because the price impact per USD traded is about 10% higher after one hour of news announcements. In the same fashion, Andersen, Bollerslev, Diebold, and Vega (2003) characterise the conditional means of USD using a dataset of six years of ER quotes (tick by tick), macroeconomic expectations, and macroeconomic releases. They find that:

a) Unexpected results on event releases generate conditional mean jumps. Therefore, fundamentals are linked to the ER dynamics at high frequencies. This raises the question; do the unexpected results on event releases trigger the trading activity? And if so, what type of trading strategy is better under these circumstances?
b) Very interestingly and directly affecting the trading strategy is the 'sign effect' which means that there is an asymmetric reaction to news, i.e. that prejudicial news have a greater influence than good economic news.

These latter findings are extended by Andersen, Bollerslev, Diebold, and Vega (2007). They researched the U.S., German and British stock, bond, and Forex markets under the influence of real-time U.S. news releases using a high-frequency futures dataset. Importantly, they propose the following findings:

a) Announcements generate conditional mean jumps; therefore, stock, bond and ER dynamics are connected to fundamentals.
b) Equity markets respond in a different way to news depending on the business cycle. The low correlation between average stock and bond returns is explained by the business cycle.
c) When controlling for the state of the economy, the equity and the Forex markets seem to be similarly responsive to news.
d) It is documented that there is significant contemporaneous relations across all markets and countries, even if the impacts of macroeconomic events are controlled.

This time using the number of news items (Reuters) as a proxy for information arrivals, Chang and Taylor (2003) have studied the information releases and intraday DEM/USD volatility. Importantly for the trading strategy topic, they found that by splitting news into categories, the total headline news is significant (even U.S. and German news). This might lead to the idea of this research that there is a significant relationship between trading strategy as a dependent variable, and market news as the explanatory variable. They also used an ARCH approach (intraday seasonal volatility terms), and found support for the previous findings on a 'two-stage adjustment process of public information arrivals' (Fleming and Remolona 1999). In line with the Fleming and Remolona process, Chang and Taylor's evidence has suggested that trading activity diminishes before economic announcements (illiquidity, high spreads, and low volatility), and it increases after the event release. (Their results indicate persistency of intraday ER volatility generated by public information. This persistency is prolonged 15 minutes due to traders' private information.) More explicitly, Faust et al. (2007) studied macro events comprising 14 years (high frequency and short-times around the macro-releases), and concluded that higher than expected announcement appreciates USD and must either:

a) Decrease the risk premium for the foreign currency instead of USD.

b) Involve net expected USD devaluation over the subsequent decade.

The studies above bring about the question of whether the risk premium is associated or not with trading strategies. This study also focuses on this latter question and provides explanation for the linkages between risk and trading strategies. Another question related to the reviewed literature is whether economic announcements are related to organisational risk? Even though this is not the main objective of this thesis, it has provided an explanation on the linkage between economic risk and organisational risk using a survey approach.

Most of the previous evidences suggest that the trading strategy might be related to customer order flows. Sager and Taylor (2008) research the predictive power of customer order flows to ER prices. In their work, they also provide a review of the recent literature on order flow and ER determination. Moreover, they investigate the empirical value of a commercially available customer order flow data, and the predictive power and attributes of interdealer order flow. Their findings include weak evidence of the forecasting use, and lack of evidence about the practical benefit to market practitioners from commercially accessible data.

There is; however, contrary results in the paper of Cerrato, Sarantis, and Saunders (2011). They find strong evidence on the explanatory and predictive power of the customer order flows. Their paper is essential for this research as they examined the heterogeneity of customer orders flows in ER. They obtained a proprietary and segmented dataset with the customer flows from nine currency pairs. Their findings are important and subject of comparison with the findings of this study, their findings include:

a) Evidence that profit-motivated traders such as leveraged or hedge funds investors and assets managers have a high influence on ER and are more informed. They claim that order flow is the investor's gauge of the macroeconomic conditions of the market.
b) However, they did not find any evidence of predictive power.

The trading strategy may also have a relation with the informational linkages across regions. Following the work of Evan and Lyons (2002), the work of Cai, Howorka, and Wongswan (2008) studied the informational linkages between the EUR/USD and the USD/JPY across five trading regions. They used returns, direction of returns, volatility, trading activity, and order flow as a proxy of information. Their findings show that:

a) Informational relations are statistically significant at single-regions and overlaps.
b) Single-region spill over dominate in economic significance.
c) Order flows' spill over from the European and American regions' and overlaps are the most significant.

Particularly, the findings below bring about the question whether there are trading strategies linkages among regions.

There are also some studies examining two different structures, the spot market (studied in this empirical investigation) and the futures currency markets. This strand of literature is important for the trading strategy analysis because it contributes by comparing these two markets and the relationship among them. Excellent representative examples of this literature constitute the works of Cabrera, Wang, and Yang (2009) and Rosenberg and Traub (2009). These works used futures datasets from the Chicago Mercantile Exchange (CME) and the spot market data. The work of Cabrera, Wang, and Yang found that the spot market consistently leads the price discovery process. (They researched the EURJPY.) Moreover, e-mini futures do not influence any more the price discovery process than other electronically traded futures. On the other hand, Rosenberg and Traub also compared the price discovery between futures and spot markets, but during a spot period of less transparency and greater volume than the futures market. Their research is inspiring for future studies on trading strategy, because they developed a proxy for the order flow measurement from the order flow seen by the CME pit traders. However, their findings are intriguing from the point of view of the trading strategy and generate some questions:

a) Why the foreign currency futures and spot order flow conveys unique information applicable to the ER pattern? Is the trading strategy then different in these markets?
b) They found (in the sample) that the spot market has the foremost information portion. Is there a relationship between trading strategy and information in the spot market? And, is there a different relationship with the information in the futures markets? This empirical investigation studies the former question. The latter question can be analysed in a future research.

The information conveyed in currency futures prices is by far higher than that expected from the relative market size in 1996. However, in 2006, the results are different possibly due to an upsurge in spot market transparency (Rosenberg and Traub 2009).

Additionally, Chen and Gau (2010) also examine the Price discovery competition between spot and futures rates for the EUR/USD and JPY/USD in the context of scheduled macroeconomic events. They use the information shares approach and the weighted common factor component approach for the futures prices from the CME, and the dealer spot prices from the Electronic Broking Services (EBS). They analyse how the spot and the futures respond to news of unexpected outcomes. Compared to the previous evidence they found that the spot rates generate more price discovery than futures overall. However, the influence of the futures to price discovery increases during the period of time that is surrounding the macroeconomic event releases.

The difference in market structure and transparency is also researched in the works of Hau, Killeen, and Moore (2002a and 2002b). They studied the EUR and DM prior to 1999. Against the general expectative, their first work provides evidence indicating that the Euro devaluated against the USD in the spot trading. They pointed out a change in the Forex market structure with the inclusion of the Euro. The market structure changed especially due to the increase of market transparency via currency elimination. Higher market transparency brings about greater inventory risk, because the inventory imbalances are disclosed to other dealers. Therefore, dealers increase the spreads due to higher inventory costs, generating less attractiveness for the Euro as a transaction medium in comparison to DM. In their second paper, Hau, Killeen, and

Moore (2002b) additionally found evidence that higher transparency has inverse relation to the inventory risk sharing efficiency, inducing the increase of the Euro spread and decrease on transaction volume.

The limit and stop loss orders in a spot market are related to ‘take profit’ and ‘cut loses’ respectively. Particularly, Savaser (2011) studied the micro-effects of macro-news and the surge of stop loss and profit placement orders. Very importantly from the point of view of the trading strategy, they found that ‘price-contingent orders’ (limit and stop loss orders) increases from 3 to 5 hours before important calendar events. Meaningfully, their results imply the increased use of stop and limit orders in the trading strategy. This implies that market agents use price-contingent orders to limit the risk in the trading strategy. On the other hand, they also found that price-contingent orders can improve the capability to explain post-announcement ER returns by 50%.

Finally, this thesis is directly related to the research on ‘minors’ (less traded currencies), ‘majors’ (most important and traded currencies), market regimes, and market environment stages (e.g. ‘calm’ and ‘stormy’ in Rime and Tranvag 2012). The evidence shows that these concepts are very important to the trading strategy. One of the most recent studies (Rime and Tranvag 2012) found that on Asian and Australasian currencies, order flow strongly influences all ER. However, the order flow impact is greater on floating regimes, even when the effect is considerable also on fixed regimes.

The effect from order flow is particularly high during stormy periods. By examining a measure of regional order flow, Rime and Tranvag have demonstrated that ER depreciate as order flows move out from Asia and Australasia to U.S., no matter what the ER regimes are. More specifically addressing the trading regimes, Killen, Lyons, and Moore (2006) studied the regime-dependent volatility in the case of

Europe's recent shift to rigidly fixed rates (EMS to EMU). They found that there is more induced volatility under flexible rates due to the shocks from order flow, and the endogenous low elasticity of speculative demand. These results increase the portfolio-balance effects. They found that order flow has lasting effects on the ER before the announcement of EMU parities. As expected, ER after the announcement was detached from order flow.

2.6.3. Awareness on other previous Research and Trading Strategy

This review of the literature also shows awareness of other findings and contributions from a relevant source of literature presented below. This literature is less directly linked with the objectives of this research; however, it is important to document their principal conclusions in terms of thoroughness and research rigour. However, they are not commented on given that they are not considered essential or directly related to this research.

a) A strand of the literature in MMM researches the market transaction costs and the vehicle currencies:

- Black (1991) uses a transactions costs approach in the inter-bank market and a vehicle currency (USD) between 1980 and 1987. The contemporary dependence spreads on volume is estimated from a cross-section time series dataset comprising seven currencies. Related to the trading strategies, their results indicate a slight decline in the attractiveness and usage of USD as vehicle currency.
- Ramadorai (2008) examines a dataset comprising the currency transactions of institutional fund managers. He finds that ‘Funds’ with extraordinary returns on currency holdings have inferior transaction costs on currency trades over the

cross-section (i.e. among funds) and through time. This is in line with the idea that FX dealers bid for specific information from profiting traders. This is also consistent with Forex dealers taking advantage of price inelastic demand for currencies, or funds providing liquidity as secondary providers. Related to the trading strategy, this study is aware of the bid for insider information.

b) Other strand of MMM literature researches the bid-ask spreads.

- This thesis is aware of the findings of Bollerslev and Domowitz (1993) related to intraday spread patterns and concentration of market activity over time (This is an early paper for price clustering). They examine the quote arrivals and spreads for DM/USD taking into account locations, and the type of market agents. Their findings are indeed consistent with theories of trading patterns. In a nutshell, they find trading activity does not have an independent impact on returns volatility, but on bid and ask spreads volatility. The volatility of price returns boosts with the bid-ask spread sizes. Following this up further, Bollerslev and Melvin (1994) positively related the market uncertainty to the spreads (300,000 observations for DM/USD quotes from April 1989 to June 1989).
- Using the spreads increments relative to asset value, Bessembinder (1994) has found that spreads increase when inventory-carrying costs increases. This is related to the objective of intermediation studied in this thesis. He has also found that spreads increase in line with the price risk forecasts and liquidity costs. He suggests that increments in spreads before non-trading periods might be due to inventory costs.

- Demos and Goodhart (1996) studied the relation between the Forex spot and conditional volatility, average spread, and quotations quantity. Similar to the proposed methodology in this research, they use a two-stage least squares method to estimate the transformed variables in a simultaneous equation system structure. They found that the number of quotations is an efficient proxy of the activity in the market.
- Goodhart and Payne (1996) examined the relations between quotations, spreads and transactions in the Forex market. They focus on the determinants of quotes and bid-ask spreads. They find that trades are an important explanatory factor for spreads and quoting, and provide evidence of negative auto-correlation between quote returns and market 'thinness'.
- Another remarkable finding related to quotes that show that at tick frequency, the volume has a negative low and significant coefficient, whereas volatility is positive (Hartmann 1998). This confirms the influence of trading activity on spreads in the long run. Hartmann used a dataset comprising of a short panel with Reuter's quotes and global transaction volumes. In the same fashion, Hartmann (1999) examined the determinants of bid–ask spreads for USD/JPY using a Generalized Method of Moments (GMM). Following the standard spread models and volume theories, he demonstrated that an irregular Forex turnover (as a measure of information arrivals) increases spreads. Contrary, predictable turnover decreases spreads.

c) A strand of the literature in Microstructure Markets researches the spot volatility from a valuable point of view for the trading strategies. This literature is important in terms of research awareness especially for the chapter on Combined Results, where volatility is a topic linked with trading strategies.

- An early paper by Andersen and Bollerslev (1998) characterise the daily Forex volatility and the essential ‘driving forces’ underpinning the volatility process. The model covers the intraday activity patterns, the economic releases, and the volatility persistence (ARCH model) for DM/USD returns. They identified three sets of characteristics of the volatility process related to the trading strategy:
  - Calendar effects. They found that the extreme slowdown in the market activity is conducive to a systematic lack of reliable returns during certain intervals during the day. They decided to eliminate these episodes from the sample.
  - Announcements. They controlled for four different types of economic announcements and calculated the conditional jump together with the daily impact.
  - ARCH effects. They found that the long-memory features appear intrinsic to the return series, even over shorter time spans.
- Mende (2006) studied the relation between Forex trading activity and volatility on USD/EUR at a small German bank during 2001. He finds no persistent effect between volatility and spreads. He also finds a positive correlation between volume and volatility, which is stronger when arrivals of new information are intense and the risk increases.
- The study of Chaboud, Chernenko, and Wright (2008) indicates that spikes in trading volume arise even when calendar economic events fit the market consensus. Contrary to the standard theoretical prediction, the greater *ex ante*

dispersion of the market consensus, the less evidence of volume *ex post* announcements. At ultra-high frequency, they find evidence that spikes in prices take place before a surge in volume after announcements.

- Adding to the contributions above, the research of Cai, Howorka, and Wongswan (2009) focus on the transmission mechanism of volatility and trading activity across trading regions (for EUR/USD and USD/JPY). Interestingly, instead of using indicative quote frequency to measure trading activity, they used regional and overlaps trading volumes. Their findings include:
    - Evidence on volatility spill overs at single regions and overlaps.
    - Own-region spill overs are much more important than overlap spill overs.
- It is important to mention the work of Berger, Chaboud, and Hjalmarsson (2009) because they propose a new measure of volatility based on price sensitivity to information flow. Their research suggests that changes in the agents’ sensitivity to information are as important as the rate of information arrival to explain the persistence of volatility. They supply non-conclusive evidence of changes in the aggregated agents' behaviour linked with volatility. Their model explains the long-run variations in volatility. They argue that, at high frequencies, movements in volatility are dependent on the sensitivity to information and order flows.
- Ranaldo and Soderlind (2010) studied the topic on volatility and liquidity risk premium. They applied a factor approach to estimate linear and non-linear relations between Forex, stock and bond markets. Moreover, they also used proxy variables for volatility and liquidity. They found that CHF and JPY appreciate against the USD when U.S. stock prices diminish and U.S. bond

prices and FX volatility augment. These safe haven characteristics hold at diverse time granularities, even when controlling for the volatility factor and throughout crises (e.g. JPY during the recent financial crisis).

- Fischer and Ranaldo (2011) studied the currency volume at the Federal Open Market Committee (FOMC) days. Their dataset comprised the Continuous Linked Settlement (CLS) Bank. They found that Forex trading volume increases about 5% during the FOMC deliberations.

d) A strand of the literature in Microstructure Markets related to flows, and transitory and permanent shocks. This strand of literature might be important because the shocks could be categorized according to the impact on certain trading strategy.

In this line of research, Froot and Ramadorai (2005) decomposed currency returns into two shocks: permanent (intrinsic-value) and transitory (expected-return). Permanent shocks are diminished by transitory shocks as price returns overemphasize them; permanent shocks are unrelated to flows. On the other hand, transitory shocks have a close relation with flows, whereas permanent shocks are correlated positively with predicted and cumulated-interest rate differentials.

Froot and Ramodarai also find evidence on flows associated to short-term price returns. Long-term price returns are better explained by fundamentals. They argue that the discussion of the apparent exchange rate disconnection from fundamentals (the ER determination puzzle) has ignored the distinction between 'permanent' and ‘transitory’ ER shocks, and this has resulted on disconnection between currencies and fundamentals.

e) A strand of the literature in Microstructure Markets analyses the market liquidity through key situations such as agents’ protecting their capitals in safe heavens’ countries. This strand of research is valuable to analyse the trading strategy over this type of circumstances.

Important for future research, Kaul and Sapp (2006) studied the influence of safe haven flows on Forex liquidity. More precisely, they observed the EUR/USD spot spreads and forward markets close to the Y2K (a concern on the probability of losing data, and therefore investments, due to a failure in data storage in systems just before the year 2000.)

Ex-ante Y2K, the U.S. is believed to be better prepared. Under these circumstances, funds would tend to flow into U.S. assets. At intraday horizons, they found that spot and forward spreads increased a month *ex ante* and a month *ex post* Y2K, given the related uncertainty. They believe the most consistent explanation is that Y2K brought about flows to flight safe heavens affecting dealers' inventories.

f) Literature related to how trading strategies occur amid high interest rates and the ‘forward premium puzzle’ is also related to this study.

For example, Burnside, Eichenbaum, and Rebelo (2009) studied the currency appreciation of high-level interest rate versus low-level interest rate currencies. They find that the market participant’ adverse selection problem might explain the forward premium puzzle. Particularly, they stress in their paper that the market makers adverse selection problem is severer when an agent wants to trade in an opposite direction to the signal of a public release. Therefore, the adverse selection related to a sell order is greater, when based on public news or information, and therefore an appreciation is expected to occur.

2.7. Forecasting and strategy content

The notion of 'Strategic content' refers to the variables used by market agents and researchers to explain and forecast the ER. Of course, order flow is analysed here again, but from the point of view of a proxy variable to forecast and explain the market prices or returns. Apart from order flow, it is also essential to analyse the literature on variables such as, fundamental, non-fundamental news, risk and volatility. Furthermore, the strategy content also is directly related to among others: the concept of asymmetric information, the forecasting performance, and the presence of unit roots.

2.7.1. Essential References – Strategic Content

The strategic content makes reference to the choice of variables from market agents to forecast and/or explain the ER. In the literature reviewed above, these strategic variables are brought about from the market structure, the fundamentals, and the news that the market agents commonly associate to the currency prices. So far, this literature review documented the following variables found in the previous research:

- Currency returns.
- Order flow (e.g. Evans 2010).
- Order flows from customers and dealers (e.g. Osler 2006; Cao, Evans, and Lyons 2006).
- Order flows from Financial and non-Financial Corporations (Fan and Lyons 2003).
- Order flow and trading volume has been used as a proxy for private information.
- Order flow and medium-sized orders (stealth trading); large trading volume; orders coming from a financial centre; orders coming from the early trading session; when there are wide spreads (Menkhoff and Schmeling 2010b).

- Order flows from cross rates (e.g. Moore and Payne 2011).
- Depth of the order book.
- Trading activity represented by number of transactions (e.g. Wang 2003).
- ER Regimes (dummy variable) (Vitale 2004).
- Fundamentals (Evans 2011).
- Geographic locations substituted by dummies for Tokyo, London and New York in the work of Ito and Hashimoto (2006).
- Japanese quotes relative to foreign quotes (Covrig and Melving 2002).
- Financial centre's overlapping periods (e.g. Ito and Hashimoto 2006).
- Technical analysis (e.g. Taylor 1990; Taylor and Allen 1992).
- ER volatility (e.g. Evans 2002).
- Order flow time frequency (Gradojevic 2011).
- Time period (Gradojevic 2011).
- Tokyo lunch, dummy variable. (E.g. Ito, Lyons, and Melvin 1998).
- Normal periods; a proxy is obtained by high contemporaneous correlation between quotes and news (e.g. Covrig and Melvin 2002).
- High and low informed trader clustering periods (e.g. Covrig and Melvin 2005).
- 'Informed trading' linked to spreads, volatility, momentum and depth (Menkhoff, Osler, and Schmeling 2010).
- Bid and ask spreads (e.g. Ding and Hiltrop 2010)
- Brief violations to the covered interest rate parity (CIP) (e.g. Akram, Rime, and Sarno 2008 and 2009).
- Central bank interventions (e.g. Gnabo, Laurent, and Lecourt 2009).
- Periods before and after central banks' interventions (e.g. Marsh 2011).

- Spot quotes and futures quotes (e.g. Huang and Masulis 1999; Cabrera, Wang and Yang 2009).
- Price uncertainty represented by volatility (e.g. Lo and Sapp 2006) and by spreads (Bollerslev and Melvin 1994).
- Limit and stop orders (Savaser 2011).
- Calm and stormy environments (Rime and Tranvag 2012).
- Transitory and permanent shocks (Froot and Ramodarai (2005).
- Public news intensity (quantity) (e.g. Evans and Lyons 2002a).
- Stock and bonds (e.g. Andersen, Bollerslev, Diebold, and Vega 2007).
- Market liquidity, a proxy obtained through key events such as the Y2K concern (Kaul and Sapp 2006).
- Interest rates (e.g. Burnside, Eichenbaum, and Rebelo 2009).
- Macro surprises (i.e. news not typically considered fundamentals. Dominguez and Pathaki 2006).

This empirical investigation has found to be relevant all the literature regarding strategic variables that market agents' can apply to forecast and explain the ER. However, this research specifically considers as essential variables: order flow, fundamentals, technical analysis and correlated assets, because they have evidenced relevancy within the Microstructure Models.

On the other hand, the explanation of statistical characteristics of the ER is one of the most essential features to take into account to forecast or explain the ER. Baillie and Bollerslev (1989) studied the evidence of a unit root in the autoregressive polynomial at the daily ER horizon. Interestingly, they found that the first differences of the logarithms are not correlated in the course of time. They used a generalized autoregressive conditional heteroscedasticity approach with dummies and conditionally distributed errors to offer a better account of the leptokurtosis and time dependent heteroscedasticity. In the six studied currencies, they found that the parameter estimations and the models' attributes are evidenced to have very comparable results. These outcomes remain from weekly to monthly data even when the degree of leptokurtosis and time-dependent heteroscedasticity is decreased with the increment in the length of the sampling interval.

Goodhart and Figliuoli (1991) used a high frequency spot rates dataset (1 minute) from Reuters, and found that the data series presented unit roots, including leptokurtosis (time-varying), and first-order negative correlation, especially, in volatile currencies. Also, Baillie and Bollerslev (1991) applied a seasonal GARCH model to explain the time dependent volatility within the percentage nominal currency returns. Importantly regarding the strategy variables they find that there are hourly patterns in volatility similar across currencies, and they seem to have a link with the market openings and closings. They considered robust LM tests as an approach to handle the excessive leptokurtosis fails. The LM test does not evidence any indication of misspecification or the incidence of volatility spill over effects between the currencies.

To sum up, the literature above addresses the issues that any research model needs to deal with. These ER issues comprise: unit roots, timely patterns in the volatility, heteroscedasticity, and time-varying leptokurtosis. These econometric issues are often addressed in the literature with the use of the General Method of Moments (GMM) (e.g. Banti, Phylaktis, Sarno 2012; Osler, Mende, Menkhoff 2011; Mougou and Aggarwal 2011; Breedon, Rime, and Vitale 2010). This review of literature addressed 27 papers using pooled OLS, Random effects, fixed effects, and the majority using

GMM. As will be discussed in the methodology chapter, this empirical investigation applies a panel second step least squares using the fixed effects in the first step.

Evidently, the literature regarding the forecasting performance is also essential for this empirical investigation, specifically regarding the strategic content. For example, Evans and Lyons (2005a) compared the forecasting models performance from micro-based, standard macro, and random walk approaches. They have found that on the sample the micro-based model consistently outperforms the other models. Micro-based forecasts achieve 16% of the sample variance in a monthly horizon. However, Gradojevic (2007) found that the performance and robustness of the pure microstructure model in the CAD/USD is very sensitive to the choice of time frequency and forecasting horizon.

Moreover from the point of view of forecasting objectives, Boyer and Van Norden (2006) evidenced a stable long-run relation between order flow and exchange rates. Nonetheless, they found fragility of the microstructure approach as just a small number of the major currencies evidenced a stable long-run relation. More specifically, Berger, Chaboud, Chernenko, Howorka, and Wright (2008) supplied more details on the previous evidence regarding the relation between interdealer order flow, and ER returns at horizons ranging from 1 minute to two weeks. They found that the relation is less important at longer horizons. Furthermore, the association is stronger when market liquidity is lower. Thus, the market liquidity effects are a key factor for the association order flow and exchange rate changes. These findings are consistent with the Bacchetta and Van Wincoop (2006) research on heterogeneity that associates liquidity and information shocks.

The fundamentals are the other important variable that addresses the strategic content. Of course, the microstructure markets theory often associate fundamentals to order flow. Importantly, Cao, Evans, and Lyons (2006) studied the information from fundamentals, the information-based trade, and asymmetric information (from the inventory information). They found that the Forex inventory information forecasted discount factors (at a short and long run). The inventory information range effect is 15% to 30% of public information.

In addition to the latter research, Dominguez and Panthaki (2006) studied a set of macro surprises explaining the ER. Particularly, they focused on macro surprises or the type of news that are not typically studied nor habitually considered “fundamentals” in the context of classical models. They found macro surprises’ with highly significant ER explanatory power. This empirical research focuses on survey questions related to the fundamentals. However, the macro surprises would be important to test different type of news that affects the trading strategies directly.

The news and order flow is also studied in the work of Evans and Lyons (2009). They found evidence that macroeconomic news affects currency prices directly and also indirectly by order flow. At daily horizons, previous studies showed that the direct shocks of calendar events influence less than 10% the price variance. They present stronger evidence for more than a 30% effect. This is achieved by considering a broader set of macro news, not just calendar events. They find that the news impact spot prices indirectly via the volatility of the order flow; and order flow has a higher contribution to prices when there are arrivals of macro events than at different times. Order flow conveys two-thirds of the total impact of macroeconomic news on the DM/USD. Moreover, Love and Payne (2008) reported evidence that even common knowledge information is partially transmitted to prices through order flow. Approximately 1/3 of price-relevant information is conveyed via order flow.

Besides the findings presented above, Rime, Sarno, and Sojli (2010) analysed the link between macro and micro models to ER determination by investigating the relations between ER behaviour, order flow and beliefs on macroeconomic releases. Importantly to support the choice of model applied in this empirical investigation, they presented evidences on the following aspects:

a) Order flow denotes agents' heterogeneous beliefs on economic fundamentals. In this connection, order flow is associated to a wide set of actual and expected economic events.
b) Currency markets gradually learn from the economy
c) Order flow has both explanatory and forecasting power. They found that order flow is a potent predictor of daily dynamics in ER (out-of-sample), this is based on criteria such as Sharpe ratios and utility calculations.

In line with the findings above, Frommel, Kiss, and Pinter (2011) oriented their research to a small economy with a currency considered to be 'minor'. Their results on ER, economic releases and order flow point out that the HUF/EUR reacts in a very similar fashion compared to the most transacted currencies in the developed Forex markets.

Finally, there is a strand of literature regarding risk, volatility, and order flow. Importantly and relevant to the risk questions of the survey conducted in this empirical research, Cai, Cheung, Lee and Melvin (2001) studied the USD/JPY volatility of 1998, in order to analyse the risk change and hedge-fund 'herding' on JPY 'carry trade' positions. Particularly, they found that news has a significant impact on risk, and provided evidence that order flow may play a more significant role in explaining market risk.

Other important research addressing the topic of order flow and risk is the work of McGroarty, Gwilym, and Thomas (2006). They researched the microstructure effects of bid-ask spreads and volatility on transaction price series at high frequency data. They used the case of the European Monetary Union (EMU) in the electronic inter-dealer spot market. Their study follows the debate on fallen trading volumes, and higher bid-ask spreads in inter-dealer Forex markets after the European Monetary Union (EMU). Briefly, there are two microstructure effects of spreads and volatility: price and time. The former effect is related to price discreteness and price clustering, with the latter comprising the time elapsed between periods, and the gap connecting consecutive quotes or transactions. Their evidence suggests that the spreads depend on these four microstructure effects. Moreover, they find that:

a) The effect of successive transaction prices is to increase the volatility. The effect of successive bid-ask quotes is to increase the spread.
b) The commented four effects on price and time can explain the observed bid-ask spreads, but they are weak with respect to determining the price volatility.
c) The higher USD/JPY spread appears to be related to the inter-temporal variations in currency prices.

2.7.2. Directly Relevant Literature – Strategic Content

The technical trading or technical analysis is methodology to forecast the ER prices through the study of previous price data. The literature in microstructure markets on technical analysis can be traced back to the work of Curcio et al. (1997). They examined the profitability of technical analysis by simulating trading rules at daily frequency.

Explicitly, they used filter rules recognized and provided by technical analysts. Their findings suggest that some earnings are obtained by technical strategies (specially, during periods of trends). However, on average there are losses. The results are more extreme if the transaction costs are included. They also used previous study rules and offered evidence that the performance is negative in terms of profits in their intra-daily data set.

Following this further, Levin (1997) researched the development of two model approaches in which chartist and fundamentalist asset holders act together and generate ER dynamics in reaction to monetary expansion. In the initial approach, with two groups of asset holders, the dynamic pattern of the model looks like the Dornbusch model, although, only when the model has introduced destabilizing extrapolative expectations through risk-neutral chartists. In the second approach, assuming a homogeneous group of investors and preserving both chartist and fundamentalist expectations, the ER is likely to change with an unstable path, and a speculative bubble is temporarily developed.

Technical rules have been also examined by Osler (2000). She evaluates the widely used support and resistance levels in the technical analysis. Osler examined the ability of these levels to forecast intraday trend interruptions using a dataset comprising support and resistance levels made available to end-users by six FX market firms. Very importantly for the forecasting of the ER, Osler finds strong evidence that the levels of support and resistance are significant to forecast trend interruptions at intraday horizons. Nonetheless, this predictive power varies across the ER and the firms studied.

These results from Osler were confirmed by Neely and Weller (2003). At intraday horizon, they analyse the out-of-sample performance of technical strategies applying a genetic program approach, and an optimized linear forecasting approach. Consistent with Osler, their results show that when controlling for transaction costs and trading hours, there is no indication of excess returns from the trading rules resulting from both methodologies. Nonetheless, these trading rules disclose some stable patterns within the data.

Finally, the work of Austin et al. (2004) provided broader evidence on the profitability of the Forex technical trading systems. They used a bank's proprietary dataset on customer order flow and a customers' limit order book (in the context of the alliance between HSBC Global Markets and Cambridge University). Their dataset includes the customer order flows from 1994 to 1998, at 15 minutes frequency, for the currencies: JPY/USD, GBP/USD, CHF/USD; and at a 1 min frequency for EUR/USD from 1999 to 2002. Particularly, they found consistent profitability out of the sample when order flow, limit orders and technical indicators forecast the ER.

Adding to the latter, Osler and Savaser (2011) have found evidence that the relative importance of the four features of price-contingent trading (i.e. algorithmic strategies, technical trading systems, and dynamic option hedging) is almost equally important. Price-contingent trading explains half of excess kurtosis. Moreover, they suggest that extreme returns in absence of news are statistically unavoidable because of the incidence of price-contingent trading.

These works above on technical analysis are directly relevant to this empirical investigation because they demonstrate to some extent the validity of this type of strategic variables. Also, this source of literature is important, because it studies what the role of technical analysis is within the strategic content. The survey conducted in this research addresses the same issue by asking the market agents the importance of the technical analysis in relation to the trading strategy.

The literature on order flow spillovers was previously analysed. However, other elements concerning strategic variables that were taken into account is the spill overs between the currency and equity markets. As an example of this literature, Francis, Hasan, and Hunter (2006) examined the spill overs between currency and equity markets and economic factors that lead to these markets' interdependency. They find that there is a significant price transmission from the equity market to the currency market. In this connection, this thesis studies other assets that might be correlated with the ER.

Finally, the literature on indicative data and transaction data is important to supply argumentative support to the data source used in this empirical investigation (indicative).

Previous studies such as Danielsson and Payne (2002) compare the characteristics of one week of indicative data (DEM/USD) with contemporaneous, transactions-based data from an electronic FX brokerage. They find that indicative returns are more volatile and auto correlated than broker returns. Moreover, broker spreads and not indicative spreads convey information on market liquidity. Furthermore, differences between indicative and broker spreads are similar at a 5 minutes horizon, but they are indistinguishable at 10 minutes.

Contrary to the results above, and at very high frequencies (tick to 5 minutes), the work of Phylaktis and Chen (2009) compare prices between Reuters EFX and the D2000-1 transaction data using four months of high frequency data for DEM/USD and GBP/USD. They find that there is no qualitative difference when prices are matched tick-by-tick. In other words, they found that the indicative data denotes comparable influence on order flow as transaction data.

2.7.3. Awareness of previous research related to strategic content

This section further recognizes the source of literature related to variables or strategic content. It is important to document the efforts in terms of econometric models (e.g. linear and non-linear), plus specific studies on certain periods of times, and events or crises among others.

One early study on algorithmic trading is the work of Goodhart, Chang, and Payne (1997). They studied the efficiency of transaction-generating algorithms (following up Bollerslev and Domowitz 1993). However, the initial evidence at high frequency denotes poor performance of the tested types of algorithms. Alternatively and specially focusing on non-parametric methods such as neural networks, the works of Gradojevic and Yang (2006); and Gradojevic (2007a and 2007b) generated positive evidence. These works are relevant because they claim that the non-linear models outperform both RW and linear models in out-of-sample forecasts. Particularly for high frequency CAD/USD, in Gradojevic and Yang the criteria applied to assess the model performance is the root mean squared error (RMSE) and prediction of the direction of ER moves. Exceptionally, the artificial neural network (ANN) approach is consistently superior in terms of RMSE to RW and linear models (out-of-sample). Moreover, Gradojevic and Yan found that ANN performs better in terms of percentage of ER predictive direction.

The work of Gradojevic (2007) acquired an optimal daily trading rule by a model of fuzzy decisions on ER. Gradojevic found that combining non-linear, artificial neural networks and ER market microstructure model, together with a fuzzy logic controller, provides a group of more profitable trading strategies than the simple buy-and-hold strategy.

Furthermore, Gradojevic (2007b) examined two abrupt depreciations of the CAD in 1994 and 1998 respectively. Their non-parametric ER model based on fundamentals and order flow explains and predicts the big currency movements. The forecasting power increases with the use of a non-parametric model over a linear one. Additionally, they found that order flow variables have a substantial explanatory power at high frequencies.

Also using non-linear models, Mougoue and Aggarwal (2011) researched the relation between trading volume, volatility, and higher than expected returns volatility. Specifically, they use a dataset from GBP, CAD, and JPY futures contracts denominated in US dollars. They find the following:

a) Trading volumes and return volatility are inversely associated, suggesting absence of consistency for the mixture of distributions hypothesis (MDH).
b) There is a statistically significant lead–lag correlation between trading volumes and return volatility supporting the sequential arrival of information (SAI) hypothesis.
c) ER determination in the short run and medium run may be influenced by trading dynamics and not by macroeconomic events.

The literature on non-parametric methods is somehow relevant for this empirical investigation, because it provides a successful estimation framework to forecast the ER out-of-sample.

In the addition to the literature above, the construction of quantitative measures of crisis might be important for future research on strategy. This sort of work is led by

Melvin and Taylor (2009). Peculiarly and using GMM, they studied the ER dynamics implications from events such as the recent global financial crisis. They catalogued events of major importance in this episode. They constructed a quantitative measure of crises, in order to compare the current crisis to previous events. Moreover, they analysed whether the costly events could have been predicted in order to moderate risk exposures and yield better speculative returns.

Another example of this sort of literature is the research conducted by Banti, Phylaktis and Sarno (2012). From previous research in the US stock market, they constructed an indicator of the global liquidity risk for the Forex market based on the Pastor–Stambaugh liquidity measure. They found evidence on an important common factor in liquidity across currencies. Furthermore, they found that liquidity risk is valuated in across currency returns. The estimation of the liquidity risk premium is around 4.7% annually in their study.

2.8. Hypotheses

The proposed hypotheses are discussed in this section. They have close relation with the research questions. More precisely, the research hypothesis addresses:

a) The aims of diverse categories of agents (e.g. dealers, customers, banks, central banks, commercial banks, speculators, etc.). The Chapter 4 - Survey Results on the sections 4.1.2. to 4.1.4. will cover the analysis and hypotheses relevant to test the heterogeneous or homogeneous economic behaviour related to the agents' objectives. The following are the most important hypotheses related to the Agent's objectives:

	Null hypotheses for Interbank and non-interbank agents (Results in Chapter 4 - Table 21)
1	The medians of the objective 'profiting from investments' are equal. There is agents' homogeneity related to 'profit from investments.

2	The medians of the objective ‘profiting as an intermediary’ are equal. There is agents’ homogeneity related to ‘profiting as an intermediary’.
3	The medians of the objective ‘protect against currency consistent currency volatility’ are equal. There is agents’ homogeneity related to ‘protect against currency consistent currency volatility’.
4	The medians of the objective ‘protect against low or high historical prices’ are equal. There is agents’ homogeneity related to ‘protect against low or high historical prices’.
5	The medians of the objective ‘protect against inflation’ are equal. There is agents’ homogeneity related to ‘protect against inflation’.
6	The medians of the objective ‘imports, exports or the simple need to exchange currencies’ are equal. There is the agents’ homogeneity related to this strategic objective.
7	The medians of the objective ‘hedging purposes’ are equal. There is agents’ homogeneity related to this strategic objective.

	Null hypothesis for 14 types of organisations (Results in Chapter 4 - Table 23)
8	The medians of the objective ‘profiting from investments’ are equal. Market homogeneity related to this strategic objective.
9	The medians of the objective ‘profiting as an intermediary’ are equal. Market homogeneity related to this strategic objective.
10	The medians of the objective ‘protect against currency consistent currency volatility’ are equal. Market homogeneity related to this strategic objective.
11	The medians of the objective ‘protect against low or high historical prices’ are equal. Market homogeneity related to this strategic objective.
12	The medians of the objective ‘protect against inflation’ are equal. Market homogeneity related to this strategic objective.
13	The medians of the objective ‘imports, exports or the simple need to exchange currencies’ are equal. Market homogeneity related to this strategic objective.
14	The medians of the objective ‘hedging purposes’ are equal. Market homogeneity related to this strategic objective.

	Null hypothesis for financial and non-financial organisations (Results in Chapter 4 - Table 26)
15	The medians of the objective ‘profiting from investments’ are equal. There is agents’ homogeneity related to this strategic objective.
16	The medians of the objective ‘profiting as an intermediary’ are equal. There is agents’ homogeneity related to this strategic objective.
17	The medians of the objective ‘protect against currency consistent currency are equal. There is agents’ homogeneity related to this strategic objective.
18	The medians of the objective ‘protect against low or high historical prices’ are equal. There is agents’ homogeneity related to this strategic objective.
19	The medians of the objective ‘protect against inflation’ are equal. There is agents’ homogeneity related to this strategic objective.
20	The medians of the objective ‘imports, exports or the simple need to exchange currencies’ are equal. There is agents’ homogeneity related to this strategic objective.
21	The medians of the objective ‘hedging purposes’ are equal. There is agents’ homogeneity related to this strategic objective.
	Null hypothesis for four trading regions (Results in Chapter 4 - Table 28)
22	The medians of the objective ‘profiting from investments’ are equal. There is agents’ homogeneity related to this strategic objective.
23	The medians of the objective ‘profiting as an intermediary’ are equal. There is agents’ homogeneity related to this strategic objective.
24	The medians of the objective ‘protect against currency consistent currency volatility’ are equal. There is agents’ homogeneity related to this strategic objective.
25	The medians of the objective ‘protect against low or high historical prices’ are equal. There is agents’ homogeneity related to this strategic objective.
26	The medians of the objective ‘protect against inflation’ are equal. There is agents’ homogeneity related to this strategic objective.

27	The medians of the objective ‘imports, exports or the simple need to exchange currencies’ are equal. There is agents’ homogeneity related to this strategic objective.
28	The medians of the objective ‘hedging purposes’ are equal. There is agents’ homogeneity related to this strategic objective.

b) The trading management strategies (i.e. command, planning, incremental, political, cultural, enforced choice). The sections 4.1.5. and 4.1.6. cover the hypotheses related to the trading strategies.

	Null hypothesis
29	The trading strategies explain the agents’ objectives. (Results in Chapter 4 - Table 37)

As trading strategy variables are a central point of this research, Chapter 7 combined results will test these variables using an econometric estimation procedures.

	Null hypothesis
30	The trading strategies explain the exchange rates. (Results in Chapter 4 - Table 38)

c) The strategic content denoted by economic or financial variables (order flow, technical analysis, fundamentals, and other market assets). The sections 4.1.7. And 4.1.8. will cover the hypotheses related to the strategic variables.

	Null hypothesis
29	The strategic content explains the agents’ objectives (Results in Chapter 4 - Table 39).
30	The strategic content explain the trading strategies (Results in Chapter 4 - Table 40)

As reviewed before, the strategic objectives are linked to the concept of agents’ heterogeneity. In the context of microstructure markets, this empirical investigation researches whether there is a presence of objectives’ heterogeneity in the market.

In this context, this empirical investigation tests the assumption of agents with one single objective (i.e. profit in the market). If the results reject this assumption then this research establishes whether it is possible to hypothesise factors of objectives or hierarchical objectives within the ER market.

For this purpose the *7* proposed objectives are extracted from the literature. These objectives are important for future research; they are valuable for policy-making as they describe the essence of the particular strategic objectives from different types of market agents. The proposed strategic objectives comprise of the following:

a) Profit from investments

b) Profit from intermediation

c) Protection against currency volatility

d) Protection against low or high historical prices

e) Protection from inflation

f) The simple need of a currency, exports, imports

g) Hedging

The first step hypothesises whether the agents' pursue different types of strategic objectives (objectives heterogeneity). As a result, this empirical investigation compares the survey responses from different type of groups. The control groups observed and compared are the following:

a) Dealers and customers (microstructure markets).
b) 13 types of Forex organisations.
c) Financial and non-financial market agents (microstructure markets findings).
d) Agents with different degrees of risk tolerance.
e) Geographical regions (i.e. Europe, America, Asia, and Africa).

The Chapter 4, on Survey results, will explain and test the hypotheses related to strategy.

CHAPTER 3. SURVEY METHOD AND DATA ANALYSIS

This chapter is divided into two parts. The first part explains the logistic regression and statistics tests applied in the next chapter. The second part examines the survey method and related quantitative methods including the pilot test.

The survey was conducted by means of an on-line questionnaire on a dedicated web page. The data collected were stored in a database. Probabilistic sampling was applied in order to obtain universal conclusions. The survey participants included:

a) individual speculators,

b) members of mutual funds,

c) hedge funds,

d) central banks,

e) commercial banks, and

f) governments from different cultures and countries.

A pilot test is carried out in order to refine the method accuracy in terms of reliability and validity. The findings of the survey form an important input for the later econometric analysis of foreign exchange determination. These findings will be presented in Chapter 5.

3.1. Logistic regression

The majority of the variables of interest within the survey are ordinal. In other works, in this study the values are ranked using Likert or Likert-type scales (e.g. strongly agree to strongly disagree), but the real distance between categories remain unknown. This thesis uses ordered logistic regression as many problems arise from using ranked variables within the traditional multiple linear regressions.

In ordinal logistic regression the events of interests are observed using particular scores. The ranked dependent variable is modeled using the following odds:

θ_1: The probability that score equals 1 divided by the probability that the score is greater than 1.

θ_2: The probability that score equals 1 or 2 divided by the probability that the score is greater than 2.

θ_3: The probability that score equals 1, 2 or 3 divided by the probability that the score is greater than 3.

Following the definition of *θ,* the odds associated to the last category equals 1.

Originally the Logit model is specified as:

$$P_i = E(Y = 1 \mid X_i) = 1/(1 + e)^{-(\beta_0 + \beta_1 X_i)} \qquad \textbf{1)}$$

The right hand side expression is non-negative and has non-negative derivative. From the equation above $0 \leq P_i \leq 1$.

The equation 1 can be transformed to the following specification:

$$Ln\left(\frac{P_i}{1-P_i}\right) = Z_i = \beta_0 + \beta_1 X_i \qquad \textbf{2)}$$

The general logit regression model is derived from equation 2) as follows:

$$Ln\left(\frac{P_i}{1-P_i}\right) = X'\beta + \varepsilon_i \qquad \textbf{3)}$$

The method of maximum likelihood is commonly used to estimate the unknown parameters in equation 3.

When the sample is large, the normality approximate assumption can be imposed on the error term ε_i as follows:

$$\varepsilon_i \sim N(0,\ 1/(n_i P_i (1 - P_i)) \qquad \textbf{4)}$$

The following conditions must be satisfied when the dependent variable is not dichotomous:

a) Values of X increase gradually, and Y is an increasing function of X.
b) Y is bounded. $a \leq Y \leq$ b
c) Numerical values have a limit $\lim_{X \to \infty} Y(X) = a$, $\lim_{X \to \infty} Y(X) = b$

Following equation 3, the generalization of the Logit Model can be stated as follows:

$$Ln\left(\frac{Y_i - a}{b - Y_i}\right) = X'\beta + \varepsilon_i, i = 1,2, \dots, n \qquad \textbf{5)}$$

The post-estimation tests include the LR chi2 statistic. This statistic tests whether the coefficients in the regression model are different from 0.

Using two approaches, this study will test the proportional odds assumption or the parallel regression assumption. The first test performs a likelihood ratio test. The null hypothesis states that there is no difference in the coefficients between models. In this connection it is expected to obtain a non-significant result. Second, it is applied the Brant test. As in the first case, it is expected that this test is non-significant, so it is not violated the proportional odds assumption.

3.2. Wilcoxon-Mann-Whitney rank test

This is a non-parametric test; its null hypothesis is that two samples have equal values. The test involves the calculation of the *U* statistic, whose distribution under the null hypothesis is normal for samples higher than 20.

The assumptions of this test include the following:

a) Both groups are independent of each other.
b) The data is ordinal.

c) The distributions of both populations are equal; this implies $P(X > Y) = P(Y > X)$, the probability of population X exceeding an observation from population Y equals the probability of Y exceeding X.

3.3. Kruskal-Wallis rank test

This is a non-parametric test and a generalisation of the Wilcoxon-Mann-Whitney test. It allows comparing several samples that are independent. The test statistic is given by:

$$K = \frac{12}{N(N+1)} \sum_{i=1}^{g} n_i(\bar{r}_{i.} - (N+1)/2)^{2} \quad \textbf{6)}$$

n_i: the number of observations for group *i*.

$\bar{r}_{i.}$*:* is the rank of observation *j* from group *i*.

N: Total number of observations.

The assumptions of the test include:

a) The samples are drawn from a random population.

b) The samples of each group are independent.

c) The measurement is at least Ordinal.

3.4. Survey method

As discussed in the literature review, a survey approach is not widely used in economic empirical investigations. Exceptionally, the MMM assumptions are based on observed interactions from market agents and surveys. Contrary to traditional economic models, MMM assumptions include characteristics related to transactions, which were initially gathered by questionnaires. Following previous literature, this study employs direct expectations measures from survey participants. This study applies the survey method, in line with similar efforts conducted by financial-services companies (e.g. Takagi, 1991 and Frankel and Rose, 1995).

The data analysis was conducted using STATA 12. The type of survey conducted in this research is cross-sectional. The data is gathered on the internet by means of an online survey.

The population of this research is divided in two groups. The first group comprises agents with access to the interbank market. The second group comprises agents without access to the interbank market. Statistically, populations tend to the infinite because the number cannot be estimated and is large.

This chapter also groups the survey responses into financial and non-financial institutions. Other grouping alternative is to classify the responses per trading regions (i.e. America, Europe, Asia, and Africa).

In the following paragraphs, this chapter presents the descriptive statistics for all the variables, frequencies, and causal relationships within the variables. Additionally, the Shapiro-Wilk test for data normality is calculated.

Secondly, this chapter reports the tests for validity and reliability. The particular method to compute the reliability is the measure of internal consistency Cronbach's alpha. The survey validity is analysed and evaluated by means of the consistency with the literature and Discriminant Factor Analysis. This latter technique also helps to reduce the number of items in the scales of measurement.

3.5. Sample Size.

The traders of FX are a population of unknown quantity. For example, the potential reach of Facebook profiles related to the FX market is superior to 1,240,000 just for United States, Canada, the UK and Australia. The sample size varies given the type of method applied.

First, Principal Component Analysis (PCA) and Ordered Logistic Regressions are performed on diverse constructs of the survey. In the cases, the power of the statistical test cannot be performed. However, there are many studies suggesting diverse ranges of sample size to perform factor analysis and principal component analysis. The absolute minimum number of cases suggested is presented below.

Table 1. Principal Component Analysis and Exploratory Factor Analysis sample size (amended from Nathan Zhao 2009)

Minimum number of cases	Published research
100	Gorsuch(1983); Kline(1979 p.40); and Arrindell and van der Ende (1985 p.166)
51 more cases than the number of variables to support chi-square testing.	Lawley and Maxwell (1971)
5 times the number of variables or 100	Hatcher (1994)
More than 100 when communalities are low or few variables load in each factor	Garson (2008)
Between 150 and 300. Towards 150 when there are few highly correlated variables.	Hutcheson and Sofroniou (1999)
200	Guilford (1954 p.533)
250	Cattell (1978)
300	Norubis (2005); Rouquette and Falissard (2011)
100: poor ; 200: fair ; 300: good; 500: very good; 1,000 or more: excellent	Comrey and Lee (1992)

This research chooses an acceptable sample size of 250 accordingly with many authors in the Table 1. A sample of 50 questionnaires was established for the pilot survey following Sanders (2010).

An alternative sampling method, the subjects-to-variables (STV) ratio is used in other researches. The STV approach to sample size has also several suggestions for sample size. These suggestions range from 2:1 (two subjects per variable) to 20:1 (twenty subjects per variable) for a sample to be accepted.

This thesis calculates the Wilcoxon-Mann-Whitney tests (two groups). The sample size (using the software G*power 3.1.7) for two groups (agents with direct and agents with indirect access to the interbank market) is presented in the Table 2.

Table 2. Sample size for the Wilcoxon-Mann-Whitney tests (two groups)

Test Family:
t-test, Wilcoxon-Mann-Whitney test (two groups)
Type of Analisys:
sensitivity, required effect size, given alpha, power and sample size

Alpha error probability:	0.05
Power:	0.8
Sample size group 1:	113
Sample size group 2:	102
Noncentreally parameter:	2.4937
Critical t:	1.6513
Df:	233.77
Effect size d:	0.3252

The sample test is one-tailed, as the difference among samples is in one direction. In other words, the test shows whether the mean of sample A is higher than the mean of sample B. The computed effect size (i.e. the smallest difference between two groups considered to be empirically relevant; and a measure of the strength of a phenomenon), is *0.32*. Following Cohen (1988), the sample size above has a small to medium effect size (Cohen considers *0.2* a small effect size and *0.5 a* medium effect size, the smallest the more sample strength). The acceptance level (alpha) is the traditional 5% and the statistical power is *0.8* or a *20%* chance to accept the null hypothesis in error.

In the same fashion, the same sample size parameters were computed for non-financial and financial institutions. The effect size is *0.3328*, which is a very good indicator of the strength of the sample.

3.6. Polychoric principal component analysis

Principal Component Analysis is the quantitative method of choice as the questionnaire items are not defined in a nominal dimensionality but in an intrinsic dimensionality. This means that the observations are in a multidimensional space. Multidimensionality is a key issue in this study as it permits to assess whether the variables measure diverse notions. For example, this study will test whether the strategic objectives can be aggregated in a single variable. If so, the results would be in line with the traditional economic theories assuming a single strategic objective. If not, it would generate further and significant evidence on agents' heterogeneity related to strategic objectives. The same applies to other variables.

The procedure finds the space that "best" fit the observations to compress the variable in determined items and space, reducing the dimensionality.

The PCA has the following assumptions:

a) There are not combined items.
b) The components are aggregates of variables or items.
c) The PCA estimation extracts the highest amount of variance with the least number of factors.

The polychoric correlation is applied in a PCA environment, as they are more suitable for Likert scale and Likert-type items, and ordinal and skewed data (Kolenikov and Angeles, 2004). The polychoric correlation replaces the traditional matrix of Pearson's *r* (Muthen and Kaplan 1985; Gilley and Uhlig 1993). Items are assumed as a 'trait' continuously distributed within the population. All raters diagnose the level of each variable relative to some threshold. If the judged importance is above the threshold a positive result is chosen; otherwise it is negative.

In this connection, the method establishes iteratively the estimates of the true population values for the location of the thresholds, and the amplitude of the joint distribution of the variable (*rho*), which is also the correlation between the items before application of raters thresholds. In other words, the model estimates the thresholds and maximises similarities between model-expected and cross-classification proportions. The assumptions of the model comprise:

a) The trait's ratings are continuous.
b) The latent trait is normally distributed.
c) Rating errors are normally distributed.
d) The error variance is homogeneous across levels of latent traits.
e) Errors are independent between raters.
f) Errors are independent across cases.

As Kolenikov and Angeles (2004, p.34) point out, the gain of using polychoric correlations is to obtain consistent estimates of the explained proportions and better variable weights. In spite of this, the results by the polychoric matrix were compared with the Pearson's' *r* matrix, and it was re-evidenced similar final results on items loadings.

The PCA tests include:

a) The Kaiser-Meyer-Olkin (KMO) measure of sample adequacy that indicates the similarity among items.
b) The squared multiple correlations (SMC) that indicates how far items are related.
c) The Horn's Parallel Analysis (Horn 1965) for the determination of factors.

3.7. Pilot Survey

This section covers the initial results for a group of 50 targeted respondents, this number is appropriate following the work of Hertzog (2008), who determines the sample size for the pilot from 10 to 40. The purpose of this pilot survey is to refine the accuracy of the survey (style, content and response time). The pilot survey also acts as a trial version of the questionnaire to verify if the questions are valid and reliable. The initial questionnaire had 70 items, and the final version 52 items. The total reduction of items is 25.71%.

Previously, 39 out of 89 responses were dropped due to the lack of completeness, the use of a same IP address, or lack of qualification. This procedure has support in Sanders (2003), who suggest control questions to decrease the risk of low reliability. The rate of respondents’ withdrawal was high (37%), this means that 33 out of 89 survey participants withdraw the survey; and therefore, the decision was to refine the questionnaire in terms of conciseness. For the pilot survey were reached 60,100 Forex traders and therefore the response rate was 0.083%

The respondents provided comments on the questionnaire. They highlighted the following issues:

a) The length and response time
b) The complexity and ambiguity of some words
c) The validity of the variables measuring the strategy
d) The inconvenient number of options for some questions

These comments were considered for the final version of the questionnaire. More details of these modifications are discussed within each section related to the variables. The pilot survey can be accessed on https://www.surveymonkey.com/s/FXDecision. The final version is available on the link: https://www.surveymonkey.com/s/FXDecision-En. The survey pilot is presented below. Alternatively, these instruments can be also found with a different format to the original at the end of this chapter on the Appendix - Chapter 3.

3.8. Data and variables analysis

This section reports the survey variables, the type of measure, the level of measurement, and the preliminary reliability and validity.

The initial five questions (gender, age, market objective, headquarters' country and agent type) are considered demographic; these questions can generate control groups.

Predominantly, the research survey is built on 'Likert scales' and 'Likert-type scales' from 1 to 7. Following Boone and Boone (2012), this study is set to analyse the Likert scales at the interval level of measure, and the Likert-type items at the 'ordinal level of measure'.

The suggested descriptive statistics of Boone and Boone are presented in the Table 3. However, this empirical investigation disregards some statistical assumptions relative to the ordinal and interval measures when the chances of erroneous conclusions are highly low or null (i.e. robustness when an assumption is violated) (Norman 2010).

Namely, the use of t-tests and ANOVA (Parametric tests) when the data lacks of normal distribution (Pearson 1931; Boneau 1960); the employment of Pearson correlations and ANOVA even when the data are ordinal and non-normal (Havlicek and Peterson 1976 and Norman 2010); and the use of an intra-class correlation instead of Kappa or weighted Kappa even if the data is ordinal (Fleiss and Cohen 1973).

Table 3. Suggested Data Analysis Procedures (Source: Boone and Boone 2012)

	Likert-Type Data	Likert Scale Data
Central Tendency	Median or mode	Mean
Variability	Frequencies	Standard deviation
Associations	Kendall tau B or C	Pearson's r
Other statistics	Chi square	ANOVA, t-test, regression

3.8.1. Dropped Variables

The pilot survey reports respondents' portions are 3.79% females and 96.21% males. Further research may examine females are not active participants in the FX market, and how far risk tolerance is different between males and females. This study aims to obtain responses at the organisational level; as a result, this study suspends the data gathering on this variable. This variable could be a source of future research for a study analysing the low participation of women on the Forex market.

For the same reason applies for the variable 'age' (this variable is more relevant for individuals than for organisations). Therefore, the data gathering on this item is suspended to give priority to the research focus.

3.8.2. Market agents' objectives (items *i3* to *i9*)

Variable to measure: strategic objectives

Items: *i3:* Profit from investments
i4: Profit as an intermediary
i5: Protect against currency consistent currency volatility
i6: Protect against low or high historical prices
i7: Protect against inflation
i8: Imports, exports or the simple need to exchange currencies
i9: Hedging purposes

***Level of measurement*:** categorical scale

Options: 7 objectives with their correspondent Likert-type items.

***Likert-type scale*:** from 1 to 7

This construct has 7 items; however, the items *i10* and *i11* requested in the pilot survey other type of objectives not contemplated in the questionnaire. This is a common method to verify the thoroughness and completeness of the objectives selected. Nonetheless, the respond rate for new objectives was very low. Few responses stated objectives already considered or they represent a trading style or an attitude towards the trading. Items *i10* and *i11* are dropped after the pilot survey.

Examples of ‘other’ objectives received from the respondents are: “protect against loss”, “scalping”, “capital preservation”, “growing investment”, “learning”, “work hard” and “easy withdrawing”.

The Table 4 reports the suggested statistics for ordinal variables. The median present a result of 7 for profit from investments (*i3)*, being 7 the higher score in the Likert type scale. This confirms the high theoretical importance of ‘profit from investments’. This result is important for the following reasons:

a) It confirms assumptions on profit maximisation behaviour.
b) It provides a supporting reason to use the price returns in estimation models.
c) This finding evidences the dominance of this strategic objective over other market objectives.

Even though the results for *i3* tend to support the PS shift model based on the assumption of profit maximisation, it might be important to relax the profiting assumption in as the remaining strategic objectives have a median higher than 4 (the scale range from 1 to 7). The remaining strategic objectives include *i4* (profit as intermediary), *i5* (protect against consistent currency volatility), *i6* (protect against low or high historical prices), *i7* (protect against inflation), *i8* (imports, exports or the simple need to exchange currencies) and *i9* (hedging purposes).

There is a high skewness (*-1.53*) for item *i3* (profit from investments). This means *i3* distribution is highly leaning to the right of the mean. The kurtosis of *i3* indicates that the degree of concentration around the mean is high (*4.56*).

Contrary, the skewness for the remaining items (*i4* to *i9)* range from *-0.05* (item *i4*) to *-0.*56 (item *i5*). The degree of concentration around the mean (kurtosis) ranges from *2.43* (item *i4*) to *1.66* (item *i8*). These figures further support the idea that item *i3* (profit from investments) is highly important to the market. Nonetheless, the objectives represented by items *i4* to *i9* are important at a level that might be noteworthy.

Table 4. Objectives - Descriptive statistics

	i3	**i4**	**i5**	**i6**	**i7**	**i8**	**i9**
N	50	50	50	50	50	50	50
p50	7	4	5	4	4	4	4
skewness	-1.4465	0.0603	-0.3961	-0.3340	-0.1764	0.1170	0.0422
kurtosis	4.4212	1.7835	2.1606	1.9368	1.8329	1.5647	1.7959
p1	1	1	1	1	1	1	1
p5	3	1	1	1	1	1	1
p10	4	1	1	1	1	1	1
p25	5	2	3	2	3	1	2
p75	7	5	6	6	6	7	5
p90	7	6	7	6.5	7	7	7
p95	7	7	7	7	7	7	7
p99	7	7	7	7	7	7	7
iqr	2	3	3	4	3	6	3

i3: Profit from investments in currencies
i4: Profit as an intermediary (e.g. spread)
i5: Protect against consistent currency volatility
i6: Protect against high or low historical spot prices
i7: Protect against inflation
i8: Imports, exports, or the need of exchange currencies
i9: Hedging purposes

The strategic objectives above are extracted from the literature review. In a nutshell, the interpretation of the items is as follows:

a) Profit from investments in currencies (item *i3*). This is the habitual Market behaviour from market agents, and a traditional assumption in theoretical models. The selected economic model n this research (PS Model) also reports this assumption.

b) Profit as an intermediary (item *i4*). This strategic objective is often innate to arbitrageurs and dealing desks. These types of organisations usually profit from spreads in the markets.

c) Protect against consistent currency volatility (item *i5*). It is probably expected to find many volatility or options traders. It is also expected a risk averse behaviour to volatility.

d) Protect against high or low historical spot prices (item *i6*). Previous literature on price clustering found that agents tend to trade at certain prices. Central banks and governments are also likely to protect their economies from very low and very high exchange rates prices.

e) Protect against inflation (item *i7*). Investors protect their portfolios from inflation; central banks habitually target their interest rates based on inflation expectations.

f) Imports, exports, or the need of exchange currencies (item *i8*). This item represents the simple need to exchange currencies for other purposes relevant to commerce and businesses.

g) Hedging purposes (item *i9*). Investors often include in their portfolios exchange rates to protect investments from currencies dynamics.

The importance of other strategic objectives is demonstrated above.

3.8.2.1. Construct validity

After a careful review of the literature, it is reasonable that all strategic objectives are represented by questions *i3* to *i9*. Particularly, these questions are supported by the work of Moosa and Batti (2010, pp.1-25), and King et al. (2012a)**.** Also, the construct is tested with Exploratory Factor Analysis (EFA), specifically, principal component analysis (the same results are obtained using common factor analysis). This is carried on in order to verify the assumption of a single objective for the agents in the market (one latent factor).

This thesis classifies the strategic objectives and compares the findings with the Portfolio Shift (PS) theory. This methodology permits a diagnosis of the similarity of the strategic objectives. The polychoric correlation matrix, the goodness of fit tests and the likelihood ratio test of no correlation are shown in the Table 5.

Table 5. Polychoric correlation matrix

The magnitudes of the polychoric correlations show more agreement on the trait when the value approaches to 1. In this context, item *i3* denotes low agreement within other items (all correlation under *0.23*). Contrarily, items *i4* to *i9* exhibit correlations over *0.4.* The fact *i3* performs in this way; allows this research to anticipate a uniqueness that will be described in the principal component analysis in the paragraphs below.

The Table provides the items correlations (Rho) together with their standard errors. Moreover, alpha is set at a level fairly high to *0.1* to test the 'goodness-of-fit', a common practice in the field. If the *p*-value is lower than the alpha level, it evidences model fit.

Polychoric correlation matrix

	i3	i4	i5	i6	i7	i8	i9
i3	1						
i4	.19134345	1					
i5	.2256793	.66966468	1				
i6	.22822575	.57322735	.68561468	1			
i7	.20339704	.45147628	.71909897	.73778546	1		
i8	.03777718	.39730368	.69328284	.54482439	.76097724	1	
i9	.00875488	.48450773	.53052677	.48594542	.54885742	.54285196	1

Type : polychoric																					
Variables:	i3 i4	i3 i5	i3 i6	i3 i7	i3 i8	i3 i9	i4 i5	i4 i6	i4 i7	i4 i8	i4 i9	i5 i6	i5 i7	i5 i8	i5 i9	i6 i7	i6 i8	i6 i9	i7 i8	i7 i9	i8 i9
Rho =	0.19	0.23	0.23	0.20	0.04	0.01	0.67	0.57	0.45	0.40	0.48	0.69	0.72	0.69	0.53	0.74	0.54	0.49	0.76	0.55	0.54
s.e. =	0.12	0.10	0.09	0.11	0.11	0.11	0.07	0.08	0.10	0.10	0.09	0.07	0.06	0.06	0.07	0.06	0.09	0.09	0.05	0.08	0.09
Goodness of fit tests:																					
Pearson G2 =	66.71	66.76	65.98	48.07	47.01	60.38	63.14	84.87	58.46	58.52	57.59	79.51	55.72	35.07	51.48	59.07	66.02	56.27	55.15	61.07	84.46
Prob(>chi2(35)) =	0.001	0.001	0.001	0.070	0.084	0.005	0.002	0.000	0.008	0.008	0.009	0.000	0.014	0.465	0.036	0.007	0.001	0.013	0.016	0.004	0.000
LR X2 =	71.21	57.77	64.64	42.75	43.83	49.51	65.76	57.32	59.80	53.53	32.74	72.93	38.91	22.38	39.04	73.55	52.54	36.23	52.80	58.64	69.08
Prob(>chi2(35)) =	0.000	0.009	0.002	0.173	0.145	0.053	0.001	0.010	0.006	0.023	0.578	0.000	0.298	0.951	0.293	0.000	0.029	0.411	0.027	0.007	0.001
Likelihood ration test of no correlation																					
r(pLR0) =	0.00																				
r(LR0) =	34.29																				

i3: Profit from investments in currencies
i4: Profit as an intermediary (e.g. spread)
i5: Protect against consistent currency volatility
i6: Protect against high or low historical spot prices
i7: Protect against inflation
i8: Imports, exports, or the need of exchange currencies
i9: Hedging purposes

Excluding items *i5-i8,* the results shows that all the Person G2 statistics are significant. This suggests model fit given the corresponding *p*-values less than *0.1*. As a result, the assumptions of the polychoric correlation are empirically valid. This is confirmed by the goodness-of-fit.

The Table 6 reports the principal components and the eigenvalues. This importantly supports the idea of multidimensionality of market objectives. Therefore, it suggests that theoretical models shall consider combining other strategic objectives in their model assumptions.

Table 6. Strategic objectives – Principal components and eigenvalues

The table reports eigenvalues greater than 1 for the two first components and marginal significance (below 1) for the outstanding components.

```
Principal components/correlation                  Number of obs    =        50
                                                  Number of comp.  =         7
                                                  Trace            =         7
    Rotation: (unrotated = principal)             Rho              =    1.0000
```

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	3.67435	2.3479	0.5249	0.5249
Comp2	1.32645	.428628	0.1895	0.7144
Comp3	.89782	.444343	0.1283	0.8427
Comp4	.453477	.16549	0.0648	0.9074
Comp5	.287987	.0884711	0.0411	0.9486
Comp6	.199516	.0391105	0.0285	0.9771
Comp7	.160406	.	0.0229	1.0000

The results suggest that the minimum number of objectives is *2* components. The results show that there are two sets of strategic objectives to take into account. First, Component 1 comprises items *i5, i6, i7,* and *i8.* Together they represent the market agents concern on currency volatility, extreme spot prices, inflation and the normal need of currencies' exchanges. Second, Component 2 includes the traditional assumption of profiting from investments. The remaining components explain just residual variance.

The Kaiser-Meyer-Olkin (KMO) measure of sample adequacy indicates the variables have a lot in common with exception of the item *i3* (Kaiser 1960). Indeed, the item *i3* KMO indicates a 'mediocre' result (*0.6395*). The remaining items present a 'middling' KMO for *i4,i7* and *i8*, but close to the limit for being considered 'meritorious' (*0.7942; 0.7939* and *0.7968* respectively); items *i5* and *i6* are considered 'meritorious'(*0.8450* and *0.8503* correspondingly); and item *i9* 'marvellous' (*0.9113*). This test reinforces the idea that the strategic objective 'profit from investments' do not match the sample characteristics of other strategic objectives.

The inspection of the squared multiple correlations (SMC) suggests that the item *i3* (with SMC *0.1270*) cannot be explained well by the items *i4* to *i9* (*0.5243; 0.7174; 0.6331; 0.7483; 0.6636* and *0.4127* respectively). Therefore, the results show that *i3* should not be related to the other items. In other words, item *i3* (profit from investments) measure a different theoretical construct (discriminant validity). For this reason, the results in the Table 7 are recalculated without *i3*.

Table 7. Strategic objectives (excluding item *i3*)– PCA

```
                                                Number of comp.  =          6
                                                Trace            =          6
   Rotation: (unrotated = principal)            Rho              =     1.0000
```

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	3.96456	3.27263	0.6608	0.6608
Comp2	.691935	.124374	0.1153	0.7761
Comp3	.567561	.167065	0.0946	0.8707
Comp4	.400497	.195306	0.0667	0.9374
Comp5	.205191	.0349357	0.0342	0.9716
Comp6	.170255	.	0.0284	1.0000

These results above suggest that only one component is retained. This means that a single component explain the variance of items *i4* to *i9.*

The Table 8 show the items loadings in the first component. The first component has positive loadings with a similar size on all items. The results in the retained factor (*i4* to *i9*) point out low and similar loadings for all the items. Indeed, it is not possible to reject the null hypothesis of equal loadings; the statistic is *6.49* with a probability of *0.2616*.

Table 8. Objectives excluding item *i3* – items and principal components

Principal components (eigenvectors) (blanks are abs(loading)<.3)

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Unexplained
i4	0.3631	0.7660			0.4433		0
i5	0.4464			-0.3648	-0.7854		0
i6	0.4180		-0.3802	0.6753		0.4647	0
i7	0.4402	-0.3692				-0.7517	0
i8	0.4096	-0.5065		-0.4860	0.3655	0.4527	0
i9	0.3642		0.8827				0

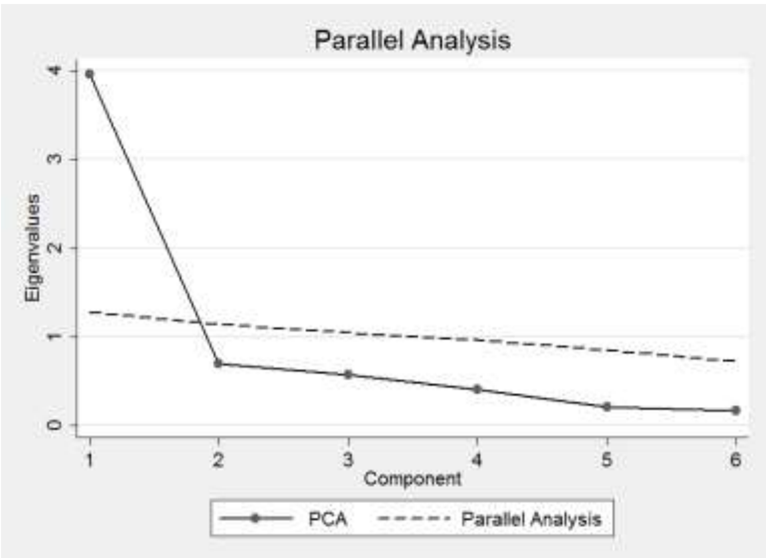
i4: Profit as an intermediary (e.g. spread)
i5: Protect against consistent currency volatility
i6: Protect against high or low historical spot prices
i7: Protect against inflation
i8: Imports, exports, or the need of exchange currencies
i9: Hedging purposes

The results above present a ‘middling’ KMO for item *i4* (*0.7862*), ‘meritorious’ for items *i5* to *i8;* and marvellous for item *i9* (*0.9207*). The overall KMO is ‘meritorious’ (*0.8292*). These variables have a lot in common to perform PCA.

Moreover, the retained principal components approximate well the correlation matrix, as can be seen from the residual correlation matrix below. The procedure is further supported by the residual correlation matrix show. Also, the SMCs’ of the items *i4* to *i9* shows strong linear relations with each other (*0.5228, 0.7124, 0.6323, 0.7424, 0.6503,* and *0.4011* in that order).

After applying the criteria of Horn’s Parallel Analysis (Horn 1965) for the determination of factors, the results confirm the need to retain just the one component or factor (see Figure 6).

Figure 6. Objectives-parallel criteria



These results are meaningful because they conduce to consider other strategic objectives aside from ‘profiting’. This can be studied further in the context of Market Microstructure Models. As a result, it is highlighted the construct validity of this question and their options.

The final version of question1 is as follows:

How important are the following objectives for your organisation?

Please rate each option from 1 to 7, meaning 1 unimportant and 7 very important

	Unimportant						Very important
Profit from investments in currencies	O	O	O	O	O	O	O
Profit as an intermediary (e.g. spread, arbitrage)	O	O	O	O	O	O	O
Protect against consistent currency volatility	O	O	O	O	O	O	O
Protect against high or low historical spot prices	O	O	O	O	O	O	O
Protect against inflation	O	O	O	O	O	O	O
Imports, exports, or the need of exchange currencies	O	O	O	O	O	O	O
Hedging purposes	O	O	O	O	O	O	O

3.8.3. Question 4: Type of FX agent

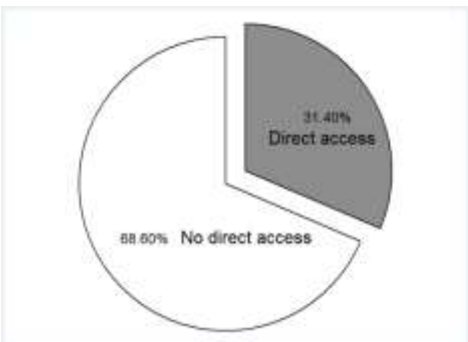
Variable to measure: Type of agent demographic question

Items: *i12:* Direct / indirect access to the interbank market
i13: 14 different types of organisations

***Level of measurement*:** Nominal.

Options: Panel 1: two options; panel 2: 14 type of organisation options.

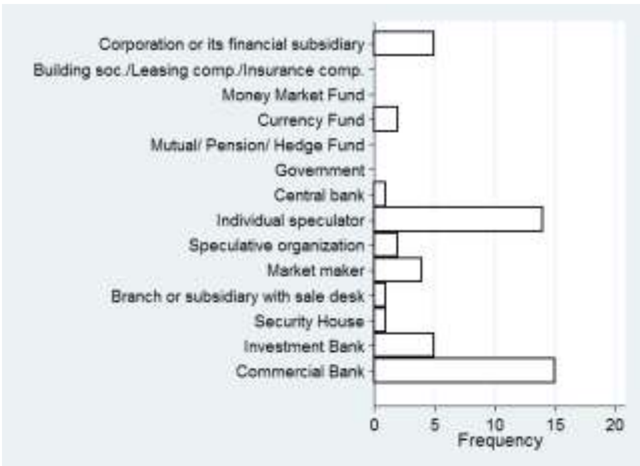
Figure 7. Access to the interbank market



The Figure 7 presents the survey pilot results on item *i12* -question 2, the participants chose either “direct access to the interbank market” or “indirect access through other market agent”. The responses are used to conform control groups.

The item *i13* aims is to generate control groups given certain type of organisations. The most representative respondents are individual speculators, followed by commercial banks, investment banks and market makers. Only building societies or leasing or insurance companies do not have responses in the survey pilot. After the pilot test the statements were refined. The Figure 8 shows the frequencies of the types of organisations.

Figure 8. Histogram - Respondents’ Type of Organisation



3.8.3.1.Content validity

The item *i12* (participants with access and participants without direct access) is supported by the PS Model (Evans and Lyons 2002a).

The item *i13* includes all possible types of market agents. These constructs have been applied in other studies based on the Triennial Bank Survey (2010) which is possibly the most important survey in the field. The categories are also comparable with the reviewed work of King et al. (2012a) in terms of denoting all the market participants. The question 2 is as follows:

2. What type of Forex agent is your organisation?

Please select one answer in each box below

Type of agent:	O Direct access to the interbank market	O Commercial Bank
	O Access through other market agent	O Investment Bank
		O Security House
		O Branch or subsidiary with sale desk
		O Market maker
		O Speculative organisation
		O Individual speculator
		O Central bank
		O Government
		O Mutual/ Pension/ Hedge Fund
		O Currency Fund
		O Money Market Fund
		O Building Soc./Leasing Co./Insurance Co.
		O Corporation or its financial subsidiary

3.8.4. Question 5: Country

Variable to measure: demographic question

Item: *i14: 66* options. This is *53* countries and *13* continents.
***Level of measurement*:** Nominal.

3.8.4.1. Content validity

The options cover all possible countries or continents. The list of countries has been downloaded from the help and resources page of www.surveymonkey.com and then edited according to the Triennial Bank Survey's (2010) using the fifty most important countries in FX trading.

The survey pilot presents the 50 responses to item *i14*. The answers come from 20 country headquarters. The sample contains predominately the responses from India, USA and UK.

The final version question 3:

3. In what country is your organisation currently headquartered? (The choices are in a drop down menu)

3.8.5. Question 6: Risk tolerance

Variable to measure: base strategic process
Items: *i15*
***Level of measurement*:** Ordinal.
Options: *4 levels of risk.*

The respondents not willing to take any financial risk are 11.5% of the total; average financial risk 27.48%; above average financial risk 35.46%; and substantial risk 25.56%.

This question aims to explore the relationship between financial risk tolerance and diverse factors such as strategic objectives, trading management, and strategic content.

This item was developed by the National Opinion Research Center at the University of Chicago and was sponsored originally by the Federal Research Board. The SCF (Survey of Consumer Finances) risk assessment item has been extensively used as a proxy of risk tolerance in the literature.

The descriptive statistics in Table 9 present the suggested statistics for the item *i15* (SCF risk assessment). The median (p.50) present a result of *2* (i.e. take above average financial risk expecting to earn above average returns). This result indicates that the sample respondents are more inclined to exhibit higher risk tolerance. Indeed there is a low skeewness in the gathered data (*0.21*) and a low degree of concentration around the mean.

Table 9. SCF risk assessment item – descriptive statistics

variable	skewness	kurtosis	p5	p10	p25	p50	p75	p90	p95	p99	iqr
i15	.2103051	1.917762	1	1	1	2	3	4	4	4	2

3.8.5.1. Construct reliability and validity

The validity of this item is based on the 'use' in the field. There is an agreement in the literature of at least a 'moderate' degree of item validity (Grabble and Lyton 1999). Besides, the item scores have been consistent over time suggesting high levels of reliability. Grabble and Lyton (2001 p.46) suggest well founded face validity for the item. They argue that the item has a score of *0.54* of concurrent validity compared with a multidimensional risk tolerance index. This survey only uses the SCF risk item because the multidimensional items proposed by Grabble and Lyton (2001) are entirely directed to individuals instead of organisations.

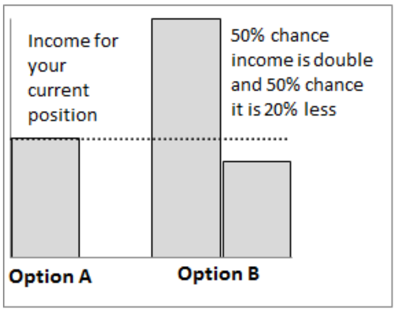
3.8.5.2. Pilot survey decision

The decision is to keep all the features of this item for further research comparison. However, in order to improve the assessment of the risk tolerance variable, a new measure of financial risk aversion is added based on income gambles (Hanna and Lindamood 2004). The measure is presented below (however, instead of considering the pension of the individual, this study considers a market position to be closed). The income gamble holds the same risk features though.

The additional multi-item measure of risk is as follows:

6. Suppose that you are about to close a trading position, and have two options. Option A gives you an income for your current trading position. Option B has a 50%

chance your income will be double, and a 50% chance that your income will be 20% less. You will have no other source of income, no chance of swaps, and no other organisational income ever in the future. All incomes are aftertax.

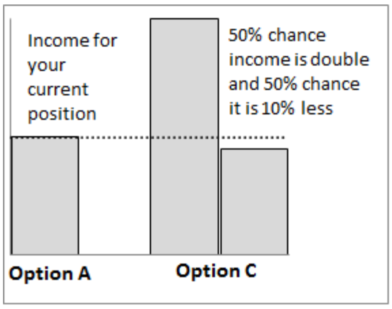


Which option would you choose? Please select one option.

O Option A (send the respondent to question 7)

O Option B (send the respondent to question 10)

7. Suppose that you are about to close a trading position, and have two options. Option A gives you an income for your current trading position. Option C has a 50% chance your income will be double, and a 50% chance that your income will be 10% less. You will have no other source of income, no chance of swaps, and no other organisational income ever in the future. All incomes are aftertax.

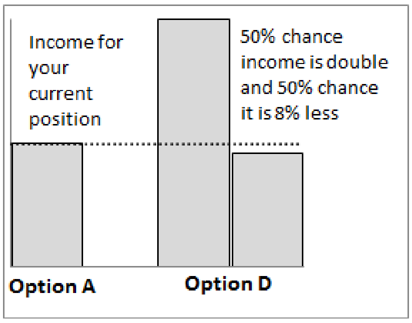


Which option would you choose? Please select one option.

O Option A (send the respondent to question 8)

O Option C, your subjective risk tolerance is moderate

8. Suppose that you are about to close a trading position, and have two options. Option A gives you an income for your current trading position. Option D has a 50% chance your income will be double, and a 50% chance that your income will be 8% less. You will have no other source of income, no chance of swaps, and no other organisational income ever in the future. All incomes are aftertax.

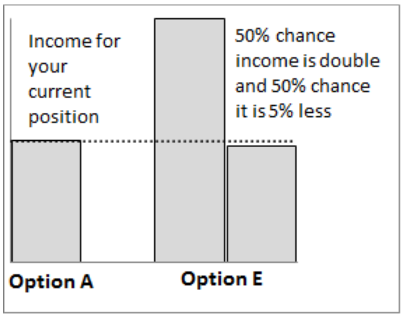


Which option would you choose? Please select one option.

O Option A (send the respondent to question 9)

O Option D, your subjective risk tolerance is low

9. Suppose that you are about to close a trading position, and have two options. Option A gives you an income for your current trading position. Option E has a 50% chance your income will be double, and a 50% chance that your income will be 5% less. You will have no other source of income, no chance of swaps, and no other organisational income ever in the future. All incomes are aftertax.

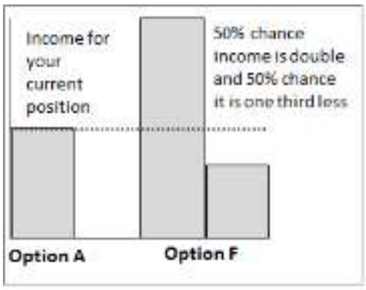


Which option would you choose? Please select one option.

O Option A, your subjective risk tolerance is extremely Low

O Option E, your subjective risk tolerance is very low

10. Suppose that you are about to close a trading position, and have two options. Option A gives you an income for your current trading position. Option F has a 50% chance your income will be double, and a 50% chance that your income will be one third less. You will have no other source of income, no chance of swaps, and no other organisational income ever in the future. All incomes are aftertax.

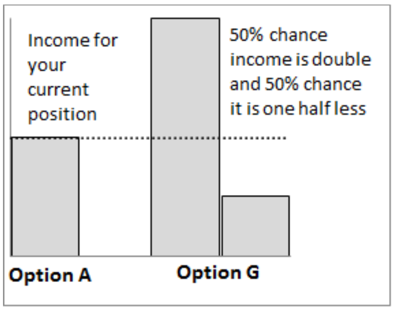


Which option would you choose? Please select one option.

O Option A, your subjective risk tolerance is moderately High

O Option F (send the respondent to question 11)

11. Suppose that you are about to close a trading position, and have two choices. Option A gives you an income for your current trading position. Option G has a 50% chance your income will be double, and a 50% chance that your income will be half less. You will have no other source of income, no chance of swaps, and no other organisational income ever in the future. All incomes are aftertax.



11. Which choice would you choose? Please select one option.

O Option A, your subjective risk tolerance is very high

O Option G, your subjective risk tolerance is extremely high

3.8.6. Question 7 to 12: strategic management approach

Variable to measure: base strategic process

Items: *i16 to i20 Command*
i21 to i28 Planning
i29 to i34 Incremental
i35 to i40 Political
i41 to i47 Cultural
i48 to i54 Enforced choice

Level of measurement**:** Likert Scale.

Options: *6* strategic approaches with their correspondent Likert scale.

Likert scale**:** from 1 to 7

3.8.6.1. Content validity

This study uses the multi-item measure developed by Bailey et al. (2000). They based the validity of content through a detailed review of the literature. The measure structure is developed and discussed by Bailey and Johnson (1991 and 1995), and Johnson and Scholes (1999).

The details of the definitions of the six dimensions of Bailey et al. are reported in the appendix – Chapter 3. The same Appendix report the results of items and factor loadings of Bailey et al. (2000, pp.158).

This pilot survey provides a sample test on a sample using *50* responses of FX agents. In accordance with Bailey et al, the construct validity was tested using exploratory factor analysis (EFA) (principal component), and oblique rotation (promax and oblimin) at different levels of promax powers and γ oblimin criterion. The Kayser-Meyer-Olkin (KMO) measure of sampling adequacy was *0.8395*, indicating ‘meritorious’ suitability.

This study inspected the loadings of each set of items within each variable. The Table 10 provides evidence of the validity, as the items of each variable load in one single factor. Nevertheless, the table also reports that item *i19* strongly underperform (*0.4446*).

Item *i29*’s loading (*0.7021)* is lower than the items component (from *0.7565* to *0.8098*), and the item fits much better into a different category (*cultural*). Similarly, the items *i41*, *i42,* and *i50* are low in their categories. As this is not suitable, this study will consider removing these items after computing the Cronbach’s alpha coefficients. If the items are removed, the new KMO increase to (0.8450).

Table 10. Question *7* to *12* – factor loadings

The first column shows the trading strategy, the second column the variable name, the third column the factor loadings, the fourth column reports the uniqueness of each item, and the remaining columns report the criteria to retain the component.

	Variable	Factor 1	Uniqueness	Kaiser criterion	90% variance criterion	Parallel criterion
Command	i16	0.7352	0.4030	1 Factor	1 Factor	2 Factors
	i17	0.8203	0.3215			
	i18	0.8222	0.3005			
	i19	0.4846	0.6161			
	i20	0.7975	0.3157			
Planning	i21	0.8612	0.2238	1 Factor	1 Factor	1 Factor
	i22	0.8352	0.1948			
	i23	0.7782	0.3434			
	i24	0.8075	0.3228			
	i25	0.7627	0.3625			
	i26	0.7744	0.3147			
	i27	0.8205	0.2319			
	i28	0.7939	0.3115			
Incremental	i29	0.7021	0.4289	1 Factor	1 Factor	4 Factors
	i30	0.7565	0.4175			
	i31	0.8080	0.2280			
	i32	0.8098	0.2738			
	i33	0.7904	0.3462			
	i34	0.7736	0.2648			
Political	i35	0.8297	0.2690	1 Factor	1 Factor	2 Factors
	i36	0.8298	0.2597			
	i37	0.8916	0.1854			
	i38	0.8084	0.3042			
	i39	0.9122	0.0984			
	i40	0.9068	0.1207			
Cultural	i41	0.7139	0.3137	1 Factor	1 Factor	4 Factors
	i42	0.6901	0.3504			
	i43	0.8728	0.2086			
	i44	0.8673	0.2212			
	i45	0.8206	0.2774			
	i46	0.8106	0.1996			
	i47	0.8542	0.1867			
Enforced Choice	i48	0.8023	0.2722	1 Factor	1 Factor	3 Factors
	i49	0.7952	0.2831			
	i50	0.7830	0.2680			
	i51	0.8332	0.2676			
	i52	0.8404	0.1954			
	i53	0.8366	0.1537			
	i54	0.8363	0.2770			

3.8.6.2. Internal consistency

The Table 11 shows the reported alpha coefficients by Bailey (2000, p.159) for the six dimensions evaluated (i.e. Command, Planning, Incremental, Political, Cultural, Enforced choice).

Table 11. Means, standard deviations, alpha coefficients (Bailey et. al 2000, p.159)

	Individual level analyses			Organizational level analyses											
	Mean	SD	α	Mean	SD	IRR	1	2	3	4	5	6	7	8	9
1. Command	4.14	1.27	0.80	4.00	0.74	0.97	–								
2. Planning	3.99	1.16	0.89	4.15	0.80	0.99	–0.21*	–							
3. Incremental	4.38	0.78	0.63	4.39	0.40	0.98	–0.17*	0.20*	–						
4. Political	4.02	1.07	0.78	4.01	0.62	0.98	0.24*	–0.45*	–0.03	–					
5. Cultural	4.20	0.91	0.71	4.20	0.53	0.97	0.10	–0.35*	0.07	0.46*	–				
6. Enforced choice	4.00	1.10	0.80	4.00	0.74	0.98	0.06	–0.15*	–0.10	0.38*	0.19*	–			
7. No. of employees				7932	18 707	–	0.05	0.07	–0.13*	0.15*	0.03	–0.01	–		
8. Performance	12.82	3.49	0.66	12.62	2.65	0.95	–0.05	0.19*	0.15*	–0.21*	–0.08	–0.39*	0.09	–	
9. Industry growth	11.39	3.68	0.70	11.51	2.58	0.79	0.02	0.00	0.13*	–0.02	0.04	–0.24*	–0.05	0.21*	–

Notes: n = 5332 n = 732–770 * $p < 0.001$ (overall familywise α rate set at approximately $p < 0.05$).
IRR = average inter-rater reliability across all organizations.

The Cronbach's Alpha coefficients are presented in the Table 12. Overall, the coefficients convey a high degree of internal consistency. From the table, the variable 'command' produce a higher Cronbach's Alpha coefficient when item *i19* is taken out (*0.8215)*; the variables 'planning', 'incremental', and 'enforced choice' perform better with all its items *(0.9048; 0.8503;* and *0.9068* respectively); the variable 'political' increases the coefficient from *0.9211* to *0.9311* when items *i35, i36, i37,* and *i38* are removed; and lastly, the variable 'Cultural' perform better when items *i41* and *i42* are standing apart (from *0.8908* to *0.8995).*

Due to underperformance, it is considered removing six items *i19, i35, i36, i38, i41* and *i42*. Items *i19, i41*, and *i42* were also underperforming in factor analysis. The item loadings, and specially, the questionnaire is inversely related to response rate, and directly related to response bias (Roszkowski and Bean 1990). For this reason, the final decision is to remove the items that are underperforming in the factor analysis and/or on Chronbach's alpha coefficients.

Table 12. Trading Strategies - Alpha coefficients

The table shows how far each trading strategy measure improves or underperforms if one consecutive item is removed.

	Items								Alpha
Command	16	17	18	19	20				0.7919
	16	17	18	X	20				0.8215
	16	17	18	X	X				0.8026
	X	17	18	X	X				0.7707
Planning	21	22	23	24	25	26	27	28	0.9048
	21	22	23	24	25	X	27	28	0.8961
	21	22	23	24	X	X	27	28	0.8878
	21	22	X	24	X	X	27	28	0.8750
	21	22	X	24	X	X	X	28	0.8611
	21	22	X	24	X	X	X	X	0.8454
	21	22	X	X	X	X	X	X	0.8461
Incremental	29	30	31	32	33	34			0.8503
	X	30	31	32	33	34			0.8397
	X	X	31	32	33	34			0.8165
	X	X	X	32	33	34			0.7938
	X	X	X	32	X	34			0.7497
Political	35	36	37	38	39	40			0.9211
	35	36	37	X	39	40			0.9148
	35	X	37	X	39	40			0.9066
	X	X	37	X	39	40			0.9149
	X	X	X	X	39	40			0.9311
Cultural	41	42	43	44	45	46	47		0.8908
	41	X	43	44	45	46	47		0.8912
	X	X	43	44	45	46	47		0.8995
	X	X	43	44	X	46	47		0.8878
	X	X	43	X	X	46	47		0.8717
	X	X	43	X	X	46	X		0.8314
Enforced Choice	48	49	50	51	52	53	54		0.9068
	48	49	X	51	52	53	54		0.8977
	X	49	X	51	52	53	54		0.8859
	X	X	X	51	52	53	54		0.8756
	X	X	X	X	52	53	54		0.8584
	X	X	X	X	52	53	X		0.8879

Summarising, this study kept the items *i16*, *i17*, *i18*, and *i20* for ‘command’; *i21*, *i22*, *i24*, and *i28* for ‘planning’; *i31*, *i32*, *i33*, and *i34* for ‘incremental’; *i39* and *i40* for ‘political’; *i43*, *i44*, *i46*, and *i47* for ‘cultural’; *i52* and *i53* for ‘enforced choice’. The new factor analysis, variances and loadings are presented in the Table 13. The alpha coefficients are still the same.

Table 13. Trading strategies - factor Analysis (oblique promax 1.4)

The first panel reports the factors, the variances, and the portion of explained variance. The second panel shows the items' loadings and uniqueness.

```
Method: principal-component factors          Retained factors =        6
Rotation: oblique promax (Kaiser off)        Number of params =      105
```

Factor	Variance	Proportion	Rotated factors are correlated
Factor1	3.64559	0.1823	
Factor2	3.59335	0.1797	
Factor3	3.12655	0.1563	
Factor4	3.00677	0.1503	
Factor5	2.76908	0.1385	
Factor6	2.04181	0.1021	

LR test: independent vs. saturated: chi2(190) = 1802.50 Prob>chi2 = 0.0000

Variable	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Uniqueness
i16			0.7484				0.2675
i17			0.7180				0.2899
i18			0.7881				0.2403
i20			0.6018	0.5599			0.2491
i21		0.7644					0.2500
i22		0.7783					0.2185
i24		0.7151					0.2864
i28		0.8093					0.2773
i31	0.5363				0.6024		0.2743
i32					0.8367		0.1774
i33					0.4997		0.3073
i34					0.6735		0.2512
i39				0.8635			0.1557
i40				0.8595			0.1220
i43	0.6525						0.2461
i44	0.7024						0.3049
i46	0.6922			0.5142			0.1988
i47	0.6732						0.2314
i52						0.9384	0.0955
i53						0.9267	0.1044

(blanks represent abs(loading)<.45)

Finally, this question follows the characteristics of the instrument proportioned by Bailey et al. with few adaptations, e.g. the words “ON TRADING” are added after “THE FOLLOWING STATEMENTS WERE DESIGNED TO ASSESS HOW STRATEGIC DECISIONS”, in the question statement. Similarly, instead of “strategy decisions” was written “trading strategy decisions”.

The final version of this question is as follows:

The following statements were designed to assess how strategic decisions on trading are made in your organisation. Trading strategy decisions are defined as those: "characterised by a large commitment of resources and deal with issues of substantial importance to the organization usually with longer rather than just short term impact; they usually involve more than one function and involve significant change" (Bailey et al. 2000). Please rate all options from 1 strongly disagree to 7 strongly agree

7. COMMAND

	Strongly disagree						Strongly agree
A senior figure's vision is our strategy	O	O	O	O	O	O	O
The chief executive determines our strategic direction	O	O	O	O	O	O	O
The strategy we follow is directed by a vision of the future associated with the chief executive (or another senior figure)	O	O	O	O	O	O	O
Our chief executive tends to impose strategic decisions (rather than consulting the top management team)	O	O	O	O	O	O	O

8. PLANNING

	Strongly disagree						Strongly agree
Our strategy is made explicit in the form of precise plans	O	O	O	O	O	O	O
When we formulate a strategy it is planned in detail	O	O	O	O	O	O	O

We have well-defined planning procedures to search for solutions to strategic problems	O	O	O	O	O	O	O
We make strategic decisions based on a systematic analysis of our business environment	O	O	O	O	O	O	O

9. INCREMENTAL

	Strongly disagree						Strongly agree
To keep in line with our business environment we make continual small-scale changes to strategy	O	O	O	O	O	O	O
Our strategies emerge gradually as we respond to the need to change	O	O	O	O	O	O	O
We keep early commitment to a strategy tentative and subject to review	O	O	O	O	O	O	O
We tend to develop strategy by experimenting and trying new approaches in the market place	O	O	O	O	O	O	O

10. POLITICAL

	Strongly disagree						Strongly agree
The information on which our strategy is developed often reflects the interests of certain groups	O	O	O	O	O	O	O
The decision to adopt a strategy is influenced by the	O	O	O	O	O	O	O

power of the group sponsoring it

11. CULTURAL

	Strongly disagree						Strongly agree
The strategy we follow is dictated by our culture	O	O	O	O	O	O	O
The attitudes, behaviours, rituals, and stories of this organization reflect the direction we wish to take it in	O	O	O	O	O	O	O
There is resistance to any strategic change which does not sit well with our culture	O	O	O	O	O	O	O
The strategies we follow develop from 'the way we do things around here'	O	O	O	O	O	O	O

12. ENFORCED CHOICE

	Strongly disagree						Strongly agree
We are severely limited in our ability to influence the business environment in which we operate	O	O	O	O	O	O	O
Many of the strategic changes which have taken place have been forced On us by those outside this organization	O	O	O	O	O	O	O

Table 14. Trading strategies - descriptive statistics

stats	i71	i72	i73	i74	i75	i76
mean	4.762868	5.641544	5.334559	4.246324	4.845588	3.702206
sd	1.716025	1.373931	1.415595	2.227768	1.712443	1.967682
cv	.3602923	.2435382	.265363	.5246345	.3534026	.5314891
skewness	-.4698743	-.9098582	-.7654433	-.220238	-.4261922	.2948946
kurtosis	2.545608	3.359996	3.516335	1.635886	2.272509	1.982821

The Table 14 presents the descriptive statistics for the final instrument. Item *i71* is the average of items *i16*, *i17, i18,* and *i20* (command); and items *i72 to i76* are the average of 'planning', 'incremental', 'political', 'cultural', and 'enforced choice' respectively. It is remarkable the importance of the 'planning' trade management approach (*i72)* among the Forex agents. It has the highest mean *(5.64)*, the lowest standard deviation *(1.37)*, and therefore, the best coefficient of variation (*0.24).* Also, *i72* has the highest skewness (*-0.90)* leaning the right of the mean, followed by 'incremental' (*-0.76),* 'command' *(-.4698)* and 'cultural' (*-0.42*). 'Enforced choice' is the only variable leaning to the left (*0.29*). All variables are leptokurtic (positive kurtosis). This indicates a substantial degree of concentration around the mean; specifically, *i73* (incremental) and *i72* (planning) have high readings (*3.51* and *3.35* respectively). Item *i74* (political) has the highest standard deviation (*2.22*) and the lowest kurtosis (*1.63)* followed by *i76* (enforced choice) with *1.96* and *1.98*. The later variables might convey more risk in terms of trading management.

3.8.7. Strategic content - variables per time frequencies

Variable to measure: trading information importance
Level of measurement**:** ordinal.
Options: 4 types of market information at 3 different time frequencies.
Items: *i55* to *i66*

3.8.7.1. Content and construct validity

This question is based in the literature on ER determination, specifically, the traditional macroeconomic models, the MMM and Chartism approaches (e.g. James et. al 2012). Indeed, the question inquiries on the importance of fundamentals (traditional approach), order flow (MMM), chart indicators (an alternative approach), and correlated assets (e.g. in the work of Kendrick and Amen 2012). The construct validity is supported empirically and theoretically. However, in the literature on economics is still rare and difficult to find validated instruments, and perhaps, this could be a field of science development and research.

Often, the literature on ER determination divides the frequencies in high and low. This research question aims to find whether there are significant changes on the agents' informational preferences across frequencies.

Factor analysis is also performed to test the validity by means of a reduction of the dimensionality of the data concerning to each variable. This method might be a better approach than PCA given the distinctive importance of each variable (order flow, fundamentals, chartism, correlated assets) at diverse time frequencies. Indeed, it probably makes more sense to allow the components to represent the shared variance of the variables, because it represents the degree at which the variables move together. The results in the Table 15 present the same eigenvalues and cumulative variances. However, the loadings of the items considerably increase.

Table 15. Order flow, fundamentals, chartism and correlated asset variables - EFA

The table shows how well items load in a single component at different time frequencies. The second column shows the eigenvalues. The fourth column reports the proportion of the explained variance. The sixth column shows the items relative to different types of informational preferences. The seventh and eight columns show the items' loadings and the uniqueness respectively.

	Eigenvalue	Difference	Proportion	Cumulative	Variable	Factor1	Uniqueness
Order Flow							
Factor1	2.1089	1.5559	0.7030	0.7030	i55	0.8098	0.3442
Factor2	0.5530	0.2150	0.1843	0.8873	i59	0.8878	0.2118
Factor3	0.3381	.	0.1127	1.0000	i63	0.8154	0.3351
Fundamentals							
Factor1	2.1370	1.5524	0.7123	0.7123	i56	0.8237	0.3215
Factor2	0.5847	0.3063	0.1949	0.9072	i60	0.9101	0.1717
Factor3	0.2783	.	0.0928	1.0000	i64	0.7938	0.3698
Chartism							
Factor1	2.3360	1.9127	0.7787	0.7787	i63	0.8670	0.2483
Factor2	0.4233	0.1825	0.1411	0.9197	i64	0.9199	0.1538
Factor3	0.2408	.	0.0803	1.0000	i66	0.8591	0.2619
Correlated asset							
Factor1	2.2587	1.8043	0.7529	0.7529	i58	0.9000	0.1901
Factor2	0.4544	0.1675	0.1515	0.9044	i62	0.8686	0.2455
Factor3	0.2869	.	0.0956	1.0000	i66	0.8332	0.3058

Final version of question 13:

13. What type of information is key for you to trade currencies?

Please rate just your trading frequency from 1 to 7, being 1 not important and 7 strongly important.

	Ask and bid Volumes (net demand)	Fundamentals (economics, political)	Chart indicator	A correlated asset
Very high frequencies (Tick- 30 minutes)				
Moderate high frequencies (1 hour - daily)				
Low frequencies (Weekly - yearly)				

3.8.7.2. Descriptive statistics

For the items addressing the strategic information, the skewness is negative, excluding items *i63* (order flow at low frequencies) and *i66* (correlated assets at low frequencies). Accordingly to the reviewed theory order flow appears to be more important at high frequencies (e.g. Chaboud et al. 2008). The kurtosis is situated between *1.5664* and *2.1193*, and therefore on a linear scale, the variables follow a density pattern between a logistic distribution and a hyperbolic secant distribution.

3.8.8. Questions 14: Lot sizes

Variable to measure: average size of trading lots (in USD millions)
Measurement**:** objective nominal value.
Items: *i67*

This question might be also considered demographical and aims to weight the answers of survey participants by the value of their lots when buying or selling within the market.

3.8.8.1.Content and construct validity

The item has comparability with previous versions of the Triennial Bank Survey (2013) and the Euromoney FX Poll, regarding the market agents' foreign exchange turnover. This latter, it is defined at these surveys as "the gross value of all new deals entered into during a given period, and is measured in terms of the nominal or notional amount of contracts" (Triennial Bank Survey, p.17).

3.8.8.2. Descriptive statistics

The survey gathered data from individual traders and big market agents. The differences in the average size of the lots are enormous. Surveyed small market agents trade during the day in average lots from 0 to 100,000 USD, meanwhile surveyed big players trade in average during a day values from 10,000,000 USD to 1,000,000,000,000 USD. Future research could analyse the impact of capital strength among players on the exchange rates.

The final version of this question is as follows:

14. What is the daily average value in USD of your lots when trading a currency?

Please write a positive number in thousands, e.g. 1000 if your average lot is 1 million dollars

Daily average of your lot size ________________________

3.8.9. Order-Flow

Variable to measure: Order flow importance

Level of measurement**:** Likert-type scale.

Items: *i68*

3.8.9.1.Construct validity

Question 15 evaluates the given importance to seven interval order flow ranges. All models of MMM are behind the aim of this question. Market agents, especially, interbank market agents, make decisions upon the order flows from their customers in the retail tier and other dealers in the interbank market tier. The literature review of this study present specifically the assumptions of MMM on heterogeneity and market expectations, together with the rounds of the PS Model (Evans and Lyons 2002a) explaining the behaviour of the market agents.

Furthermore, this item combined with the items on strategic approaches generates the equation: $X_t = \beta_1 Co_t + \beta_2 Pl_t + \beta_3 Inc_t + \beta_4 Cul_t + \beta_5 Pol_t + \beta_6 Ench_t + \zeta_t$. Where:

X_t: Order flow

Co_t: Propensity of the command strategy to buy/sell given order flow

Pl_t: Propensity of the planning strategy to buy/sell given order flow

Inc_t: Propensity of the incremental strategy to buy/sell given order flow

Cul_t Propensity of the cultural strategy to buy/sell given order flow

$Ench_t$: Propensity of the enforced choice strategy to buy/sell given order flow

More formally, the variables above are IVs or instrumental variables because: (a) the IVs are uncorrelated with the error, and (b) they are correlated with X_t.

In conclusion, this study uses individual expectations of each survey participant given order flow and it might use the lot size. In this connection, the strategy is expected to be low-time varying or non-time varying instrument in time.

Lastly, the question received comments in terms of comprehensibility. For this reason after a previous small pilot test of 39 respondents, the question was reformulated classifying the trade management strategies according to Bailey et al. (2000).

Final version of question 15:

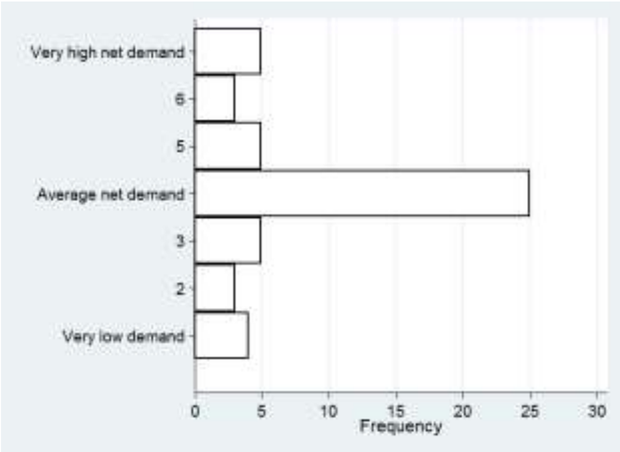
15. At which level of market net demand for a currency (buy volume - sell volume) is your interest the highest to trade the currency?

Please select one option at which your interest to buy/sell is the highest given the net demand

Very low net demand			Average net demand			Very high net demand
O	O	O	O	O	O	O

Within the preliminary descriptive statistics of this pilot test over a sample of 50 respondents, the skewness is slightly negative and the kurtosis indicates that the linear pattern of the distribution is between a hyperbolic secant distribution and a Laplace distribution. The histogram is shown in the Figure 9.

Figure 9. Histogram item *i68* – Order flow ranges importance



3.8.10. Question 16: drift in order flow.

Variable to measure: Tendency importance within Order flow
***Level of measurement*:** Likert-type scale.
Items: *i69*

3.8.10.1. Construct validity:

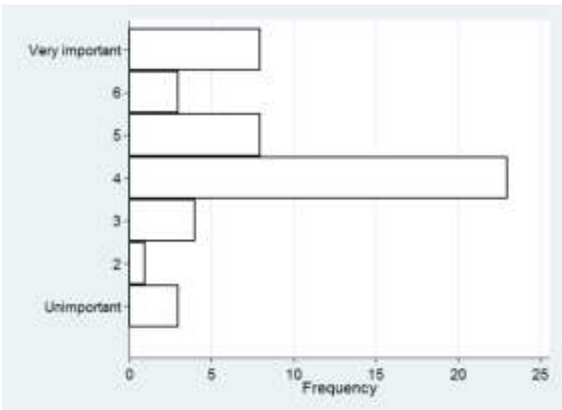
The aim of this question is to investigate the drift when traders consider order flow as a variable. In a previous small pilot test, the question has received comments from some FX traders directed to simplify the question, for this reason the question was restated with the collaboration of five traders of FX.

The question is inspired on the Portfolio Shift theory. Specifically, on the literature regarding of how is order flow transmitted through the market via trading (Evans and Lyons 2004). Following the framework on information transmission of Evans and Lyons (2006), the available information at the start of each month Ω_{t+1} (*t* is time) within the interbank tier of the market (*D*) is $\Omega_{t+1}^{D} = \{u_{t+1}, v_{t-1}, x_t\} \cup \Omega_t^D$, where

u_{t+1} are the common information at the start of each month (*t+1*), v_{t-1} are the private information during the previous month (*t-1*); *t-1* assumes that private information is partly used before and reveled during the macroeconomic releases in time *t* (ibid. p.5). Following this further, x is order flow and Ω_t is the available information at the time *t*. Order flows aggregates information on transactions and dealers learn from the sequence of submitted orders over time (Evans and Lyons 2005 p.204), that is, they convey their market interpretations by quoting prices and then gradual learn and adjust their views based on the sequence of transacted orders.

The Figure 10 portrays the histogram of the respondents. Especially, two different views on tendency of order flows are present in the item *i69* results. The respondents appear to be inclined towards the 'very important' category and the 'neutral'.

Figure 10. Histogram item *i69* – Order flow tendency importance



Final version of question 16:

16. Is the tendency of the currency net demand (buy volume - sell volume) important for your trading strategy?

Please option below, meaning 1 unimportant and 7 very important.

Unimportant			Neutral			Very important
O	O	O	O	O	O	O

3.8.11. Question 17: When is the market open?

Variable to measure: Control question

Level of measurement**:** nominal scale, 3 options, 1 correct answer.

Items: *i70*

Through this question was dropped as the three responses from the data sample did not confirm the subject knowledge on this particular question that must be known by Forex traders. The format follow three options, one of them correct, two incorrect (controls).

Appendix – Chapter 3

Pilot Survey

FX Survey

1. WELCOME

25%

Thank you for your consent to volunteer in this important survey measuring the trade management and the risk tolerance in the foreign exchange Market. The aim of this survey focuses in the strategic process of FX market-agents of trading in the context of the Microstructure Theory of exchange rates determination.
This survey should take 15-20 minutes to complete and the purpose is totally scientific. Your thoughts and opinions are absolutely confidential.
Please think thoroughly when responding, your views are very important and need to be objectively represented.
Kindest regards,

Camilo Calderon
PG Researcher

Next

FX Survey

2. DEMOGRAPHIC QUESTIONS

50%

1. What is your gender?

- ○ Female
- ○ Male

*** 2. Which category below includes your age?**

- ○ < 36
- ○ 36 - 41
- ○ 42 - 47
- ○ 48 - 55
- ○ > 55

* 3. How important are the following objectives for your organisation?
Please rate each option from 1 to 7, meaning 1 unimportant and 7 very important

	Unimportant			Moderately important			Very important
Profit from investments in currencies	○	○	○	○	○	○	○
Profit as an intermediary (e.g. spread, arbitrage)	○	○	○	○	○	○	○
Protect against consistent currency volatility	○	○	○	○	○	○	○
Protect against high or low historical spot prices	○	○	○	○	○	○	○
Protect against inflation	○	○	○	○	○	○	○
Imports, exports, or the need of exchange currencies	○	○	○	○	○	○	○
Hedging purposes	○	○	○	○	○	○	○
other?	○	○	○	○	○	○	○

Other (please specify)

*** 4. What type of forex agent is your organisation?**
Please select one answer in each box below

Type of Agent:

*** 5. In what country is your organisation currently headquartered?**

*** 6. Which of the following statements on this page comes closest to the amount of financial risk that you are willing to take when your save or make investments?**

- ○ take substantial financial risk expecting to earn substantial returns
- ○ take above average financial risk expecting to earn above average returns
- ○ take average financial risk expecting to earn average returns
- ○ not willing to take any financial risk

Prev Next

FX Survey

3. MANAGEMENT STRATEGY

75%

The following statements were designed to assess how strategic decisions on trading are made in your organisation. Trading strategy decisions are defined as those: "characterised by a large commitment of resources and deal with issues of substantial importance to the organization usually with longer rather than just short term impact; they usually involve more than one function and involve significant change" (Bailey et al. 2000).

Please rate all options from 1 Strongly disagree to 7 Strongly agree

*** 7. COMMAND**

	Strongly disagree						Strongly agree
A senior figure's vision is our strategy	○	○	○	○	○	○	○
The chief executive determines our strategic direction	○	○	○	○	○	○	○
The strategy we follow is directed by a vision of the future associated with the chief executive (or another senior figure)	○	○	○	○	○	○	○
Our strategy is closely associated with a particular individual	○	○	○	○	○	○	○
Our chief executive tends to impose strategic decisions (rather than consulting the top management team)	○	○	○	○	○	○	○

*** 8. PLANNING**

	Strongly disagree						Strongly agree
Our strategy is made explicit in the form of precise plans	○	○	○	○	○	○	○
When we formulate a strategy it is planned in detail	○	○	○	○	○	○	○
We have precise procedures for achieving strategic objectives	○	○	○	○	○	○	○
We have well-defined planning procedures to search for solutions to strategic problems	○	○	○	○	○	○	○
We meticulously assess many alternatives when deciding on a strategy	○	○	○	○	○	○	○
We evaluate potential strategic options against explicit strategic objectives	○	○	○	○	○	○	○
We have definite and precise strategic objectives	○	○	○	○	○	○	○
We make strategic decisions based on a systematic analysis of our business environment	○	○	○	○	○	○	○

*** 9. INCREMENTAL**

	Strongly disagree						Strongly agree
Our strategy develops through a process of ongoing adjustment	○	○	○	○	○	○	○
Our strategy is continually adjusted as changes occur in the market place	○	○	○	○	○	○	○
To keep in line with our business environment we make continual small-scale changes to strategy	○	○	○	○	○	○	○
Our strategies emerge gradually as we respond to the need to change	○	○	○	○	○	○	○
We keep early commitment to a strategy tentative and subject to review	○	○	○	○	○	○	○
We tend to develop strategy by experimenting and trying new approaches in the market place	○	○	○	○	○	○	○

*** 10. POLITICAL**

	Strongly disagree						Strongly agree
Our strategy is a compromise which accommodates the conflicting interests of powerful groups and individuals	○	○	○	○	○	○	○
The vested interests of particular internal groups colour our strategy	○	○	○	○	○	○	○
Our strategies often have to be changed because certain groups block their implementation	○	○	○	○	○	○	○
Our strategy develops through a process of bargaining and negotiation between groups or individuals	○	○	○	○	○	○	○
The information on which our strategy is developed often reflects the interests of certain groups	○	○	○	○	○	○	○
The decision to adopt a strategy is influenced by the power of the group sponsoring it	○	○	○	○	○	○	○

*** 11. CULTURAL**

	Strongly disagree						Strongly agree
There is a way of doing things in this organization which has developed over the years	○	○	○	○	○	○	○
Our strategy is based on past experience	○	○	○	○	○	○	○
The strategy we follow is dictated by our culture	○	○	○	○	○	○	○
The attitudes, behaviours, rituals, and stories of this organization reflect the direction we wish to take it in	○	○	○	○	○	○	○
Our organization's history directs our search for solutions to strategic issues	○	○	○	○	○	○	○
There is resistance to any strategic change which does not sit well with our culture	○	○	○	○	○	○	○
The strategies we follow develop from 'the way we do things around here'	○	○	○	○	○	○	○

*** 12. ENFORCED CHOICE**

	Strongly agree						Strongly disagree
Our freedom of strategic choice is severely restricted by our external business environment	○	○	○	○	○	○	○
Forces outside this organization determine our strategic direction	○	○	○	○	○	○	○
Barriers exist in our business environment which significantly restrict the strategies we can follow	○	○	○	○	○	○	○
We have strategy imposed on us by those external to this organization, for example the government	○	○	○	○	○	○	○
We are not able to influence our business environment; we can only buffer ourselves from it	○	○	○	○	○	○	○
We are severely limited in our ability to influence the business environment in which we operate	○	○	○	○	○	○	○
Many of the strategic changes which have taken place have been forced On us by those outside this organization	○	○	○	○	○	○	○

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FX Survey

4. STRATEGIC CONTENT

100%

* **13. What type of information is key for you to trade currencies?**
Please rate just your trading frequency from 1 to 7, being 1 not important and 7 strongly important.

	Ask and bid Volumes (net demand)	Fundamentals (economics, political)	Chart indicator	A correlated asset
Very high frequencies (Tick- 30 minutes)				
Moderate high frequencies (1 hour -daily)				
Low frequencies (Weekly - yearly)				

* **14. What is the daily average value in USD of your lots when trading a currency?**
Please write a positive number in thousands, e.g. 1000 if your average lot is 1 million dollars

Daily average of your lot size

15. At which level of market net demand for a currency (buy volume - sell volume) is your interest the highest to trade the currency?
Please select one option at which your interest to buy/sell is the highest given the net demand

Very low net demand			Average net demand			Very high net demand
○	○	○	○	○	○	○

16. Is the tendency of the currency net demand (buy volume - sell volume) important for your trading strategy?
Please select one option below, meaning 1 unimportant and 7 very important.

Unimportant			Neutral			Very important
○	○	○	○	○	○	○

* **17. Control question. When is the foreign exchange market open?**

- ○ 7 days per week, 24 hours
- ○ From Monday to Friday, 24 hours
- ○ From Monday to Friday from 8 AM to 5PM

Prev Done

Final Questionnaire

FX Strategic Decisions (EN)

1. WELCOME TO THE TRADE MANAGEMENT AND RISK TOLERANCE SURVEY

9%

Thank you for your consent to volunteer in this important survey measuring the trade management and the risk tolerance in the foreign exchange Market. The aim of this survey focuses in the strategic process of FX market-agents of trading in the context of the Microstructure Theory of exchange rates determination.

This survey should take 15-20 minutes to complete and the purpose is totally scientific. Your thoughts and opinions are absolutely confidential.

Your involvement is very important for us. You will receive free feedback, plus the opportunity to gain a prize of an Apple iMac 21.5" MD093 (RPM £1,050) by registering your participation.

Please think thoroughly when responding, your views are very important and need to be objectively represented.

Kindest regards,

Next

FX Strategic Decisions (EN)

2. DEMOGRAPHIC QUESTIONS

18%

* **1. How important are the following objectives for your organisation?**
Please rate each option from 1 to 7, meaning 1 unimportant and 7 very important

	Unimportant			Moderately important			Very important
Profit from investments in currencies	○	○	○	○	○	○	○
Profit as an intermediary (e.g. spread, arbitrage)	○	○	○	○	○	○	○
Protect against consistent currency volatility	○	○	○	○	○	○	○
Protect against high or low historical spot prices	○	○	○	○	○	○	○
Protect against inflation	○	○	○	○	○	○	○
Imports, exports, or the need of exchange currencies	○	○	○	○	○	○	○
Hedging purposes	○	○	○	○	○	○	○

* **2. What type of forex agent is your organisation?**
Please select one answer in each box below

Type of Agent

* **3. In what country is your organisation currently headquartered?**

* **4. Please rate in percentage the following financial indicators as a monthly average over the last year.**

Return on investment. It is equal to net operating profit divided by the net book value of assets

Return on equity. It is equal to net profit divided by the book value of shareholder's equity

Prev Next

FX Strategic Decisions (EN)

3. RISK TOLERANCE

27%

* 5. Which of the following statements on this page comes closest to the amount of financial risk that you are willing to take when your save or make investments?

- take substantial financial risk expecting to earn substantial returns
- take above average financial risk expecting to earn above average returns
- take average financial risk expecting to earn average returns
- not willing to take any financial risk

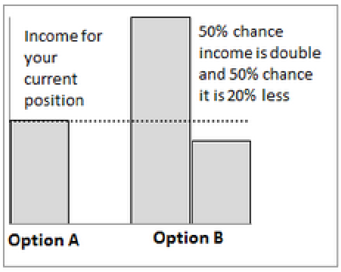
Prev Next

FX Strategic Decisions (EN)

4. SUBJECTIVE RISK TOLERANCE

36%

Suppose that you are about to close a trading position, and have two options.
Option A gives you an income for your current trading position.
Option B has a 50% chance your income will be double, and a 50% chance that your income will be 20% less.
You will have no other source of income, no chance of swaps, and no other organisational income ever in the future. All incomes are aftertax.



* 6. Which option would you choose? Please select one option.

- Option A
- Option B

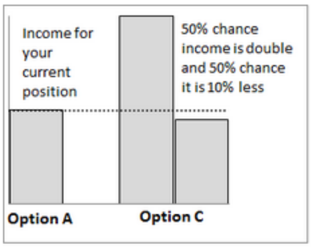
Prev Next

FX Strategic Decisions (EN)

5. RISK TOLERANCE - Question 7

45%

Suppose that you are about to close a trading position, and have two options.
Option A gives you an income for your current trading position.
Option C has a 50% chance your income will be double, and a 50% chance that your income will be 10% less.
You will have no other source of income, no chance of swaps, and no other organisational income ever in the future. All incomes are aftertax.



*** 7. Which option would you choose? Please select one option.**

- ◯ Option A
- ◯ Option C, your subjective risk tolerance is Moderate

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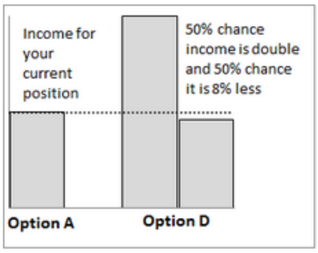
FX Strategic Decisions (EN)

6. SUBJECTIVE RISK TOLERANCE - Question 8

55%

Suppose that you are about to close a trading position, and have two options.
Option A gives you an income for your current trading position.
Option D has a 50% chance your income will be double, and a 50% chance that your income will be 8% less.
You will have no other source of income, no chance of swaps, and no other organisational income ever in the future. All incomes are aftertax.



*** 8. Which option would you choose? Please select one option.**

- ◯ Option A
- ◯ Option D, your subjective risk tolerance is Low

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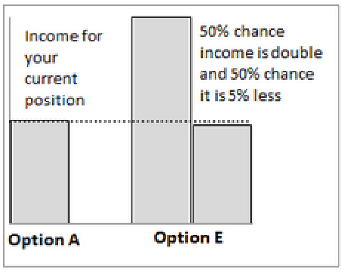
FX Strategic Decisions (EN)

7. SUBJECTIVE RISK TOLERANCE - Question 9

64%

Suppose that you are about to close a trading position, and have two options.
Option A gives you an income for your current trading position.
Option E has a 50% chance your income will be double, and a 50% chance that your income will be 5% less.
You will have no other source of income, no chance of swaps, and no other organisational income ever in the future. All incomes are aftertax.



*** 9. Which option would you choose? Please select one option.**

- Option A, your subjective risk tolerance is Extremely Low
- Option E, your subjective risk tolerance is Very Low

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FX Strategic Decisions (EN)

8. TRADE MANAGEMENT

91%

The following statements were designed to assess how strategic decisions on trading are made in your organisation. Trading strategy decisions are defined as those: "characterised by a large commitment of resources and deal with issues of substantial importance to the organization usually with longer rather than just short term impact; they usually involve more than one function and involve significant change" (Bailey et al. 2000). Please rate all options from 1 Strongly disagree to 7 Strongly agree

*** 10. COMMAND**

	Strongly disagree						Strongly agree
A senior figure's vision is our strategy	○	○	○	○	○	○	○
The chief executive determines our strategic direction	○	○	○	○	○	○	○
The strategy we follow is directed by a vision of the future associated with the chief executive (or another senior figure)	○	○	○	○	○	○	○
Our chief executive tends to impose strategic decisions (rather than consulting the top management team)	○	○	○	○	○	○	○

*** 11. PLANNING**

	Strongly disagree						Strongly agree
Our strategy is made explicit in the form of precise plans							
When we formulate a strategy it is planned in detail							
We have well-defined planning procedures to search for solutions to strategic problems							
We make strategic decisions based on a systematic analysis of our business environment							

*** 12. INCREMENTAL**

	Strongly disagree						Strongly agree
To keep in line with our business environment we make continual small-scale changes to strategy							
Our strategies emerge gradually as we respond to the need to change							
We keep early commitment to a strategy tentative and subject to review							
We tend to develop strategy by experimenting and trying new approaches in the market place							

*** 13. POLITICAL**

	Strongly disagree						Strongly agree
Our strategies often have to be changed because certain groups block their implementation							
The information on which our strategy is developed often reflects the interests of certain groups							
The decision to adopt a strategy is influenced by the power of the group sponsoring it							

*** 14. CULTURAL**

	Strongly disagree						Strongly agree
The strategy we follow is dictated by our culture							
The attitudes, behaviours, rituals, and stories of this organization reflect the direction we wish to take it in							
There is resistance to any strategic change which does not sit well with our culture							
The strategies we follow develop from 'the way we do things around here'							

*** 15. ENFORCED CHOICE**

	Strongly agree						Strongly disagree
We are not able to influence our business environment; we can only buffer ourselves from it							
We are severely limited in our ability to influence the business environment in which we operate							
Many of the strategic changes which have taken place have been forced on us by those outside this organization							

Prev Next

FX Strategic Decisions (EN)

9. STRATEGIC CONTENT

100%

* 16. What type of information is key for you to trade currencies?
Please rate just your trading frequency from 1 to 7, being 1 not important and 7 strongly important.

	Ask and bid Volumes (net demand)	Fundamentals (economics, political)	Chart indicator	A correlated asset
Very high frequencies (Tick- 30 minutes)				
Moderate high frequencies (1 hour -daily)				
Low frequencies (Weekly - yearly)				

* 17. What is the daily average value in USD of your lots when trading a currency?
Please write a positive number in thousands, e.g. 1000 if your average lot is 1 million dollars

Daily average of your lot size

18. At which level of market net demand for a currency (buy volume - sell volume) is your interest the highest to trade the currency?
Please select one option at which your interest to buy/sell is the highest given the net demand

Very low net demand — Average net demand — Very high net demand

19. Is the tendency of the currency net demand (buy volume - sell volume) important for your trading strategy?
Please select one option below, meaning 1 unimportant and 7 very important.

Unimportant — Neutral — Very important

20. Control question. When is the foreign exchange market open?

- 7 days per week, 24 hours
- From Monday to Friday, 24 hours
- From Monday to Friday from 8AM to 5PM

Prev Done

Table 16 . Characteristics of six dimensions of strategy development (Bailey et al. 2000)

	Description	Key references
Command	A particular individual is seen to have a high degree of control over the strategy followed; for example the chief executive or a similar figure with institutionalized authority. Less commonly, such influence may relate to the power of a small group of individuals at the top of the organization. Control and influence may be exercised in different ways, for example through personality, the rigid enactment of rules or through expertise. Alternatively, strategic aspirations and strategy may emerge from a vision associated with the powerful individual(s), which represents the desired future state of the organization.	Bennis and Nanus (1985) Shrivastava and Nachman (1989 Westley and Mintzberg (1989) Kotter (1990) Farkas and Wetlaufer (1996) Hayward and Hambrick (1997)
Planning	An intentional process involving a logical, sequential, analytic and deliberate set of procedures. The organization and its environment are systematically analysed. Strategic options are generated and systematically evaluated. Based on this assessment, the option is chosen that is judged to maximize the value of outcomes in relation to organizational goals. The selected option is subsequently detailed in the form of precise implementation plans, and systems for monitoring and controlling the strategy are determined. There is an assumption here that strategy is developed by top executives and implemented by those below.	Ansoff (1965) Mintzberg (1978) Steiner (1969) Argenti (1980) Rowe, Dickel, Mason and Snyder (1994)
Incremental	Strategic choice takes place through 'successive limited comparisons'. Strategic goals and objectives of the organization are not likely to be precise but general in nature. The uncertainty of the environment is accepted and as such managers are not able to know how it will change: rather they attempt to be sensitive to it through constant scanning and evaluation. Commitment to a strategic option may be tentative and subject to review in the early stages of development.	Lindblom (1959) Mintzberg *et al.* (1976) Quinn (1980) Quinn (1982) Johnson (1988)
Political	Organizations are political arenas in which decision-making and strategy development is a political matter. Differences amongst stakeholders are resolved through bargaining, negotiation and compromise. Coalitions may form to pursue shared objectives and to sponsor different strategic options. The level of influence these stakeholders are able to exercise is conditional upon the organization's dependency upon such groups for resources. Further, information is not politically neutral, but rather is a source of power for those who control it.	Cyert and March (1963) Pettigrew (1973) Hinings *et al.* (1974) Pfeffer and Salancik (1978) Wilson (1982) Feldman (1986) Hickson *et al.* (1986)
Cultural	Strategy is influenced by taken-for-granted frames of reference shared amongst organizational members. These frames of reference help to simplify the complexity of situations, provide a ready-made interpretation of new situations, enable decisions to be made in a way which makes contextual sense and provide a guide to appropriate behaviour. Their usefulness increases as situations become more ambiguous and the efficiency of formal decision-making processes decreases. These frames of reference are underpinned by routines, rituals, stories and other symbolic artefacts which represent and reinforce the organizational culture. These cultural artefacts embed frames of reference in organizational activities and provide a repertoire for action; but are in turn likely to be resistant to change.	Weick (1979) Deal and Kennedy (1982) Schon (1983) Gioia and Poole (1984) Trice and Beyer (1985) Johnson (1987) Spender (1989)
Enforced choice	Factors in the environment encourage the adoption of organizational structures and activities which best fit that environment. These external constraints may take the form of regulative coercion, competitive or economic pressures or normative pressures as to what constitutes legitimate organizational action. These pressures limit the role organizational members play in the choice of strategy. So the strategies an organization can follow tend to be common to organizations within their industrial sector or organizational field; with changes coming about through variations in organizations' processes and systems which may occur unintentionally or through imperfect imitation of successful structures, systems or processes.	Aldrich (1979) DiMaggio and Powell (1983) Hannan and Freeman (1989) Deephouse (1996)

Table 17. Items and factor loadings (Bailey 2000, pp.158)

	1	2	3	4	5	6
1. Command						
A senior figure's vision is our strategy	0.77					
The chief executive determines our strategic direction	0.74					
The strategy we follow is directed by a vision of the future associated with the chief executive (or another senior figure)	0.67					
Our strategy is closely associated with a particular individual	0.62					
Our chief executive tends to impose strategic decisions (rather than consulting the top management team)	0.51					
2. Planning[a]						
Our strategy is made explicit in the form of precise plans		–0.76				
When we formulate a strategy it is planned in detail		–0.75				
We have precise procedures for achieving strategic objectives		–0.72				
We have well-defined planning procedures to search for solutions to strategic problems		–0.72				
We meticulously assess many alternatives when deciding on a strategy		–0.66				
We evaluate potential strategic options against explicit strategic objectives		–0.66				
We have definite and precise strategic objectives		–0.65				
We make strategic decisions based on a systematic analysis of our business environment		–0.64				
3. Incremental						
Our strategy develops through a process of ongoing adjustment			0.66			
Our strategy is continually adjusted as changes occur in the market place			0.62			
To keep in line with our business environment we make continual small-scale changes to strategy			0.59			
Our strategies emerge gradually as we respond to the need to change			0.50			
We keep early commitment to a strategy tentative and subject to review			0.48			
We tend to develop strategy by experimenting and trying new approaches in the market place			0.47			
4. Political						
Our strategy is a compromise which accommodates the conflicting interests of powerful groups and individuals				0.64		
The vested interests of particular internal groups colour our strategy				0.61		
Our strategies often have to be changed because certain groups block their implementation				0.47		
Our strategy develops through a process of bargaining and negotiation between groups or individuals				0.43		
The information on which our strategy is developed often reflects the interests of certain groups				0.35		
The decision to adopt a strategy is influenced by the power of the group sponsoring it				0.34		
5. Cultural						
There is a way of doing things in this organization which has developed over the years					0.74	
Our strategy is based on past experience					0.66	
The strategy we follow is dictated by our culture					0.62	
The attitudes, behaviours, rituals, and stories of this organization reflect the direction we wish to take it in					0.57	
Our organization's history directs our search for solutions to strategic issues					0.55	
There is resistance to any strategic change which does not sit well with our culture					0.53	
The strategies we follow develop from 'the way we do things around here'					0.52	
6. Enforced choice[a]						
Our freedom of strategic choice is severely restricted by our external business environment						–0.57
Forces outside this organization determine our strategic direction						–0.54
Barriers exist in our business environment which significantly restrict the strategies we can follow						–0.51
We have strategy imposed on us by those external to this organization, for example the government						–0.49
We are not able to influence our business environment; we can only buffer ourselves from it						–0.46
We are severely limited in our ability to influence the business environment in which we operate						–0.43
Many of the strategic changes which have taken place have been forced on us by those outside this organization						–0.30

CHAPTER 4. Survey results

The survey results comprise of 215 respondents which are different from those in the pilot test. Random sampling was the method applied for the data collection, as the respondents were selected randomly. The questionnaires were distributed by internet through an online questionnaire; the response rate was 0.143%.

The targeted population are organisations and individual traders in the Forex market. These organisations were discussed on the Literature Review Chapter. Briefly these organisations are sorted by their direct or indirect access to the market, and they are typified as either commercial banks, investment banks, security houses, branches or subsidiaries with sale desk, market makers, speculative organisations, individual speculators, central banks, governments; mutual, pension, hedge funds, currency funds, money market funds; building societies., leasing companies, Insurance companies, or corporations or its financial subsidiaries. The gathering process comprised invitations to answer the survey through Facebook using a survey from surveymonkey.com.

The following sections review the descriptive statistics of the gathered responses. This section also reports the hypothesis tests (e.g. Anova, Wilcox-Mann-Whitney, and the Kruskal-Wallis rank test used for more than two groups) related to the research questions.

4.1.1. Agents' objectives descriptive statistics

The Table 18 presents the descriptive statistics that are related to the importance of the different market objectives. The descriptive statistics denote several similarities with the descriptive results of the survey pilot. However, skewness was found to be more pronounced and negative. Also, it has been found that the kurtosis is greater for all the items (*i3* to *i9)* compared to the pilot survey. Finally it can also be shown that the median (percentile 50) is also greater than the previous results for all the items.

The results in the Table 18 indicate a high degree of concentration around the mean, and the high importance levels of the strategic objectives. Also noted is the relevance and dominance of item *i3* (profit from investments) as its percentile *50* is rated *7* and its percentile *25* is *6*. This result provides support for the models assuming profiting to be the main rationale of the householders. However, at the same time, the results have increased the relevancy of researching the question of whether or not there is objective heterogeneity.

Table 18. Strategic objectives - Descriptive statistics

The item *i3* represents the objective 'profit from investments'; *i4* shows 'profit as an intermediary'; *i5* symbolises the 'protect against currency consistent currency volatility'; *i6* represents the 'protect against low or high historical prices'; *i7* shows the 'protect against inflation'; *i8* denotes the 'imports, exports or the simple need to exchange currencies'; and finally item *i9* represents the objective 'hedging purposes'.

Stats	i3	i4	i5	i6	i7	i8	i9
Median	7	5	6	6	6	6	5
p25	6	4	4	4	4	4	3
Skewness	-1.8553	-0.7002	-0.9421	-0.7628	-0.8973	-0.8251	-0.4395
Kurtosis	5.7580	2.5512	2.8287	2.4122	2.6509	2.4282	1.9025

This thesis conducts several hypotheses tests between groups to test if the means of the groups are equal. These tests report whether or not there are agents' heterogeneity on strategic objectives.

The p- values for the Shapiro-Wilk test of non-normality are less than *0.05* with just one exception, which is item *i9* (hedging purposes) (whose *Prob>z* equals *0.093*). Therefore, here the null hypothesis of non-normality is not rejected; or in other words, it is assumed that there is non-normality for items *i3* to *i8*. Consequently, it can therefore be concluded that the non-parametric tests are more appropriate for these set of items representing the strategic objectives.

4.1.2. Agents' objectives and economic heterogeneity tests on diverse groups

Given the non-normality and the fact that the sample data is ordinal, this study chooses to use the non-parametric Wilcox-Mann-Whitney test. The hypotheses tested, as presented below, aim to evidence either the presence of homogeneity or heterogeneity on market objectives among the different types of market agents.

The Table 19 suggests that there is no significant difference between the underlying distributions (the item *i3's* *z* score is *0.109* and the *p-value* is *0.9224).* Interestingly, it can also be determined that group 1 (agents with direct access to the interbank market) has the lower rank than group 2 (agents with indirect access to the market). The results support the traditional economic assumption of agents' homogeneity with regard to the objective of the 'profit from investments'.

Table 19. Two agents' groups, and 'profit from investments' – The Wilcoxon-Mann-Whitney test

The table reports the results of the Wilcoxon-Mann-Whitney test (for two groups) on the objective as represented by item *i3* (profit from investments). The agents with direct access to the interbank are shown as group 1 in the table, and those without direct access as group 2.

Two-sample Wilcoxon-Mann-Whitney tes

i12	obs	rank sum	expected
1	113	12245	12204
2	102	10975	11016

Ho: *i3(i12==1) = i3(i12==2)*
z = 0.109
Prob *z* 0.9129

The Wilcoxon-Mann-Whitney test is also conducted separately for items *i4, i5, i6, i7, i8* and *i9* (other strategic objectives). Except for item *i4* which is the 'profit as an intermediary', all the results clearly suggest that there is not a significant difference between the underlying distributions of the items scores (see *Prob* >|*z*| in the Table 20). This finding is very important because it highlights that 'intermediation' might be the most significant source of heterogeneity within these two market groups. Against the most plausible expected results, these two tiers (direct and indirect access to the market) are not particularly heterogeneous in terms of strategic objectives. (Indeed, similar findings are obtained through one-way anova.)

Table 20. Two agents' groups and other strategic objectives – The Wilcoxon-Mann-Whitney test

The table reports the results of the Wilcoxon-Mann-Whitney test (for two groups) on the objective represented by items *i3* to *i9.* Agents with direct access to the interbank are group 1 in the table, and those without direct access are group 2. The item *i3* represents the 'profit from investments'; *i4* is the 'profit as an intermediary'; *i5* symbolises the 'protect against currency consistent currency volatility'; *i6* represents the 'protect against low or high historical prices'; *i7* is the 'protect against inflation'; *i8* denotes 'imports, exports or the simple need to exchange currencies'; and finally item *i9* represents the objective 'hedging purposes'.

Item	ranksum(1)	Expect.(1)	ranksum(2)	Expect.(2)	z	Prob >|z|
i3	12383.5	12420	10836.5	10800	0.109	0.9129
i4	13246.5	12420	9973.5	10800	1.88	0.0602
i5	11935	12420	11285	10800	-1.114	0.2653
i6	12271.5	12420	10948.5	10800	-0.34	0.7339
i7	11634	12255	11371	10750	-1.458	0.1447
i8	12957.5	12362.5	10047.5	10642.5	1.374	0.1693
i9	12734	12420	10486	10800	0.706	0.4802

The results in Table 20 are highly important from an economic point of view; they suggest that strategic objectives are homogeneous among the two market agents, which are those with direct access to the interbank market, and those without. The hypotheses are presented in the Table 21.

Table 21. Strategic objectives and economic heterogeneity for Dealers and Customers

The table summarises the decisions from the previous results related to the hypothesis tests.

Items	Null hypothesis	Decision
Item *i3*	The medians of the objective 'profiting from investments' (item i3) for interbank agents and non-interbank agents are equal. This is the agents' homogeneity related to this strategic objective.	Fail to reject
Item *i4*	The medians of the objective 'profiting as an intermediary' (item *i4*) for interbank agents and non-interbank agents are equal. This is agents' homogeneity related to this strategic objective.	Reject at 6 % alpha.
Item *i5*	The medians of the objective 'protect against currency consistent	Fail to reject

	currency volatility' (item *i5*) for interbank agents and non-interbank agents are equal. This is the agents' homogeneity related to this strategic objective.	
Item *i6*	The medians of the objective 'protect against low or high historical prices' (item *i6*) for interbank agents and non-interbank agents are equal. This is the agents' homogeneity related to this strategic objective.	Fail to reject
Item *i7*	The medians of the objective 'protect against inflation' (item *i7*) for interbank agents and non-interbank agents are equal. This is the agents' homogeneity related to this strategic objective.	Fail to reject
Item *i8*	The medians of the objective 'imports, exports or the simple need to exchange currencies' (item *i8*) for interbank agents and non-interbank agents are equal. This is the agents' homogeneity related to this strategic objective.	Fail to reject
Item *i9*	The medians of the objective 'hedging purposes' (item *i9*) for interbank agents and non-interbank agents are equal. This is the agents' homogeneity related to this strategic objective.	Fail to reject

As reviewed before, the portfolio shift (PS) model assumes that the agents' heterogeneity is between two groups or tiers: agents with direct access to the interbank market, and the 'customers' or agents without direct access. The results on the table above bring about three important conclusions:

a) The PS assumptions on risk averse market agents whose objective is to profit in the market are confirmed (Evans 2002; Evans, and Lyons 2006; Evans 2010; and Evans 2011). The results above indicate that there is a non-significant difference regarding the objective 'profit from investments'.

b) As could be predicted from the MMM assumptions found in the literature (e.g. Fan and Lyons 2003; Osler, 2006; Cao, Evans, and Lyons 2006; Evans 2010; Evans 2011), the main source of the agents' heterogeneity is the objective 'profit from intermediation'. The PS model argues that the main difference between the interbank market agents and the 'customers' is the access to private information. This private information is related to customer transactions; the main source of agents' heterogeneity. Therefore, in line with the assumptions of the model, the results presented here confirm the market agents' homogeneity and heterogeneity for the objective 'profiting from intermediation'.

c) From the table above, this study contributes to the literature by evidencing the underlying homogeneity regarding other strategic objectives, apart from *i3*. Therefore, it can be concluded that these objectives might bring about modifications in the PS model assumptions regarding the agents' objectives. Based on the high importance of items *i5 to i9* (other strategic objectives), the tests above suggest refinements to the PS model supporting the use of other variables along with the order flow.

The results above are contrasted examining the same strategic objectives, but with different control groups. In other words, this study examines if other groups of agents have heterogeneous objectives. This time using the Kruskal Wallis test for more than two groups (the non-parametric version of ANOVA and generalised form of the Wilcoxon-Mann-Whitney test), this study examines the responses on the strategic objectives within 14 groups (item *i13)* as follows:

a) commercial banks

b) investment banks

c) security houses

d) branches or subsidiaries with sale desk

e) market makers

f) speculative organisations

g) individual speculators

h) central banks

i) governments

j) mutual/pension/hedge funds

k) currency funds

l) money market funds

m) building societies, leasing companies or insurance companies

n) and corporations or its financial subsidiaries

With or without ties, the results indicate that the null hypothesis of economic homogeneity among the 14 types of organisations cannot be rejected, with one interesting exception of item *i5* reported in the Table 22. The item *i5* ‘protect against currency volatility’ has a significant χ^2 of *27.098* with a probability of *0.0121 (*see table 22). This means economic heterogeneity. Contrary, the results for items *i3, i4, i6, i7, i8,* and *i9* are economic homogeneity.

This finding is new and provides further economic evidence on agents’ homogeneity related to the strategic objectives. Only item *i5* ‘protect against currency volatility’ evidences agents’ economic heterogeneity.

Table 22. The market agents and ‘protect against volatility’*;* the Kruskal-Wallis rank test

In the table, the numbers from 1 to 14 (item i13) represent commercial banks, investment banks, security houses, branches or subsidiaries with sale desk, market makers, speculative organisations, individual speculators, central banks, governments, mutual/pension/hedge funds, currency funds, money market funds, building societies, leasing companies or insurance companies, and corporations or its financial subsidiaries.

Kruskal Wallis - Equality of populations rank test

i13	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Obs	45	28	9	7	26	7	41	6	6	6	16	6	2	10
Rank Sum	4000	2729	1037	862	3243	193	4720	721	701	822	2085	670	344	997

Chi2(13)	26.8
Prob>Chi2	0.01
With ties	
Chi2(13)	29
Prob>Chi2	0.01

These results bring about the question whether volatility, as a source of economic heterogeneity, is significant to determine and forecast the exchange rates. This matter will be tackled in Chapter 7 where this finding leads to an empirical test to find out whether the different levels of currency volatility affect the exchange rates determination. The Table 23 summarises and show the hypotheses tests.

Table 23. Strategic objectives and economic heterogeneity for 14 types of organisations

The table summarises the decisions on the previous results related to the hypothesis tests.

Items	Null hypothesis	Decision
Item *i3*	The medians of the objective 'profiting from investments' (item i3) for 14 types of organisations are equal. Market homogeneity related to this strategic objective.	Fail to reject
Item *i4*	The medians of the objective 'profiting as an intermediary' (item *i4*) for 14 types of organisations are equal. Market homogeneity related to this strategic objective.	Fail to reject
Item *i5*	The medians of the objective 'protect against currency consistent currency volatility' (item *i5*) for 14 types of organisations are equal. Market homogeneity related to this strategic objective.	Reject
Item *i6*	The medians of the objective 'protect against low or high historical prices' (item *i6*) for 14 types of organisations are equal. Market homogeneity related to this strategic objective.	Fail to reject
Item *i7*	The medians of the objective 'protect against inflation' (item *i7*) for 14 types of organisations are equal. This is agents' homogeneity related to this strategic objective.	Fail to reject
Item *i8*	The medians of the objective 'imports, exports or the simple need to exchange currencies' (item *i8*) for 14 types of organisations are equal. Market homogeneity related to this strategic objective.	Fail to reject
Item *i9*	The medians of the objective 'hedging purposes' (item *i9*) for 14 types of organisations are equal. Market homogeneity related to this strategic objective.	Fail to reject

These results are very important and new in the literature, and can be a source of empirical research. The same results hold when grouping the 14 types of organisations as follows:

a) Banks

b) market makers

c) speculators

d) public institutions

e) funds

f) and other type of organisations

These groups are represented by item *i80* in the Table 24; the same latter hypotheses decisions hold for the groups represented for *i80.* As it can be seen in the table the chi-squared statistics are significant (*0.03* and *0.02* without ties and with ties respectively).

Table 24. Grouped market agents and 'protect against volatility', The Kruskal-Wallis rank test

The first column shows six groups: Banks, market makers, speculators, public institutions, funds, and other type of organisations related to numbers 1 to 6 respectively.

Kruskal Wallis - Equality of populations rank test

i80	1	2	3	4	5	6
Obs	73	26	26	48	12	30
Rank Sum	6728.5	2895.5	3242.5	4912	1522	3919.5

Chi2(13)	26.794
Prob>Chi2	0.0327
With ties	
Chi2(13)	29.034
Prob>Chi2	0.0218

This study has also tested the null of objectives homogeneity for financial and non-financial organisations. The items scores for the financial organisations (i.e. commercial bank, investment bank, security house, branch or subsidiary, central bank, government, funds, and building society) and non-financial organisations (i.e. corporation or its financial subsidiary, market maker, individual speculator, and speculative organisation) suggest economic heterogeneity for the objectives represented by items *i8* and *i9* ('imports, exports or the simple need to exchange currencies' and 'hedging purposes'). The test was conducted using the Wilcoxon-Mann-Whitney test (for two groups). The Table 25 reports a significant *z* statistic for items *i8* and *i9*.

Table 25. Financial and non-financial institutions - The Wilcoxon-Mann-Whitney test

Two-sample Wilcoxon-Mann-Whitney test

i79	obs	rank sum	expected
1	131	15275.5	14148
2	84	7944.5	9072

Ho: *i8(i79==1) = i8(i79==2)*
z = 2.635
Prob *z* 0.0084

Two-sample Wilcoxon-Mann-Whitney tes

i79	obs	rank sum	expected
1	131	15268.5	14148
2	84	7951.5	9072

Ho: *i9(i79==1) = i9(i79==2)*
z = 2.572
Prob *z* 0.0101

The results suggest that the underlying distributions of the objectives represented for items *i8* and *i9,* that is 'imports, exports, or the need of exchange currencies' and 'hedging purposes' are different for these two groups. This supports economic heterogeneity, and contributes to the documental evidence. This is also reported in the literature regarding why the order flows from financial institutions are more informative, than the flows from non-financial institutions.

Table 26. Strategic objectives and economic heterogeneity for the financial and non-financial organisations

The table summarises the decisions on the previous results related to the hypotheses tests.

Items	Null hypothesis	Decision
Item *i3*	The medians of the objective 'profiting from investments' (item i3) for financial and non-financial organisations are equal. Market homogeneity related to this strategic objective.	Fail to reject
Item *i4*	The medians of the objective 'profiting as an intermediary' (item *i4*) for financial and non-financial organisations are equal. Market homogeneity related to this strategic objective.	Fail to reject
Item *i5*	The medians of the objective 'protect against currency consistent currency volatility' (item *i5*) for financial and non-financial organisations are equal. Market homogeneity related to this strategic objective.	Fail to reject
Item *i6*	The medians of the objective 'protect against low or high historical prices' (item *i6*) for financial and non-financial organisations are equal. Market homogeneity related to this strategic objective.	Fail to reject
Item *i7*	The medians of the objective 'protect against inflation' (item *i7*) for financial and non-financial organisations are equal. This is agents' homogeneity related to this strategic objective.	Fail to reject
Item *i8*	The medians of the objective 'imports, exports or the simple need to exchange currencies' (item *i8*) for financial and non-financial organisations are equal. Market homogeneity related to this strategic objective.	Reject
Item *i9*	The medians of the objective 'hedging purposes' (item *i9*) for financial	Reject

	and non-financial organisations are equal. Market homogeneity related to this strategic objective.	

The decisions of these hypotheses support the literature related to economic heterogeneity for financial and non-financial organisations (e.g. Fan and Lyons 2003; Osler 2006). The literature shows that order flows from financial organisations appear to be more significant than order flows from non-financial organisations. These results contribute to the field and to previous literature by explaining that the heterogeneity of financial and non-financial firms is related to the strategic objectives represented by items *i8* and *i9* ('imports, exports or the simple need to exchange currencies' and 'hedging purposes' respectively). This means that order flows are less important when they are related to 'the simple need of currencies', and more importantly when they are related to 'hedging purposes'.

This thesis also researches the heterogeneity related to the strategic objectives for geographic regions. The item *i4* represents the country headquarters of the survey respondents. Therefore, this study reviews the responses on strategic objectives using the following regions:

a) Europe

b) Asia

c) countries from America

d) countries from Africa (4)

The significant chi-square results are presented in the Table 27. These results confirm previous literature that suggests economic heterogeneity of the trading regions.

Table 27. Geographic Regions and heterogeneous strategic objectives - *The* Kruskal-Wallis test

Kruskal Wallis - Equality of populations rank test

i81	1	2	3	4
Obs	54	119	25	17
Rank Sum	5576	12377	2807	2460
Chi2(3)	6.84			
Prob>Chi2	0.0772			
With ties				
Chi2(3)	7.412			
Prob>Chi2	0.0599			

Kruskal Wallis - Equality of populations rank test

i81	1	2	3	4
Obs	54	119	25	17
Rank Sum	5011	13197	2647	2364
Chi2(3)	7.758			
Prob>Chi2	0.0513			
With ties				
Chi2(3)	8.39			
Prob>Chi2	0.0386			

Importantly, the results of this empirical research suggest that the heterogeneity in terms of objectives for the trading regions might be related to the *'imports, exports, or the need of exchange currencies'* (item *i8*) and to the *'protect against consistent currency volatility'* (item *i5*). The Table 28 shows the results of the tests.

Table 28. Strategic objectives and economic heterogeneity for four trading regions

The table summarises the decisions on the previous results related to the hypotheses tests.

Items	Null hypothesis	Decision
Item *i3*	The medians of the objective 'profiting from investments' (item i3) for four trading regions are equal. Market homogeneity related to this strategic objective.	Fail to reject
Item *i4*	The medians of the objective 'profiting as an intermediary' (item *i4*) for four trading regions are equal. Market homogeneity related to this strategic objective.	Fail to reject
Item *i5*	The medians of the objective 'protect against currency consistent currency volatility' (item *i5*) for four trading regions are equal. Market homogeneity related to this strategic objective.	Reject
Item *i6*	The medians of the objective 'protect against low or high historical prices' (item *i6*) for four trading regions are equal. Market homogeneity related to this strategic objective.	Fail to reject
Item *i7*	The medians of the objective 'protect against inflation' (item *i7*) for four trading regions are equal. This is agents' homogeneity related to this strategic objective.	Fail to reject
Item *i8*	The medians of the objective 'imports, exports or the simple need to exchange currencies' (item *i8*) for four trading regions are equal. Market homogeneity related to this strategic objective.	Reject
Item *i9*	The medians of the objective 'hedging purposes' (item *i9*) for four trading regions are equal. Market homogeneity related to this strategic objective.	Fail to reject

These results are important because they support a strand of the literature related to the geographic regions heterogeneity. They also provide a contribution that indicates the intrinsic heterogeneity as denoted by items *i5 and i8.* Moreover, they also imply evidence of the geographic regions homogeneity for the objectives represented by items *i1, i2, i3, i4, i6, i7,* and *i9.* These results might also indicate that pooling the data among countries from exporting or importing economies could bring about better explanatory and forecasting results. Also, the hypothesis decisions might also support the idea of controlling for regional levels of volatility tolerance.

4.1.3. Agents' strategic objectives and correlations

Adding to the above evidence on diverse agents groups' heterogeneity or homogeneity, a correlation test was conducted among items *i3* to *i9.* The test selected is the non-parametric Kendall's partial ranks correlations, because the items are ordinal from 1 to 7. The aim here is to confirm the presence of the presumable strong relationship between the strategic objectives proposed in this research. The theoretical implications of these results are very important as they contribute to understanding the agents' heterogeneity in terms of strategic objectives. The results are presented in the Table 29.

Table 29. Correlations for the strategic objectives

The table reports the Kendall's partial correlations test, which is often applied on ordinal measures and non-parametric settings. They permit a test of the null of independence versus the alternate hypothesis of independence.

Kendall's partial correlations

	i3	i4	i5	i6	i7	i8	i9
i3	1.0000						
i4	0.1232**	1.0000					
i5	0.2562***	0.3419***	1.0000				
i6	0.2056***	0.2715***	0.4307***	1.0000			
i7	0.2007***	0.1841***	0.4055***	0.3679***	1.0000		
i8	0.1743***	0.2082***	0.3980***	0.2779***	0.4141***	1.0000	
i9	0.1344**	0.1898***	0.3271***	0.2377***	0.3157***	0.3878***	1.0000

Significance levels * 10% ** 5% ***1%

As reported in the table above, there are significant levels for all the correlations among items. These results implicate that market objectives are mutually related and bring about more understanding on how heterogeneity takes place in the FX market. Therefore, the results suggest that the 'profiting' assumption from traditional economic models (or representative householder behaviour) should stress the relationship with other strategic objectives. The Table 30 summarises the tests of hypotheses.

Table 30. Strategic objectives and economic heterogeneity for four trading regions

The table summarises the decisions on the previous results related to the hypotheses tests.

Items	Null hypothesis	Decision
Items i3 to i9	The strategic objectives (items *i3* to i9) are mutually independent	Reject

The results above are contrasted using Kendall's partial correlations for each control groups in the survey as follows:

a) Agents with direct access to the interbank market and agents with indirect access
b) financial and non-financial institutions

The results suggest that strategic objectives are mutually dependent with some exceptions (see Table 31). The Kendall's correlations related to the control groups above generate the following results:

Table 31. Correlations by diverse control groups

The item *i3* represents the 'profit from investments'; *i4* is the 'profit as an intermediary'; *i5* symbolises a 'protect against currency consistent currency volatility'; *i6* represents a 'protect against low or high historical prices'; *i7* is 'protect against inflation'; *i8* denotes the 'imports, exports or the simple need to exchange currencies'; and finally item *i9* represents the objective 'hedging purposes'.

	Non-significant correlations
Agents with direct access to the interbank market	Correlation between *i3* and *i4* (*p-value 0.2467*)
Agents with indirect access	Correlation between items *i3* and *i8 (p-value 0.4382).* Correlation between items *i3* and *i9 (p-value 0.3393).* Correlations between items *i4* and *i7 (p-values 0.25).* Correlations between items *i4* and *i8 (p-values 0.12).* Correlations between items *i4* and *i9 (p-values 0.10).*
Financial institutions	None, all correlations are significant.
Non-financial organisations	Correlation between items *i3* and *i4 (p-value 0.1599).* Correlation between items *i3* and *i7 (p-value 0.1481).* Correlation between items *i3* and *i8 (p-value 0.6023).* Correlation between items *i3* and *i9 (p-value 0.9308).*

The non-significant correlations are an important finding as they suggest competing objectives within the interbank market.

Importantly, agents with no direct access to the market (customers) have less significant relations among the market objectives. Therefore, the customers (Agents with indirect access to the market) report more competing objectives in the market, as the correlations fail to reject the null hypotheses of independence. These findings lead to a conclusion that the strategic objective heterogeneity is more complex in the tier with indirect access to the market. This same finding applies to non -financial organisations. As can be seen in the Table 31, non-financial organisations have also competing strategic objectives as they have many independent strategic objectives.

The results above are very important because they highlight:

a) That the habitual objective ‘profiting from investments’ is related to other objectives for most of the time. There are few exceptions for non-financial institutions and customers, whose strategies compete in some cases to the ‘profit from investments’.
b) That the objective ‘profit from intermediation’ is associated with all the objectives within the financial institutions.

Kendall’s correlations were also calculated within four regions (Europe, Asia, American, and Africa). These results are presented in the appendix in chapter 4. Overall, these results are important for future research and can contribute to hypothesise the economic heterogeneity caused by geographic regions. The results generate the following findings:

a) The African region has a very different relationship among objectives compared to Europe, Asia, and America. This might be as a result of a lack of an important financial centre such as those found in Tokyo, Hong Kong, London, Frankfurt, Chicago or New York.

b) Item *i3* ‘profiting from investments’ and *i4* ‘profit from intermediation’ are associated only with the Asian region. The Asian region follows the trading time of America and Europe. This might be a reason why the Asian dealers appear to have more speculative positions together with the profits from the intermediation in the market. This result could be confirmed in future research by comparing the trading balances of the dealer at the end of the trading day.

c) Item *i5* ‘protect against consistent currency volatility’ is significantly related to profit from investments for Europe and Asia, whereas it is non-significant for America and the African region. This is probably because the American trading times generates the higher volatility, as this region’s macroeconomic releases tend to dominate in terms of volatility. The case of Africa is difficult to explain; perhaps the expected very low volatility from this continent’s trading time makes non-significant the protection against volatility. Briefly, the results appear to show that regions with very low and very high volatility generate high tolerance to risk.

4.1.4. Agents’ strategic objectives factor analysis

This analysis takes a step further by examining whether there are latent variables from the strategic objectives. The aim here is to find factors of strategic objectives within the market that might be used to explain and forecast the exchange rates empirically.

Before proceeding to the factor analysis, the Cronbachs' alpha statistic is computed with the aim of testing the unidimensional degree of a set of items measures or latent construct. Certainly, several researchers (e.g. Cortina 1993; Cronbach 1970; Green et al. 1977; and Revelle and Zinbarg 2009) indicate that alpha can have a very high result even when the set of items are unrelated. Therefore, alpha is better applied when the items measure different areas within a single academic concept or construct.

Table 32. Cronbachs' alpha statistic

The results reported in the table shows that dropping *i3* generates a Cronbach alpha equal to *0.7802*. The item *i3* represents the 'profit from investments'; *i4* is the 'profit as an intermediary'; and *i5* symbolises a 'protect against currency consistent currency volatility'; *i6* represents 'protect against low or high historical prices'; *i7* is 'protect against inflation'; *i8* denotes the 'imports, exports or the simple need to exchange currencies'; and finally item *i9* represents the objective 'hedging purposes'.

	item-test correlation	item-rest correlation	average interim	alpha
i3	0.4251	0.2641	1.4940	0.7802
i4	0.5874	0.4191	1.3064	0.7563
i5	0.7915	0.6860	1.0757	0.7014
i6	0.6769	0.5202	1.1884	0.7359
i7	0.6677	0.5118	1.2044	0.7377
i8	0.6837	0.5252	1.1751	0.7348
i9	0.6776	0.5087	1.1720	0.7388
Test scale				0.7706

This result indicates that the scale improves when *i3* is removed, and suggests that the items possess a 'good' internal consistency.

A factor analysis was performed as a method to reduce the number of strategic objectives. Again it has been shown that item *i3* does not load significantly even when oblique and orthogonal rotations are applied. The factors were computed using a principal-component factor, but the model is inappropriate due to the considerable uniqueness (a high uniqueness is considered above *0.6*). The same occurs using iterated principal factors (even if recalculating thereby forcing fewer factors). As a result, the squared multiple correlations are examined as a pre-estimation test to assess whether the variables have enough in common to use a factor analysis.

The results reported in Table 33 show that item *i3* (*smc 0.1696*) cannot be explained well from the other variables. The anti-image correlation and covariance matrices confirm the latter; therefore, it is not possible to obtain a low-dimensional reduction of the data.

Table 33. Squared multiple correlations (SMCs) and strategic objectives

The squared multiple correlations are a pre-estimation test to assess whether the variables have enough in common to use a factor analysis.

The item *i3* represents the 'profit from investments'; *i4* is the 'profit as an intermediary'; *i5* symbolises a 'protect against currency consistent currency volatility'; *i6* represents 'protect against low or high historical prices'; *i7* is 'protect against inflation'; *i8* denotes the 'imports, exports or the simple need to exchange currencies'; and finally item *i9* represents the objective 'hedging purposes'.

SMC - Squared Multiple correlations

Items	smc
i3	0.1696
i4	0.2886
i5	0.6076
i6	0.4189
i7	0.417
i8	0.4571
i9	0.3643

As a result, *i3* is removed from the analysis and the factor is conducted within items *i4* to *i9*.

The results for items *i4* to *i9* are much better for obtaining the low-dimensional data *(*SMCs are *0.2863*; *0.5782*; *0.4184*; *0.4157*; *0.4546*; *0.3631* for items *i4* to *i9* respectively).

The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy indicates that items *i4* to *i9* have a lot in common (all items have a KMO above *0.8* and an overall KMO *0.8340*).

As a result, the factor analysis was conducted using the polychoric correlation (for ordinal variables) and varimax rotation (orthogonal). The retained factors are two using a parallel analysis. The results are presented in Table 34.

Table 34. Factor Analysis items *i4 to i9*

Factor Analysis: principal factors, orthogonal varimax rotation

Factor	Variance	Cumulative
Factor 1	1.5480	0.6152
Factor 2	1.4187	1.1789

LR test, chi2(15) 454, Prob>Chi2 0.0000

Variable	Factor 1	Factor 2
i4		0.564
i5		0.648
i6		0.6115
i7	0.5848	
i8	0.677	
i9	0.5859	

These factor analysis results imply the following:

a) The objective ‘profit from investments’ (item *i3*) does not have a lot in common with items *i4* to *i9* representing the other strategic objectives to conform factors (Even though the correlation tests showed that *i3* is associated with the other objectives). The results imply that *i3* is not suitable to generate a latent variable using other objectives.

b) The uniqueness of item *i4* (*0.6512*) and its KMO (*0.2886*) might indicate the same, but at least in the case of item *i4* the KMO is higher than the one for *i3*.

c) Moreover, an ordered logistic regression was conducted to test if the ‘profit from investments is explained by the other strategic objectives but the results are exclusively significant for the ‘protect from currency volatility (item *i5*). This can lead to a suggestion that the ‘profit from investments’ (item *i3*) and presumably that the ‘profit from intermediation’ (item *i4*) are the main objectives.

d) Items *i4* to *i9* might conform to two factors. The first factor comprises items *i7*, *i8*, and *i9*; and the second factor items *i4*, *i5*, and *i6*.

This evidence on a microstructure of strategic objectives is a key contribution of this research. From the reasons discussed above, it is important to take the analysis a step further and hypothesize on a hierarchy of strategic objectives. This can be a topic of further research. In this connection, the Appendix in chapter 4 shows some preliminary results and a discussion related to some hierarchical structures for strategic objectives using hierarchical cluster analysis.

Another source of future research could be the relationship between strategic objectives and risk tolerance. This study used two measures of risk tolerance. However, contrary to the findings of Hanna and Lindamood (2004), this thesis did not find any strong or weak relationships between these two risk measures. These results may imply in Forex that the economic risk tolerance is not related to the organisational risk tolerance. The Appendix in Chapter 4 reports some results and discussion on this important topic.

4.1.5. Agents' trading management descriptive statistics

Before the analysis of trading management was done the Shapiro-Wilk test was conducted for normality. The *p- values* are less than *0.05* for items *i83* to *i88* (the six trading management dimensions). This means it is not rejecting the null of non-normality. Therefore, non-parametric tests are more suitable on these variables.

Items *i83* to *i88* are the averages of the items representing trading management strategies, i.e. 'command', 'planning', 'incremental', political, 'cultural', and 'enforced choice' respectively. Moreover, the Table 35 reports the descriptive statistics from the trading management items.

Table 35. Trading management descriptive statistics

Items *i83* to *i88* represent the trading strategies 'command', 'planning', 'incremental', political, 'cultural', and 'enforced choice' respectively.

Descriptive statistics

	i83	i84	i85	i86	i87	i88
mean	5.0825	5.7698	5.4314	4.4868	4.8512	3.5256
skewness	-0.6508	-1.053	-0.8495	-0.4194	-0.4266	0.3544
kurtosis	3.0003	3.7929	3.4347	2.1232	2.2068	2.1562
sd	1.5251	1.2328	1.379	1.9444	1.6849	1.8377
iqr	2.25	1.75	2.25	2.6667	2.5	3

The results show that 'planning' (item *i84*), 'incremental' (item *i85*) and 'command' (item *i83*) have a mean superior to five. These results suggest that this three trading strategies are the most important for the exchange rate determination. These results are highly important as they are strongly linked to the research questions.

There is a negative skewness for items *i83* to *i87,* and a positive one for item *i88* (*2.1561*). Also, the kurtosis shows that the central tendency is high ranging from *2.12* (for item *i86*) to *3.7929* (for item *i84).* Finally, in terms of the standard deviation the most disperse responses come from item *i86* which is the 'political' trading strategy (*1.9443*) followed by enforced choice (*1.8377*).

The results in the Table 36 show if there are significant correlations among items *i83* and *i88.* The Table 36 reports the results for the correlations.

Table 36. Kendall's partial correlation - trading strategies

Kendall's partial correlations

	i83	i84	i85	i86	i87	i88
i83	0.9279 1					
i84	0.291 0.321***	0.8854 1				
i85	0.286*** 0.311***	0.402*** 0.448***	0.908 1			
i86	0.257*** 0.279***	0.202*** 0.225***	0.304*** 0.334***	0.915 1		
i87	0.356*** 0.383***	0.266*** 0.293***	0.331*** 0.360***	0.398*** 0.411***	0.9334 1	
i88	-0.084* -0.091*	-0.110** -0.122**	-0.165*** -0.180***	-0.200*** -0.218***	-0.179*** -0.192***	0.9245 1

Significance levels: * 10% **5% ***1%

The Table 36 indicates that item *i88* 'enforced choice' has negative correlations with the other trading management dimensions. All correlations are significant at an alpha of 10%. The correlation between *i88'enforced choice'* and *i83* 'command' is the lowest, but significant at an alpha level equal to *0.0628.* Items *i84* 'planning' and *i85* 'incremental' have the highest correlation, followed by the correlation between items *i86* and *i87,* the trading strategies 'political' and 'cultural' respectively.

The results indicate that the null hypotheses of statistic independence, using Kendall's partial correlations for all items' combinations, are rejected. This means that trading strategies have a relationship of mutual dependency.

The same results are obtained when this study is controlled for the different types of control groups (e.g. direct or indirect access to the interbank market, financial and non-financial institutions). It can then be affirmed that the trading management strategies are mutually dependent and important in the exchange rates determination.

4.1.6. Agents' objectives and trading management

This section addresses the question of whether the agents' strategic objectives are explained by the trading management strategies. This study uses an ordered logistic regression to find statistical significance among the seven objectives and six trading strategy items. Overall, it is evidenced that there is a consistent explanatory relationship, as well as strong evidence suggesting that the objectives are explained by the trading management strategies.

Namely, item *i84* 'planning' evidences that there is an explanatory power over all the items representing the strategic objectives. Item *i83* 'command' has the same attribute, though with less explanatory power than 'planning'.

In other words, this study finds that a high degree of centralised control over the trading strategy (item *i83*), and a high degree of a planned and systematic analytical process, (*i84*) increases the odds of high importance within the strategic objectives.

The Table 37 report the results of this finding.

Table 37. Strategic objectives and - trading strategies

Panel 1 shows the logistic regression between *i3* 'profit from investments' (dependent variable) and *i84* 'planning' strategy (explanatory variable). Panel 2 shows the logistic regression between *i3* 'profit from investments' (dependent variable) and *i83* 'command' strategy (explanatory variable).

Logistic regression

LR Chi2(1)	8.67		LR Chi2(1)	3.95	
Prob > chi2	0.003		Prob > chi2	0.047	
Pseudo R2	0.0189		Pseudo R2	0.009	
Log Likelihood	-224.59		Log Likelihood	-226.95	
	Panel 1			Panel 2	
	Coef.	Std Err.		Coef.	Std Err.
i84	0.3548***	0.1205	i83	0.189**	0.9450
LR test			LR test		
Chi2(4)	5.68		Chi2(4)	2.27	
Prob>Chi	0.224		Prob>Chi	0.687	

The tables above support the assumption of the ordered logistic regression regarding proportionally odds across response categories. The results report the approximate likelihood-ratio tests for the regression between *i3* and *i84;* and *i3* and *i83* (Prob > chi2 equal to *0.2239* and *0.6865* respectively). The Brant test of the parallel regression assumption further supports the regression assumption (Prob > chi2 equal to *0.236* and *0.625* respectively).

Moreover, the odds of high importance of the objective 'profit from intermediation' increases with higher levels of item *i84* (coefficient is *0.3548*). The same applies for 'profit from investments' and item i83 'planning' (coefficient is *0.1890*). The estimation process compares the high categories with the combined middle and low categories. Likewise, the odds of the combined middle and high categories versus the low importance of the objective 'profit from intermediation' (profit from investments) are greater *0.3548* (*0.1889*).

Following the same interpretation above, a multiple ordered logistic regression was conducted for all the items representing the objectives as dependent variables, and items *i83* to *i88* as explanatory variables (command, planning, incremental, political, cultural, and enforced choice). The Table 38 reports the individual regressions and the best explanatory specification in terms of Pseudo R2.

Table 38. Ordered logistic regressions, objectives and trading strategies

The table reports simple and multiple ordered logistic regressions. The first column reports the strategic objectives. The item *i3* represents the 'profit from investments'; *i4* is the 'profit as an intermediary'; *i5* symbolises 'protect against currency consistent currency volatility'; *i6* represents 'protect against low or high historical prices'; *i7* is 'protect against inflation'; *i8* denotes the 'imports, exports or the simple need to exchange currencies'; and finally item *i9* represents the objective 'hedging purposes'. The second column reports the simple ordered logistic regressions with items *i83* to *i88* representing the trading strategies command, planning, learning, cultural, political, and enforced choice. The fifth column reports the best multiple logistic regressions in terms of pseudo R2.

Dependent	independent variable (individually)	Coef.	P > |z|	Best combined specification	Coef.	P > |z|
i3	i83	0.1889	0.047			
	i84	0.3549	0.003	i84	0.3549	0.003
	i88	-0.1461	0.064			
i4	i83	0.3681	0.000	i85	0.3404	0.001
	i84	0.4697	0.000	i87	0.2749	0.001
	i85	0.4480	0.000			
	i86	0.1921	0.003			
	i87	0.3685	0.000			
i5	i83	0.2441	0.004	i84	0.3796	0.001
	i84	0.5140	0.000	i87	0.3274	0.000
	i85	0.4500	0.000			
	i86	0.1591	0.017			
	i87	0.4119	0.000			
	i88	-0.1377	0.055			
i6	i83	0.3391	0.000	i84	0.4263	0.000
	i84	0.5477	0.000	i87	0.3646	0.000
	i85	0.3145	0.001			
	i86	0.2699	0.000			
	i87	0.4397	0.000			
i7	i83	0.3209	0.000	i84	0.574	0.000
	i84	0.6168	0.000	i86	0.162	0.020
	i85	0.3544	0.000			
	i86	0.2237	0.001			
	i87	0.3014	0.000			
i8	i83	0.2642	0.002	i84	0.266	0.012
	i84	0.3216	0.002	i86	0.189	0.006
	i85	0.2276	0.014			
	i86	0.2218	0.001			
	i87	0.2289	0.003			
i9	i83	0.2780	0.001	i84	0.280	0.006
	i84	0.3250	0.001	i86	0.195	0.003
	i85	0.3044	0.001			
	i86	0.2237	0.001			
	i87	0.2580	0.000			
	i88	-0.1620	0.020			

These ordered regression results have the following important implications:

a) Individually, items *i83* and *i84* (command and planning) can explain all the objectives (individual significance column in the table). This means that market events impacting the *Forex* organisations' control (*i83*) or planning (*i84*) might critically affect all the market structure. This could be tested in future research using non-planned news releases.

b) The multiple logistic regression shows that the objective 'profit from intermediation' (item *i4*) is better explained by items *i85* (learning) and *i87* (cultural) with a positive coefficient equal to *0.3404* and a *p-value 0.001*. This implies that learning and evaluating the uncertainties (item *i85*), and using models of reference to simplify the complexity of situations (item *i87*) are very important factors for the intermediation process. These two trading strategies represented by items *i85* and *i87* affect the intermediary agents the most.

c) The objectives represented by items *i5* 'protect against currency volatility' and *i6 '*protect against high or low historical prices' are explained by items *i84* (planning) and *i87 (cultural)* (for item *i5 the* coefficient is *0.3796* and *03274; P>|z| 0.001* and *0.000* respectively; and for *i6* coef. *0.4263* and *03646; P>|z| 0.000* and *0.000*). Factors or market events are positively (negatively) influencing the trading strategies oriented to planning (*i84*), and the power to explain the market complexity via models (*i87*) affects positively (negatively) those organisations pursuing the objectives to 'protect against currency volatility' and 'protect against high or low historical prices'.

d) In the table, the objectives denoted by items *i7*, *i8* and *i9* (protect against inflation, the simple need of currencies, and hedging, respectively) are explained by items *i84* and *i86* (planning and political strategies). The planned trading strategy is more important for *i7* than for *i8* and *i9 (*coef. *0.574, 0.162,* and

0.280, respectively). Market events affecting positively (negatively) *i84* and *i86* (planning and political strategies) affect positively (negatively) the objectives represented by items *i7* to *i9.*

e) Except for the item *i88* representing ’enforced choice’, individually, all the trading management strategies (*i83* to *i87)* explain objectives denoted by items *i4* to *i9* (item *i3* is explained individually just by *i83, i84,* and weekly by *i88*). This might imply that diverse types of news have diverse impacts and effects on market agents. This can be a topic for further research.

f) Also, it is pinpointed that the multiple logistic regressions (best specifications) denote similarities with the groups analysed in both their factor analysis and hierarchical cluster analysis.

g) Item *i88* ‘enforced choice’ has a strong causal relationship with item *i9.* When strategies tend to be externally and commonly imposed (*i88*) they generate negative effects on ‘hedging purposes’ (item *i9*).

4.1.7. Agents’ objectives and strategic content

The study of the strategic content is also a central topic of this research. Are the odds of high scores in the strategic objectives related to the high scores in the type of information used by traders? The answer to this question would suggest whether the agents are heterogeneous in terms of this type of information.

The items *i55* to *i66* measured the importance of the four variables (i.e. order flow, fundamentals, chart indicator, and correlated asset) at three different time frequencies: high frequency (tick to 30 minutes), moderately high (1 hour to daily), and low frequencies (weekly to yearly).

The following items represent the agents’ strategic information:

d) i55’order flow at very high frequency’

e) i56 ‘fundamentals at very high frequency’

f) i57 ‘chart indicator at very high frequency’

g) i58 ‘correlated asset at very high frequency’

h) i59 ‘order flow at moderate high frequency’

i) i60 ‘fundamentals at moderate high frequency’

j) i61 ‘chart indicator at moderate high frequency’

k) i62 ‘correlated asset at moderate high frequency’

l) i63 ‘order flow at low frequency’

m) i64 ‘fundamentals at low frequency’

n) i65 ‘chart indicator at low frequency’

o) i66 ‘correlated asset at low frequency’

From the items above only *i57, i61*, and *i66* are non-normal. The Shapiro-Wilk test for normal data was conducted on items *i55* to *i66* with a significant value that impedes to reject the null of non-normality.

The Kendall’s partial correlations among item *i55* to *i66* are all significant. The results are reported in the Appendix in Chapter 4. Importantly, as expected these results suggest the rejection of the null hypothesis of competing sources of used strategic information from agents. This research also computed the results controlling for two groups (direct or indirect access to the market; and financial and non-financial institutions), and the results indicate the same findings.

In order to find out if certain strategic variables increase or decrease the odds of high or low strategic objectives scores, order logistic regression is performed. The Table

39 reports the results for items *i3* to *i9* representing the objectives, and items *i55* to *i66* the strategic content.

Table 39. Ordered logistic regressions objectives versus strategic content

In the table, *i55* is the ’order flow at very high frequency’, *i56* is the ‘fundamentals at very high frequency’, *i57* is the ‘chart indicator at very high frequency’, *i58* is the ‘correlated asset at very high frequency’, *i59* is the ‘order flow at moderate high frequency’, *i60* is the ‘fundamentals at moderate high frequency’, *i61* is the ‘chart indicator at moderate high frequency’, *i62* is the ‘correlated asset at moderate high frequency’, *i63* is the ‘order flow at low frequency’, *i64* is the ‘fundamentals at low frequency’, *i65* is the ‘chart indicator at low frequency’, and *i66* is the ‘correlated asset at low frequency’. Moreover, the item *i3* represents the ‘profit from investments’; *i4* is the ‘profit as an intermediary’; *i5* symbolises ‘protect against currency consistent currency volatility’; *i6* represents ‘protect against low or high historical prices’; *i7* is ‘protect against inflation’; *i8* denotes the ‘imports, exports or the simple need to exchange currencies’; and finally item *i9* represents the objective ‘hedging purposes’. The first column shows the dependent variable, the remaining columns report the explanatory variables in each regression.

	i55	i56	i57	i58	i59	i60	i61	i62	i63	i64	i65	i66
i3												
i4	0.12027		0.142626	0.121349	0.129058			0.151993				
	0.04		0.021	0.064	0.04			0.017				
i5	0.195054	0.142079	0.254375	0.170921	0.188813	0.181396	0.218441	0.182453				
	0.001	0.019	0.000	0.011	0.003	0.007	0.001	0.004				
i6	0.180885	0.102054	0.1826	0.163404	0.142091			0.168094	0.143802	0.122894	0.115507	
	0.002	0.087	0.003	0.013	0.023			0.008	0.025	0.044	0.069	
i7	0.215053	0.192052	0.142615	0.189305	0.143365	0.133763		0.195528				
	0.000	0.002	0.022	0.004	0.024	0.048		0.003				
i8	0.110825			0.176175								
	0.059			0.008								
i9	0.120824	0.157359		0.147564	0.134383	0.19401						
	0.035	0.009		0.022	0.031	0.004						

These ordered regression results have the following important implications:

a) The objective ‘profit from investments’ (item *i3*) is not explained by any strategic variable. This finding can be a subject of further research. The fact that this objective is explained by the trading strategies, and not by the strategic information brings about the question of whether it is possible to improve the empirical results on exchange rate determination. The chapter on combined results will address this point.

b) The type of information ‘correlated asset at low frequencies’ (item *i66*) do not increase the odds of higher scores in any objective. Conversely, at very high frequencies, ‘correlated assets’ is related to the odds of high scores in the strategic objectives represented by items *i4* to *i9* (see Table 39). The 'correlated assets' are also significant at moderately high frequencies to explain the objectives *i4* to *i7*. This finding might be also subject future research.

c) Variables at low frequencies (items *i63* to *i66*) have considerably less significant results among objectives and strategic contents. Market agents increase their odds of high scores in the objective 'protect against low or high historical prices' (item *i6*) only when at low frequencies the scores from either 'order flow', 'fundamentals' or 'chart indicator' are high. For the variables at low frequencies, 'order flow' (*i63*) has the higher coefficient (*0.1438*) and lower *p-value (0.025).*

d) The results suggest that order flow, technical analysis and fundamentals explain the objective 'protecting against low and high historical prices'.

e) The objective 'the simple need of currencies, exports or imports' is only explained at high frequencies by 'order flow' (coef. *0.110825* P>|z| *0.*059), and especially by a 'correlated asset' (coef. *0.176175* P>|z| *0.008*).

f) Distinctively from the strategic variables, the 'order flow' explains the objectives scores at high, moderately high, and low frequencies (items *i55, i59,* and *i63*). Overall, observing the coefficients and the number of objectives explained in the Table 39, it can be concluded that the order flow is more important at high frequencies than at moderately high frequencies. This finding supports the previous evidence on strong order flow explanatory power. This study contributes to the literature by providing one reason why order flow decreases its explanatory power at low frequencies.

g) At high the frequencies the Chartist indicators (items *i57, i61.* and *i65*) explain many objectives (*i4* to *i7*). Chartist indicators at very high frequencies and moderately high frequencies (item *i57*and *i61* respectively) explain item *i5* 'protect against currency volatility' (high frequencies: coef. *0.2543* P>|Z| *0.000;* moderately high frequencies: coef. *0.218441* P>|Z| *0.001*).

h) Fundamentals explain the odds of high scores on 'protect against currency volatility', 'protect against inflation', and 'hedging', at both very high frequencies and moderately high frequencies.

4.1.8. Agents' trading strategies and strategic information

The trading strategies together with the strategic information are key concepts to this research. If significant relationships are founded, the results might be the subject of econometric analysis; they also would be of importance for the trading strategy literature.

The Table 40 presents the results of the individual regressions between each trading strategy (item *i83* to *i88*) and each strategy variable at different time frequencies (item *i55* to *i66*).

Table 40. Ordered logistic regression for the Trading strategies and strategic variables

The table reports simple ordered logistic regressions for items i83 to i88 representing the trading strategies (dependent variable), this is in order command, planning, learning, cultural, political, and enforced choice. In the table, *i55* is the 'order flow at very high frequency', *i56* is the 'fundamentals at very high frequency', *i57* is the 'chart indicator at very high frequency', *i58* is the 'correlated asset at very high frequency', *i59* is the 'order flow at moderate high frequency', *i60* is the 'fundamentals at moderate high frequency', *i61* is the 'chart indicator at moderate high frequency', *i62* is the 'correlated asset at moderate high frequency', *i63* is the 'order flow at low frequency', *i64* is the 'fundamentals at low frequency', *i65* is the 'chart indicator at low frequency', and *i66* is the 'correlated asset at low frequency'. Items highlighted in a grey colour denote the best regression in terms of the pseudo R2.

	i55	i56	i57	i58	i59	i60	i61	i62	i63	i64	i65	i66
i83				0.1931				0.1155	0.1079		0.0990	
				0.001				0.062	0.080		0.099	
i84	0.1655	0.1450	0.1435		0.1209	0.1606	0.1271					
	0.004	0.018	0.018		0.05	0.015	0.042					
i85	0.1848	0.1906	0.1405	0.1472	0.1810	0.1675	0.1571	0.2185	0.1238	0.1047	0.1016	
	0.001	0.002	0.017	0.021	0.003	0.010	0.014	0.000	0.044	0.075	0.093	
i86				0.1151	0.1051							
				0.077	0.083							
i87	0.0959			0.1251					0.1717			
	0.086			0.053					0.006			
i88		0.1238				0.1169				0.1441	0.1482	
		0.036				0.073				0.014	0.013	

The results were tested for the assumption of proportionality of odds. The assumption was confirmed using both the approximate likelihood-ratio test and the Brant test. The results above show that the trading strategy represented by item *i83* (command) has a significant relationships with the strategic information represented by items *i58*, *i62*, *i63,* and *i65.*

The ‘Command’ (*i83*) strategy is better explained by the ‘correlated asset’ at very high frequencies (*i58*). ‘Planning’ (*i84*) is better explained by ‘order flow’ at very high frequencies (*i55*). ‘Learning’ (*i85*) is explained by many items (*i55* to *i65*).Nonetheless, the best regression comprises of ‘order flow’ at very high frequencies (i55), and ‘correlated assets’ at moderately high frequencies (*i62*). ‘Political’ (*i86*) is better explained by ‘order flow’ at moderately high frequencies (*i59*), but the level of significance is low (P > |z| *0.083*). ‘Cultural’ (*i87*) is better explained by order flow at low frequencies (*i63*); and lastly, ‘enforced choice’ (*i88*) is better explained by ‘fundamentals’ at very low time frequencies (*i64*).

The following implications can be taken from these results:

a) The ‘command’ and ‘planning’ trading strategies appear to be explained more by strategic information at very high frequencies. Firstly, by the ‘command’ trading strategy, symbolising the control and the rigid influence on the strategy. Secondly by the ‘planning’ trading strategy, representing the evaluation and the analysis by means of formal procedures.

b) The ‘incremental’ trading strategy is related to all the variables at all frequencies with one exception, which is the correlated assets at very high frequencies. The ‘incremental’ trading strategy is characterised by a learning process on the market uncertainties and the self-strategy. The ‘incremental’ trading strategy is for the most part explained by order flow at high frequencies and correlated assets at moderately high frequencies.

c) The 'political' trading strategy is the less explained by the strategic variables. Minimally, correlated assets at high frequencies, and particularly order flow at moderately high frequencies might explain the odds of high scores within this trading strategy (P > |z| *0.077* and *0.083*). The 'political' trading strategy denotes the efforts to influence the market, habitually, through coalitions.

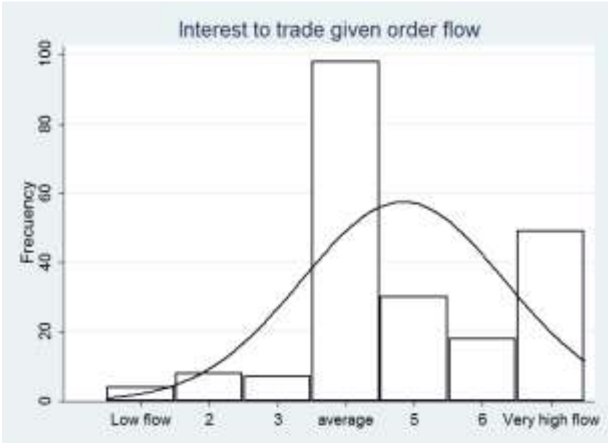
d) There are two trading strategies related particularly to low frequencies. First, the 'cultural' trading strategy indicates the use of reference frames to simplify the complexity of market situations. This trading strategy is explained for the most part by order flow at low frequencies. Second, the 'enforced choice' trading strategy represents the coercion of the market on the strategy through imposition of activities that best fit the market. This trading strategy is explained by the strategic variables related to 'fundamentals', particularly, at low frequencies.

e) Chart indicators are particularly related to 'command' 'planning at very high and moderately high frequencies, and with 'enforced choice' at very low time frequencies.

Adding to all the findings in this chapter, this study also explored the possible influence of the concept of 'induced trade' as explained in the literature review. The concept of induced trade is important as it is related to the trading strategies. The results here have confirmed the evidence, as found in the literature, regarding the importance of order flows from different sizes. Previously, this study computed the Shapiro-Wilk test for normality on a variable representing the interest to trade given order flow. The results showed that it is not possible to reject the null of non-normality.

Figure 11. Histogram item *i68*

The figure shows that the 'interest to trade given order flow' is high when traders are exposed to 'normal' order flows; these results give some support to the concept of induced trades. The results show; however, a weak tendency for very high order flows.



Regarding the relationship with trading objectives, the odds of higher scores in item *i68* is explained individually by higher scores in the trading objectives *i4* to *i9* (not item *i3* (see ordered logistic regressions in the Appendix for Chapter 4). This item has a close positive relationship with the trading strategies. Particularly, item *i87* 'cultural' (P > |z| *0.040*); item *i85* 'incremental' (P > |z| *0.001*); and item *i84* 'planning' (P > |z| *0.004*) explains the high odds in the scores of the intentions given order flow. These results reinforce the importance of empirically researching the trading strategies as a very important element in the exchange rates determination. The following chapters will introduce the estimation methods and the procedure to estimate the trading strategies variables.

Appendix – Chapter 4

Table 41. Kendall's partial correlations, items *i3* to *i9,* agents with direct access to the interbank market

	i3	i4	i5	i6	i7	i8	i9
i3	0.5111 1.0000						
i4	0.0572 0.0936 0.2467	0.7317 1.0000					
i5	0.1283 0.2040 0.0101	0.3094 0.4111 0.0000	0.7741 1.0000				
i6	0.1005 0.1638 0.0416	0.2156 0.2936 0.0002	0.2523 0.3341 0.0000	0.7370 1.0000			
i7	0.1344 0.2162 0.0068	0.2195 0.2951 0.0001	0.2610 0.3411 0.0000	0.2227 0.2983 0.0001	0.7565 1.0000		
i8	0.1579 0.2570 0.0013	0.2073 0.2820 0.0003	0.3701 0.4894 0.0000	0.2636 0.3572 0.0000	0.3481 0.4657 0.0000	0.7388 1.0000	
i9	0.1141 0.1791 0.0235	0.1828 0.2397 0.0017	0.2882 0.3675 0.0000	0.1518 0.1984 0.0094	0.2589 0.3339 0.0000	0.2729 0.3562 0.0000	0.7945 1.0000

Table 42. Kendall's partial correlations, items *i3* to *i9,* agents with indirect access

	i3	i4	i5	i6	i7	i8	i9
i3	0.5036 1.0000						
i4	0.1059 0.1668 0.0523	0.8002 1.0000					
i5	0.2026 0.3337 0.0001	0.2089 0.2730 0.0009	0.7319 1.0000				
i6	0.1713 0.2731 0.0015	0.1980 0.2504 0.0019	0.4184 0.5532 0.0000	0.7814 1.0000			
i7	0.1063 0.1844 0.0368	0.0685 0.0943 0.2560	0.3192 0.4595 0.0000	0.3196 0.4452 0.0000	0.6594 1.0000		
i8	0.0420 0.0670 0.4382	0.0970 0.1227 0.1295	0.2349 0.3108 0.0002	0.1521 0.1948 0.0163	0.2855 0.3979 0.0000	0.7806 1.0000	
i9	0.0525 0.0815 0.3393	0.1053 0.1296 0.1050	0.2036 0.2621 0.0012	0.2329 0.2902 0.0003	0.2228 0.3022 0.0002	0.3414 0.4256 0.0000	0.8244 1.0000

Table 43. Kendall's partial correlations, items *i3* to *i9*, financial institutions

	i3	i4	i5	i6	i7	i8	i9
i3	0.5523						
	1.0000						
i4	0.0922	0.7773					
	0.1407	1.0000					
	0.0577						
i5	0.1914	0.3118	0.7698				
	0.2936	0.4031	1.0000				
	0.0001	0.0000					
i6	0.1075	0.2956	0.3075	0.7553			
	0.1664	0.3858	0.4032	1.0000			
	0.0256	0.0000	0.0000				
i7	0.1163	0.1650	0.2991	0.2735	0.7398		
	0.1819	0.2176	0.3964	0.3659	1.0000		
	0.0150	0.0024	0.0000	0.0000			
i8	0.1394	0.1226	0.3340	0.2101	0.2995	0.7342	
	0.2189	0.1623	0.4443	0.2821	0.4063	1.0000	
	0.0034	0.0237	0.0000	0.0001	0.0000		
i9	0.1387	0.1590	0.2794	0.1772	0.2955	0.3018	0.7971
	0.2090	0.2020	0.3567	0.2284	0.3848	0.3945	1.0000
	0.0045	0.0042	0.0000	0.0013	0.0000	0.0000	

Table 44. Kendall's partial correlations, items *i3* to *i9*, non-financial institutions

	i3	i4	i5	i6	i7	i8	i9
i3	0.4337						
	1.0000						
i4	0.0783	0.7923					
	0.1336	1.0000					
	0.1599						
i5	0.1520	0.2427	0.7593				
	0.2649	0.3129	1.0000				
	0.0055	0.0004					
i6	0.1182	0.1457	0.4019	0.7923			
	0.2016	0.1839	0.5181	1.0000			
	0.0331	0.0371	0.0000				
i7	0.0780	0.1222	0.3227	0.2616	0.7263		
	0.1390	0.1611	0.4346	0.3449	1.0000		
	0.1481	0.0721	0.0000	0.0001			
i8	0.0293	0.1566	0.2823	0.1933	0.3158	0.8029	
	0.0496	0.1964	0.3615	0.2424	0.4136	1.0000	
	0.6023	0.0258	0.0000	0.0057	0.0000		
i9	0.0052	0.1509	0.2596	0.2613	0.1982	0.3058	0.8379
	0.0086	0.1852	0.3255	0.3207	0.2541	0.3728	1.0000
	0.9308	0.0335	0.0002	0.0002	0.0039	0.0000	

Table 45. Kendall's partial correlations, items *i3* to *i9,* Europe

	i3	i4	i5	i6	i7	i8	i9
i3	0.5549						
	1.0000						
i4	-0.0790	0.8071					
	-0.1180	1.0000					
	0.3125						
i5	0.2027	0.2082	0.7834				
	0.3074	0.2619	1.0000				
	0.0084	0.0182					
i6	0.1132	0.2306	0.4410	0.7966			
	0.1703	0.2876	0.5582	1.0000			
	0.1433	0.0091	0.0000				
i7	0.0608	0.2208	0.3082	0.1845	0.7827		
	0.0923	0.2778	0.3936	0.2336	1.0000		
	0.4335	0.0124	0.0004	0.0354			
i8	0.0769	0.2327	0.4354	0.3445	0.3529	0.8022	
	0.1152	0.2892	0.5492	0.4309	0.4454	1.0000	
	0.3244	0.0089	0.0000	0.0001	0.0001		
i9	0.1111	0.2488	0.3802	0.3152	0.3159	0.4249	0.8281
	0.1639	0.3043	0.4720	0.3880	0.3923	0.5213	1.0000
	0.1564	0.0055	0.0000	0.0004	0.0004	0.0000	

Table 46. Kendall's partial correlations, items *i3* to *i9,* Asia

	i3	i4	i5	i6	i7	i8	i9
i3	0.5001						
	1.0000						
i4	0.1352	0.7925					
	0.2147	1.0000					
	0.0061						
i5	0.1598	0.2988	0.7902				
	0.2542	0.3776	1.0000				
	0.0012	0.0000					
i6	0.0856	0.2423	0.2488	0.7680			
	0.1381	0.3106	0.3194	1.0000			
	0.0798	0.0000	0.0000				
i7	0.0746	0.0872	0.2475	0.2202	0.7378		
	0.1229	0.1140	0.3242	0.2925	1.0000		
	0.1219	0.1284	0.0000	0.0001			
i8	0.0433	0.0528	0.2260	0.1104	0.2624	0.7643	
	0.0700	0.0679	0.2909	0.1441	0.3494	1.0000	
	0.3745	0.3616	0.0001	0.0540	0.0000		
i9	0.0630	0.1091	0.2089	0.1508	0.2201	0.2222	0.8271
	0.0979	0.1348	0.2585	0.1893	0.2817	0.2795	1.0000
	0.2061	0.0650	0.0004	0.0100	0.0001	0.0001	

Table 47. Kendall's partial correlations, items *i3* to *i9,* America

	i3	i4	i5	i6	i7	i8	i9
i3	0.4733						
	1.0000						
i4	0.0533	0.7233					
	0.0911	1.0000					
	0.6337						
i5	0.1500	0.3800	0.7367				
	0.2540	0.5206	1.0000				
	0.1633	0.0025					
i6	0.2633	0.3900	0.5933	0.7733			
	0.4353	0.5214	0.7861	1.0000			
	0.0155	0.0024	0.0000				
i7	0.2333	0.4100	0.5633	0.6333	0.6967		
	0.4063	0.5776	0.7864	0.8629	1.0000		
	0.0259	0.0009	0.0000	0.0000			
i8	0.2533	0.2733	0.4233	0.4700	0.4000	0.7900	
	0.4143	0.3616	0.5549	0.6013	0.5392	1.0000	
	0.0209	0.0355	0.0011	0.0004	0.0017		
i9	0.0800	0.3533	0.3967	0.3333	0.3500	0.4467	0.8100
	0.1292	0.4616	0.5135	0.4212	0.4659	0.5584	1.0000
	0.4805	0.0066	0.0023	0.0125	0.0063	0.0009	

Table 48. Kendall's partial correlations, items *i3* to *i9,* Africa

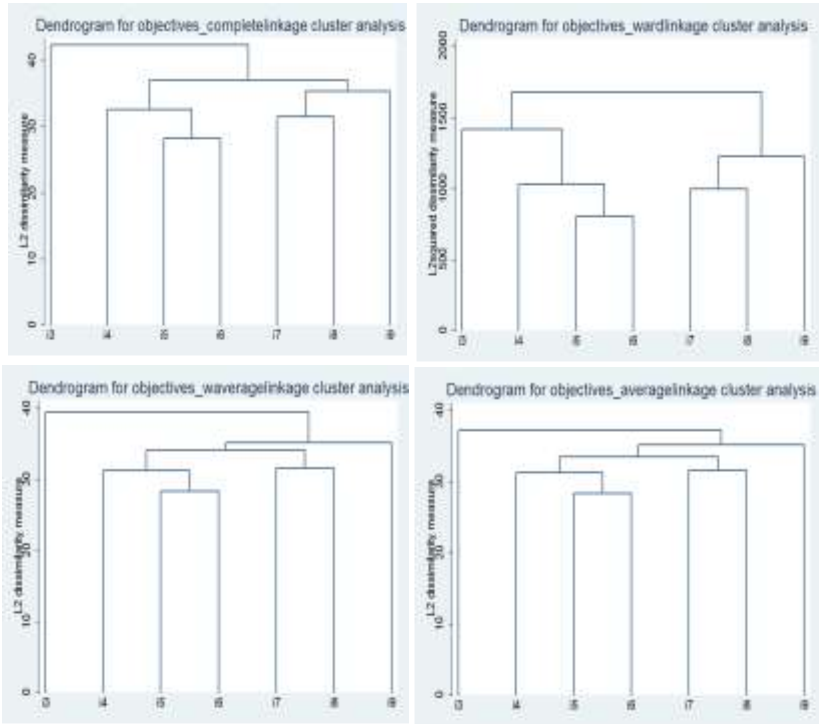
	i3	i4	i5	i6	i7	i8	i9
i3	0.5074						
	1.0000						
i4	0.2279	0.7426					
	0.3713	1.0000					
	0.0991						
i5	0.1471	0.2132	0.4191				
	0.3189	0.3822	1.0000				
	0.1862	0.0953					
i6	0.1103	0.0000	0.2794	0.7279			
	0.1815	0.0000	0.5059	1.0000			
	0.4423	1.0000	0.0278				
i7	0.1103	-0.0735	0.1471	0.2647	0.5662		
	0.2058	-0.1134	0.3019	0.4123	1.0000		
	0.3950	0.6397	0.2111	0.0692			
i8	0.0662	0.2132	0.0809	-0.0735	0.1250	0.5662	
	0.1235	0.3288	0.1660	-0.1145	0.2208	1.0000	
	0.6269	0.1453	0.5104	0.6403	0.3577		
i9	0.0588	-0.0588	-0.0441	0.0882	0.0588	0.2868	0.7206
	0.0973	-0.0804	-0.0803	0.1218	0.0921	0.4490	1.0000
	0.6985	0.7403	0.7644	0.6031	0.7140	0.0467	

Agents' strategic objectives hierarchy

The results presented here still bring about the question of whether the objectives follow a hierarchical pattern. The cluster analysis provides several hierarchical and partition methods for observations. Hierarchical methods are preferred over partition methods because the relationship among groups is important in this research. The central mechanism in the hierarchical cluster analysis comprises the similarity or dissimilarity measure to compare between two observations, and is called the linkage method.

The single linkage method is discarded for the analysis of the Forex strategic objectives, because the dissimilarity measure is given by the closest pair of observations between the two groups (i.e. the objectives). And because the closest points between the two groups (two strategic objectives) determines the next merger; therefore, this suggests that thin clusters might result in the process. Of course, in this case the results are not appropriate as the groups (strategic objectives) have different levels of similarity (dissimilarity). The Figure 12 reports the average linkage, the waver linkage, the wards linkage and the complete linkage.

Figure 12. Hierarchical cluster dendrograms strategic objectives (items *i3* to *i9*)



From the dendograms above are noted important aspects to hypothesize empirically within the ER field:

a) Confirming the factor analysis results the four linkage methods, strategic objectives represented by items *i4*, *i5*, and *i6* conform to a first group of strategic objectives which is led by item *i4*.

b) There is a second group of objectives comprising the objectives represented by items *i7* and *i8*, which are the ‘protect from inflation’ and ‘the simple need of a currency, exports and imports’.

c) The items *i3* and *i9* ‘profit from investments’ and ‘hedging purposes’ respectively, are the more dissimilar strategic objectives. And they are also competing in all dendrograms for the highest hierarchy.

d) From the four panels in the figure above, it is possible to hypothesize three structures of strategic objectives, as being complete and the waver linkage having an equal structure.

Agents' strategic objectives and risk tolerance

An ordered logistic regression was performed in order to research if there is a causal relationship between the risk tolerance (item *i15*) as a dependable variable of the market objectives. The remind item *i15* was developed by the National Opinion Research Center at the University of Chicago, and was initially sponsored by the Federal Research Board. The item is known in the literature on risk assessment as SCF. The aim here is to answer the question of whether there is a causal relationship among the items representing the objectives and the risk.

The expected results based on the assumptions from macro and micro economic models are consistent with the 'profiting' homogeneous behaviour together with the risk-averse agents. This implies, that the regression will produce significant and coefficient-negative results for items *i3* and *i4* representing the agents whose main objective is either profiting from investments or from intermediation. Moreover, even when there is no theoretical support, it is expected to see similar results for items *i5* to *i7,* as these items imply protecting from particular risks is needed, i.e. currency volatility, low or high historical prices, and inflation. The greater the importance of these objectives could imply less risk tolerance. It is also expected that there will be a significant causal relationship between risk tolerance and items *i8* and *i9.* Nonetheless in the above, only items *i3,* and especially *i4* are significant. The results for item *i4* (P>|z| = *0.057*) are presented in Table 49.

Table 49. Strategic objective: 'profit from intermediation' and risk tolerance item *i15*

```
Iteration 0:   log likelihood = -297.02413
Iteration 1:   log likelihood = -295.19956
Iteration 2:   log likelihood = -295.19809
Iteration 3:   log likelihood = -295.19809

Ordered logistic regression                       Number of obs   =        215
                                                  LR chi2(1)      =       3.65
                                                  Prob > chi2     =     0.0560
Log likelihood = -295.19809                       Pseudo R2       =     0.0061
```

i15	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
i4	-.1259611	.0661559	-1.90	0.057	-.2556242	.003702
/cut1	-1.69209	.3769186			-2.430837	-.9533432
/cut2	-.4526165	.3579905			-1.154265	.249032
/cut3	.6596246	.360092			-.0461427	1.365392

The results show the iteration log that fits the model until the difference in the log likelihood between successive iterations becomes sufficiently small. The final log likelihood (*-295.19809*) can be used in the comparison of the nested models. The likelihood ratio with chi-square *3.65* and *p-value 0.0560* indicates that the model is statistically significant (slightly high than a 5% alpha level), as compared to the null model with no predictors. The coefficient is negative (-*.1259*) indicating that low risk tolerance (high risk aversion) is expected when the objective represented by item *i4* 'profit from intermediation' becomes more important. It is expected that a *0.12* decrease in the logarithmic odds will be in the highest levels of risk tolerance from a one unit increase in the item *i4*. The cutting points at the bottom of the output indicate where the latent variable is cut to make the four groups as observed in the data.

Moreover, the regression was also computed displaying the proportional odds ratios. For the one unit increase in the item *i4* the odds of high risk tolerance decrease versus the combined middle and low categories which are *0.8816491* higher. Likewise, the odds of the combined middle and high categories versus low risk tolerance are greater (*0.8816491)*.

Of course, the ordered logistic regression assumes that the relation between each pair of outcome groups is the same. More precisely, 'the proportional odds assumption' or 'the parallel regression assumption' states that the coefficients describing the relationship between e.g. the lowest versus all the higher categories of the variable are the same as those describing the relation between the next lowest category and all high categories. The approximate likelihood-ratio test was conducted of proportionality of odds across response categories. The results report a chi-square equal to *1.43* and a *Prob* > chi-square equal to *0.4894,* in other words, the referred assumption holds. The result is verified using the Brant test of parallel regression assumption (chi-square *1.22, Prob* > chi-square *0.543*). Both tests indicate that the assumption of the proportional odds holds.

The ordered logistic regression was also conducted using *i3*. However, the results are significant just at a $P>|z|=0.071$. The coefficient is also negative (*-0.1444*) following a similar interpretation for item *i4.* Finally, both the approximate likelihood-ratio test and the Brant test are conducted, and their results support the 'proportional odds assumption' (see Table 50)

Table 50. Strategic objective: 'profit from investments' and risk tolerance item *i15*

```
Iteration 0:   log likelihood = -297.02413
Iteration 1:   log likelihood = -295.37226
Iteration 2:   log likelihood = -295.37107
Iteration 3:   log likelihood = -295.37107

Ordered logistic regression                       Number of obs   =        215
                                                  LR chi2(1)      =       3.31
                                                  Prob > chi2     =     0.0690
Log likelihood = -295.37107                       Pseudo R2       =     0.0056
```

i15	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
i3	-.1444219	.0800153	-1.80	0.071	-.301249	.0124052
/cut1	-1.934911	.5202898			-2.95466	-.9151614
/cut2	-.7040655	.5074467			-1.698643	.2905117
/cut3	.4012832	.5087982			-.5959429	1.398509

The ordered logistic regression was conducted also separately by groups and the results are non-significant. These results support the assumptions of classical economic models, but not the microstructures models based on agents with and without access to the interbank market. The significant results might mean that there is an inverse relation with risk tolerance, and the objectives that presumably are primary in the Forex market (profiting from investments and intermediation). However, risk aversion (risk tolerance) appears not to have any causal relation with the objectives represented by items *i5* to *i9.* Moreover, it was indeed expected that there would be a strong significant causal relation among all items representing the objectives and this particular risk tolerance measure. One explanation of these results might be that the item *i15,* representing the SCF measure, indicates self-risk aversion. Therefore, the items *i3* and *i4* representing organisation internal strategic objectives, i.e. not dependable from the environment are more prone to relate to the SCF measure.

This research also applied the graphic-based survey instrument (item *i78* here) developed by Hanna and Lindamond (2004) and based on Hanna et al. (2001). The measure of the risk is based on gambles scenarios that might be more prone to measure the economic risk than the organisational risk. An ordered logistic regression was conducted using as a dependent variable, the risk; and as independent variable, the objectives. Together and individually, the risk measure from item *i78* is found to be non-significant with respect to the objectives. Moreover and opposed to the results with the item *i15*, the items *i3* and *i4* are non-significant with *0.140* *0.593* p-values respectively. The items *i78* and *i15* are not correlated (Kendall's correlation Prob > |z| = *0.5654*), not even discriminating among groups such as direct or indirect access to the market; or financial and non-financial institutions.

These results, have cast doubts on the findings of Hanna and Lindamood (2004). They have claimed a strong and significant relationship between these two risk measures. Contrary, the results are in line with Hanna et al. (2001), in other words, a non-significant correlation. These results imply that market agents are not consequent with the risk required by the organisation, and the economic risk applied in the real economic environment? There is not an obvious explanation to this result. However, I can conclude that both measures do not evidence any relation between risk and the objectives represented by items *i5* to *i9.* The results generate more questions than answers; how then can the market agents mitigate the risk associated with the Forex transactions? This might be a research question for future empirical investigation.

Table 51. Kendall's partial correlations strategic content – type of variables.

	i55	i56	i57	i58	i59	i60	i61	i62	i63	i64	i65	i66
i55	0.8426											
	1.0000											
i56	0.3956	0.8501										
	0.4674	1.0000										
	0.0000											
i57	0.3369	0.3701	0.8394									
	0.4006	0.4381	1.0000									
	0.0000	0.0000										
i58	0.3269	0.3799	0.2953	0.8564								
	0.3848	0.4452	0.3483	1.0000								
	0.0000	0.0000	0.0000									
i59	0.4342	0.3617	0.2572	0.2478	0.8570							
	0.5109	0.4238	0.3032	0.2892	1.0000							
	0.0000	0.0000	0.0000	0.0000								
i60	0.2655	0.4475	0.2857	0.2970	0.4001	0.8537						
	0.3130	0.5253	0.3375	0.3473	0.4677	1.0000						
	0.0000	0.0000	0.0000	0.0000	0.0000							
i61	0.2356	0.3138	0.4430	0.2553	0.3448	0.4009	0.8313					
	0.2815	0.3733	0.5303	0.3026	0.4085	0.4758	1.0000					
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000						
i62	0.3009	0.3660	0.2985	0.4810	0.3530	0.3412	0.3613	0.8594				
	0.3536	0.4282	0.3514	0.5607	0.4114	0.3983	0.4275	1.0000				
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000					
i63	0.3069	0.2490	0.1606	0.2098	0.3960	0.2593	0.2118	0.2974	0.8414			
	0.3645	0.2945	0.1911	0.2471	0.4664	0.3059	0.2533	0.3497	1.0000			
	0.0000	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000				
i64	0.2293	0.3170	0.3311	0.2744	0.2626	0.3892	0.3916	0.3196	0.3747	0.8519		
	0.2707	0.3725	0.3915	0.3212	0.3074	0.4564	0.4654	0.3735	0.4426	1.0000		
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000			
i65	0.2087	0.2602	0.3200	0.2999	0.2109	0.3201	0.3976	0.3232	0.3475	0.4745	0.8583	
	0.2454	0.3046	0.3770	0.3498	0.2459	0.3739	0.4707	0.3763	0.4089	0.5549	1.0000	
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
i66	0.2436	0.2219	0.2455	0.3862	0.2190	0.2375	0.2858	0.4240	0.3265	0.3857	0.3621	0.8476
	0.2883	0.2615	0.2911	0.4533	0.2570	0.2792	0.3405	0.4967	0.3866	0.4540	0.4245	1.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	

Table 52. Intentions to trade given order flow and 'planning' trading strategy (item *i84*)

```
Iteration 0:   log likelihood = -318.42817
Iteration 1:   log likelihood = -314.16419
Iteration 2:   log likelihood =  -314.1442
Iteration 3:   log likelihood = -314.14419

Ordered logistic regression                       Number of obs   =        214
                                                  LR chi2(1)      =       8.57
                                                  Prob > chi2     =     0.0034
Log likelihood = -314.14419                       Pseudo R2       =     0.0135
```

i68	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
i84	.3168474	.1087722	2.91	0.004	.1036577	.530037
/cut1	-2.217643	.7703112			-3.727425	-.7078608
/cut2	-1.063585	.6601104			-2.357378	.2302075
/cut3	-.5497295	.64468			-1.813279	.7138202
/cut4	2.038294	.653631			.7572009	3.319387
/cut5	2.642606	.6593066			1.350389	3.934823
/cut6	3.078806	.6663598			1.772765	4.384847

Table 53. Intentions to trade given order flow and 'incremental' trading strategy (item *i85*)

```
Iteration 0:   log likelihood = -318.42817
Iteration 1:   log likelihood = -313.29695
Iteration 2:   log likelihood = -313.27083
Iteration 3:   log likelihood = -313.27082

Ordered logistic regression                       Number of obs   =        214
                                                  LR chi2(1)      =      10.31
                                                  Prob > chi2     =     0.0013
Log likelihood = -313.27082                       Pseudo R2       =     0.0162
```

i68	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
i85	.3099187	.097589	3.18	0.001	.1186478	.5011896
/cut1	-2.373168	.7001961			-3.745527	-1.000809
/cut2	-1.227116	.5718384			-2.347899	-.1063338
/cut3	-.7203397	.5487639			-1.795897	.3552178
/cut4	1.881751	.5547804			.7944012	2.9691
/cut5	2.50049	.5649152			1.393276	3.607703
/cut6	2.944392	.5748236			1.817759	4.071026

Table 54. Intentions to trade given order flow and 'cultural' trading strategy (item *i87*)

```
Iteration 0:   log likelihood = -318.42817
Iteration 1:   log likelihood = -316.29036
Iteration 2:   log likelihood = -316.28658
Iteration 3:   log likelihood = -316.28658

Ordered logistic regression                       Number of obs   =        214
                                                  LR chi2(1)      =       4.28
                                                  Prob > chi2     =     0.0385
Log likelihood = -316.28658                       Pseudo R2       =     0.0067
```

i68	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
i87	.1594922	.077614	2.05	0.040	.0073716	.3116128
/cut1	-3.22406	.6150503			-4.429537	-2.018584
/cut2	-2.08473	.4612107			-2.988686	-1.180774
/cut3	-1.58441	.4294673			-2.42615	-.7426694
/cut4	.9633818	.4043422			.1708856	1.755878
/cut5	1.566977	.411328			.7607893	2.373165
/cut6	2.001758	.4205865			1.177423	2.826092

Table 55. Intentions to trade given order flow and 'profit from intermediation' trading objective (item *i4*)

```
Iteration 0:   log likelihood = -318.42817
Iteration 1:   log likelihood = -316.01783
Iteration 2:   log likelihood = -316.01205
Iteration 3:   log likelihood = -316.01205

Ordered logistic regression                       Number of obs   =        214
                                                  LR chi2(1)      =       4.83
                                                  Prob > chi2     =     0.0279
Log likelihood = -316.01205                       Pseudo R2       =     0.0076
```

i68	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
i4	.1548551	.0712793	2.17	0.030	.0151503	.29456
/cut1	-3.212096	.6068332			-4.401467	-2.022724
/cut2	-2.06933	.4516111			-2.954471	-1.184188
/cut3	-1.570596	.4183201			-2.390488	-.7507031
/cut4	.9811054	.3934069			.2100421	1.752169
/cut5	1.584925	.4005353			.7998906	2.36996
/cut6	2.018092	.4091433			1.216186	2.819998

Table 56. Intentions to trade given order flow and 'Protect against currency volatility' trading objective (item *i5*)

```
. ologit i68 i5

Iteration 0:   log likelihood = -318.42817
Iteration 1:   log likelihood = -313.77977
Iteration 2:   log likelihood = -313.75979
Iteration 3:   log likelihood = -313.75978

Ordered logistic regression                       Number of obs   =        214
                                                  LR chi2(1)      =       9.34
                                                  Prob > chi2     =     0.0022
Log likelihood = -313.75978                       Pseudo R2       =     0.0147
```

i68	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
i5	.2099173	.0697294	3.01	0.003	.0732502	.3465844
/cut1	-2.924014	.6038461			-4.10753	-1.740497
/cut2	-1.7762	.4485557			-2.655353	-.8970468
/cut3	-1.278276	.414202			-2.090096	-.4664546
/cut4	1.314551	.4031105			.5244688	2.104633
/cut5	1.932053	.4134341			1.121737	2.742369
/cut6	2.370473	.4228329			1.541735	3.19921

Table 57. Intentions to trade given order flow and 'Protect against high and low historical prices' trading objective (item *i6*)

```
Iteration 0:   log likelihood = -318.42817
Iteration 1:   log likelihood = -312.92408
Iteration 2:   log likelihood = -312.89516
Iteration 3:   log likelihood = -312.89515

Ordered logistic regression                       Number of obs   =        214
                                                  LR chi2(1)      =      11.07
                                                  Prob > chi2     =     0.0009
Log likelihood = -312.89515                       Pseudo R2       =     0.0174
```

i68	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
i6	.2188701	.0670289	3.27	0.001	.0874959	.3502442
/cut1	-2.931313	.5879798			-4.083733	-1.778894
/cut2	-1.77392	.4292452			-2.615225	-.9326153
/cut3	-1.270848	.3948149			-2.044671	-.4970249
/cut4	1.313291	.3762284			.575897	2.050685
/cut5	1.92933	.3864616			1.171879	2.68678
/cut6	2.373736	.3979354			1.593797	3.153675

Table 58. Intentions to trade given order flow and 'Protect against inflation' trading objective (item *i7*)

```
Iteration 0:   log likelihood = -318.42817
Iteration 1:   log likelihood = -313.07497
Iteration 2:   log likelihood = -313.04491
Iteration 3:   log likelihood =  -313.0449

Ordered logistic regression                       Number of obs   =        214
                                                  LR chi2(1)      =      10.77
                                                  Prob > chi2     =     0.0010
Log likelihood =  -313.0449                       Pseudo R2       =     0.0169
```

i68	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
i7	.223215	.0689814	3.24	0.001	.0880139	.3584161
/cut1	-2.882938	.5956057			-4.050304	-1.715572
/cut2	-1.726501	.4397723			-2.588438	-.8645627
/cut3	-1.222709	.4067405			-2.019906	-.4255121
/cut4	1.375788	.3964168			.5988254	2.152751
/cut5	1.994755	.407069			1.196915	2.792596
/cut6	2.437708	.4179867			1.618469	3.256947

Table 59. Intentions to trade given order flow and 'the simple need of currencies, exports, and imports' trading objective (item *i8*)

```
Iteration 0:   log likelihood = -318.42817
Iteration 1:   log likelihood = -316.05507
Iteration 2:   log likelihood =  -316.0498
Iteration 3:   log likelihood =  -316.0498

Ordered logistic regression                       Number of obs   =        214
                                                  LR chi2(1)      =       4.76
                                                  Prob > chi2     =     0.0292
Log likelihood =  -316.0498                       Pseudo R2       =     0.0075
```

i68	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
i8	.1388781	.0643241	2.16	0.031	.0128052	.2649509
/cut1	-3.288038	.5890959			-4.442645	-2.133431
/cut2	-2.143484	.4279015			-2.982155	-1.304812
/cut3	-1.64522	.3922828			-2.414081	-.8763604
/cut4	.8976512	.3595622			.1929222	1.60238
/cut5	1.503283	.3676979			.7826083	2.223958
/cut6	1.939339	.3780278			1.198418	2.68026

Table 60. Intentions to trade given order flow and 'Hedging' trading objective (item *i9*)

```
Iteration 0:   log likelihood = -318.42817
Iteration 1:   log likelihood = -316.40395
Iteration 2:   log likelihood =  -316.4008
Iteration 3:   log likelihood =  -316.4008

Ordered logistic regression                       Number of obs   =        214
                                                  LR chi2(1)      =       4.05
                                                  Prob > chi2     =     0.0440
Log likelihood =  -316.4008                       Pseudo R2       =     0.0064
```

i68	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
i9	.1201346	.0599925	2.00	0.045	.0025515	.2377176
/cut1	-3.437424	.565388			-4.545564	-2.329284
/cut2	-2.295167	.393156			-3.065739	-1.524596
/cut3	-1.798629	.3530417			-2.490578	-1.10668
/cut4	.7464398	.3134759			.1320383	1.360841
/cut5	1.354531	.3232418			.7209885	1.988073
/cut6	1.787955	.3332247			1.134847	2.441063

CHAPTER 5. METHODOLOGY

This empirical investigation examines three strategy components (objectives, trading management, and variables). This has been conducted in the context of the ER microstructure markets models. Of course, this examination is based on the empirical findings available in Chapter 4. This implies the discussion and the appropriate selection of the econometric approach. This chapter explains the choice of the econometric estimators, and also explains how the variables fit into each model. This chapter discusses the following:

a) Research philosophy
b) How the strategic variables fit in the estimation models,
c) How the trading strategy variables fit in the Portfolio Shift Model (Evans and Lyons 2002), and
d) How key econometric issues are solved by the selected econometric model.

Following the order listed above, the paragraphs below, therefore, begin with the implications of the strategic variables.

5.1. Research Philosiphy

This section on research philosophy shows the methods to achieve the purpose of research (Saunders et. al, 2003). The epistemological nature of this research is positivism as some contributions are regarded as acceptable knowledge of the reality (Bryman and Bell 2007). The positive approach is commonly applied in social sciences such as economy and finance. In this research the positive approach is suitable as the objective is to explain the causality and regularity of variables. Alternative approaches are not normally used in the field of the Exchange rate determination.

Usually the positive approach is associated to research hypotheses, this research derive its hypotheses from key theories and previous literature on exchange rates.

5.2. Research Approach

The deductive and inductive approaches are chosen in this research. This thesis departs from theories (deductive approach) and also contributes to the theory using research observations.

Following Robson (2002), this empirical study uses five stages of deductive progress. First, the hypotheses are deduced from theories related to the exchange rate determination field. Second, the hypotheses are expressed in operational terms. Third, the hypotheses are tested. Fourth, the specific outcome of the hypotheses is examined. Finally, the underlaying theoretical approach is adapted or modified.

5.3. Research Methods

In accordance with the positivism and the deductive approach (Bryman and Bell 2007), the quantitative method is selected in this empirical study. The alternative qualitative method is not suitable for the field and objective of this research.

Given the time series and the research dataset, the quantitative approach is the best method to attain the research objective. This study analyses quantitative data on exchange rate determinants and also compare the results with other literature contributions.

5.4. Estimation implications from the strategic components

The survey results have assessed the importance of the seven strategic objectives extracted from the literature. The seven strategic variables within the survey are defined as:

a) *Price returns* that are associated with the 'profit from investments'.

b) *Spreads* that are related to the profit from intermediation.

c) *Volatility* that is linked to protection against currency volatility.

d) *Support and resistance price levels* which are associated with protection from high or low currency prices.

e) *Imports and exports* which are associated with foreign trade.

f) The variable *inflation* denotes the objective 'to protect against inflation'.

g) *Volatility* is also a proxy for the hedging.

The survey has also covered four sets of other variables: *order flow, fundamentals, technical analysis,* and *correlated assets*. They are studied at three different time frequencies (very high, moderately high, and low). As explained in the literature review (Chapter 2), previous studies have encompassed mostly the order flows and fundamentals. Nonetheless, there are also some works on technical analysis. The literature on correlated assets in the microstructure markets' literature, however, is limited.

The variables related to the trading strategies are different from the above strategic components. They are more descriptive in nature because they address how the agents have carried out their trading strategy. In effect, a problem surge has been given when the variables regarding the trading strategies need to be somehow proxied. Therefore, it is essential to propose the different approaches available to empirically estimate their importance. For example, the trading strategies may be proxied for:

a) A measure of risk tolerance from the different agents.

b) Strategic variables at the different time frequencies. (Effectively, the survey results have confirmed the significant relationships between trading strategies and strategic variables).

More importantly, the cross-sectional nature of the survey variables brings about the necessity to choose an estimation approach to deal with time-invariant variables and instrumental variables.

5.5. Estimation implications from the Portfolio Shift (PS) Model

This empirical investigation applies the PS approach. The key variables of the model are a) transaction prices and b) order flow. The version first proposed by Lyons (1997) and Evans and Lyons (2002) comprises the equation (1). This model is explained in more detail in the literature review (Chapter 2).

$$S_t - S_{t-1} = \lambda\big(X_t - \mathbb{E}(X_t|CI_t)\big) + \xi_t \qquad (1)$$

Where the variables are defined as:

t: Day (end of the round III in the theoretical model)

S_t: Common and quoted dealers' spot price (measured in foreign currency per USD dollar)

ξ_t: Price impact of common knowledge news

X_t: Aggregate interdealer order flow

$\mathbb{E}(X_t|CI_t)$: Expected interdealer order flow conditioned on dealers' common information (*CI)* at the start of day *t*.

λ: Coefficient that quantifies the impact of the independent variable on $S_t - S_{t-1}$

The theoretic model has important implications for the choice of estimator. The PS model offers unusual assumptions with respect to the error term that influences the selection of the estimation method. The common knowledge information ξ_t is assumed to be serially uncorrelated with the explanatory variables (e.g. order flows). Therefore, the common knowledge factor ξ_t can be treated as an error term in the regression. However, the error can be contemporaneously correlated in the cross-section unit. Effectively, there is common information relevant for the multiple currency pairs. Within a panel data environment this has the following consequences for this study:

a) There are omitted variables within the common knowledge factor ξ_t. These omitted variables are theoretically serially uncorrelated with the explanatory variables in the model. However, Evans and Lyons (2002a) also choose those estimation procedures that account for serial correlation. In effect, this is the most feasible empirical behaviour of the variables in economics. This implies that random effects might be considered theoretically. Nonetheless, the fixed effects model is more convenient as it assumes the possibility of serial correlation of the explanatory variables with the error. Under this assumption, panel fixed effects almost always perform better than random effects. For this reason, the fixed effect is the key estimation approach applied within this research.

b) When the explanatory variables are serially correlated with the omitted variables, the fixed effect models control for omitted variable bias. It is necessary; however, to highlight in this study that the omitted variables effects on the cross-section units are constant. This means that they will generate the same influence at a later time. As a result, their effects will be ‘fixed’ or constant across time.

c) Due to the exchange rates returns vary across time, and FEM is expected to perform well. In other words, there is within-unit variability in the variables to control for unit omitted bias. Therefore, the standard errors of the panel fixed effects are not large. As a result, the fixed effects standard errors are a tolerable issue in this study.

d) The drawback is the FEM's inability to estimate the effects of time-invariant variables. Indeed, the estimation procedure partial them out. Of course, this flaw is overcome by applying the panel 2SLS to recover the time-invariant estimates as will be examined below. Again, the estimates of this time invariant-variables are important for variables related to the strategic component in this empirical investigation.

This study has highlighted the implications of the theoretical model regarding the estimation procedure. It will also examine the econometric implications of the empirical specification. This study departs from the research of Evans and Lyons (2002a), and has three important differences from their theoretical model (1):

$S_t - S_{t-1} \equiv lnS_t - lnS_{t-1}$, the quoted prices ($S$) are substituted by their logarithms.

$\mathbb{E}(X_t|CI_t) = 0$, where, expected interdealer order flow (X_t) is conditioned on dealers' common information (*CI)* at the start of day *t*.

$\xi_t \equiv \Delta(R_t - R_t^*) + \zeta_t$, where:

R_t: Nominal interest rate per dollar

R_t^*: Nominal non-dollar interest rate

Therefore, $\Delta(R_t - R_t^*)$: Nominal interest rate differential

ζ_t: Common knowledge news that can be now correlated with $\Delta(R_t - R_t^*)$ and X_t

As a result:

$lnS_t - lnS_{t-1} = \lambda_1 X_t + \lambda_2 \Delta(R_t - R_t^*) + \zeta_t$ (2) (Evans and Lyons 2002a)

This empirical investigation applies the equation (2) using multiple currencies. Contrary to Evans and Lyons (2002b), this study ignores the order flows of other currency pairs in the equation model, because the dynamics between currencies are considered by pooling the data and allowing for individual effects. Specifically, the equation specification for multiple currencies, therefore, is the following:

$$LnS_t^k - LnS_{t-1}^k = \lambda_1 X_t^k + \lambda_2 \Delta(R_t^{\mathrm{d}} - R_t^k) + \zeta_t^k \qquad (3)$$

Where k denotes the k multiple foreign currencies based dollar, and d the nominal interest rate for the investments based dollar.

This study examines the profit expectations given X_t^k and $\Delta(R_t - R_t^k)$, hypothesising that the agents' strategy (objectives, trading management, and strategic variables) plays a fundamental role in the determination process. Also, this empirical investigation follows Evans and Lyons (2009) and Evans (2010), and their measure of the "real-time estimates of macro variables". This measure estimates the contemporaneous macroeconomic conditions. Therefore, it assumes that market agents update the measure from noisy macroeconomic releases and other information available.

Following the work of Evans (2011), this study addresses the common knowledge information with the measure of the macro-real variables. This brings about a diminishing effect on the contemporaneous correlation of the error across the multiple exchange rates. Of course, this should improve the unbiasedness of the fixed effects (FE) estimator chosen in this study. Moreover, the use of FE in the first step is supported by the seminal works of Cerra and Saxena (2010), Ince (2010), Groen (2005), Mark and Sul (2001), who have found that panel-regressions' forecasts outperform the time series, as well as RW, and provide significant currencies' heterogeneity in the estimated coefficients. The equation specification that further specialise the common knowledge news (error term) is:

$$LnS_t^k - LnS_{t-1}^k = \lambda_1 X_t^k + \lambda_2 \Delta\left(R_t^{\mathrm{d}} - R_t^k\right) + \lambda_1 M_t^d + \lambda_1 M_t^k + \zeta_t^k \qquad (4)$$

Where *M* is the macroeconomic real-measure for the *d* dollar based currencies and *k* the foreign multiple currencies.

As reviewed before in the chapter covering the essential references for the strategic variables, researchers specialize the error term using a variety of variables. These variables are important to conduct future research using FEM. Also, they allow for the selection of similar procedures to examine the strategic components, and the related survey results, for instance:

- Trading volume used as a proxy for private information.
- Order flows from other currency flows.
- ER Regimes (dummy).
- Fundamentals (such as interest rates).
- Geographic locations.
- Time dummies for the financial centres overlapping periods.
- Technical analysis proxies.
- ER volatility.
- Order flow time frequency (Gradojevic 2011).

- Trading activity proxied by a number of transactions.
- Events (e.g. Tokyo lunch).
- Normal periods and abnormal periods (e.g. Covrig and Melvin 2002).
- High and low informed trader clustering periods (e.g. Covrig and Melvin 2005).
- Spreads.
- Momentum.
- Depth (Menkhoff, Osler, and Schmeling 2010).
- Brief violations to the covered interest rate parity (CIP) (e.g. Akram, Rime, and Sarno 2008 and 2009).
- Central bank interventions (e.g. Gnabos, Laurent, and Lecourt 2009).
- Periods before and after central banks' interventions (e.g. Marsh 2011).
- Futures order flow (e.g. Huang and Masulis 1999; Cabrera, Wang and Yang 2009).
- Price uncertainty proxied by volatility (e.g. Lo and Sapp 2006) and by spreads (Bollerslev and Melvin 1994).
- Limit and stop orders (Savaser 2011).
- Calm and stormy environments (Rime and Tranvag 2012).
- Transitory and permanent shocks (Froot and Ramodarai 2005).
- Public news intensity (quantity) (e.g. Evans and Lyons 2002).
- Stock and bonds prices (e.g. Andersen, Bollerslev, Diebold, and Vega 2007).
- Interest rates (e.g. Burnside, Eichenbaum, and Rebelo 2009).
- Macro surprises (i.e. news not typically considered fundamentals. Dominguez and Pathaki 2006).

5.6. Other estimation implications from known ER time series issues

Furthermore, the other estimation issues are heteroskedasticity, unit roots and cointegration. The previous research on these is addressed in the literature review in the section comprising essential literature for strategic variables and forecasting.

Of course, it is logically expected that the dataset in this empirical investigation should contain the issues identified in tests for unit roots and cointegration in panels. These issues include reduced interpretation and the spurious regression problem. Furthermore, it is certain to address also the estimation issues of endogeneity given the variables in the model. In effect, traders learn presumably on variables such as lagged order flow and lagged prices.

On the other hand, unit roots could be present in the explanatory variables such as order flow, interest rates, correlated asset, or fundamentals. However, it may be not a problem in the spot prices where a logarithm is being used, and therefore, the variable is stationary. This thesis lessens these generating processes issues by applying specific estimation procedures explained below.

5.7. The estimation procedure of choice - panel 2SLS

The estimation procedure in this empirical investigation includes a panel two-step least squares regression (panel 2SLS). This section describes the estimation procedure assumptions, and their relevancy for this study in estimating the ER. Each model has underlying assumptions on the data generating process (DGP) that in many cases are testable. This habitually requires examining the residual series. The panel 2SLS begins with a first step calculating the panel Fixed Effects Model (FEM). It is, however, expected a simple FEM will obtain spurious results because of a wide range of data generating processes. Namely, these are driftless unit roots, unit roots with drift, long memory, trend and broken-trend stationarity.

In correspondence with the PS model assumptions (Evans and Lyons 2002) that are applied in this study, the assumptions for pooled-estimators include:

a) The error parameters and the regressors' parameters are common across *N* (except in some advanced estimators such as the Common Correlated Effects of Pesaran or CCEP). This feature is in line with the dynamics among currencies from the portfolio shift model. They also coincide with the previous research regarding why pooled panel-data regression perform better. Indeed, it forecasts the ER with more precision than time-series specifications (Mark and Sul 2010). This study finds strong methodological support in the arguments of Mark and Sul. They highlight evidence that the pooled regressions estimated on panel fixed effects perform much better even when the currency heterogeneity is important.

b) Variables need to be stationary to avoid spurious regression models, or to avoid having been identified as the cointegrating relationship (common across *N*; currency pairs in this research). Of course, this research conducts diverse pooled panel fixed effect estimation procedures to tackle these DGP issues and the spurious regression results.

Some survey variables and economic variables within this study are time-invariant. Therefore, the model cannot be estimated with the single or even the basic double fixed effects panel model. This is because the FEM control for the omitted variables partial out the effects of the time-invariant variables. This is a key drawback of using FEM within this research. Indeed, there are two data sets in this study:

a) The cross-sectional survey data (associated with weak instruments and time-invariant variables).

b) Secondary data (economic variables) comprising time series and cross-sectional data, and also time-invariant variables in some cases.

As a result and highly relevant for this study, the above implies that the empirical specification and estimation should comprise of:

a) Macro panel data models where *N* (the currency pairs) is small and *T* (time) is large.

b) A pooled estimation with instrumental variables (IV) and time-invariant variables from the survey results.

c) In spite of the use of time-invariant variables, a fixed effects panel regression that allows for correlation among the explanatory variables and the error term is used.

For these reasons, this study has selected a very advanced and highly sophisticated procedure: the two-step least squares panel data model (2SLS) with weak instruments and time-invariant regressors (Atkinson and Cornwell 2014). Broadly, it conducts FEM as a first step, and as a second step it recovers the estimates from the time-invariant variables or instrumental variables.

The panel 2SLS approach has a growing number of empirical applications, and there has been very enthusiastic discussion in the econometric field about this. The Atkinson and Cornwell's panel 2SLS model, selected in this empirical investigation, is a 'fixed effects vector decomposition' type of model. Fixed effects vector decomposition models depart from the identification of time-invariant variables (T-IV) (Hausman and Taylor 1981). T-IV are present in this research through the survey, and in the form of certain market features and variables. Indeed, given a significant presence of unit heterogeneity, it is difficult to separate the heterogeneous effects of observed and unobserved T-IV.

Furthermore, another key observation for this study is that the random and the fixed effects estimators lack of multicollinearity issues and bias if *T* (time) is large. Particularly under circumstances of small *T*, a common practice is to use the different frameworks of the Generalized Method of Moments (GMM). In spite of this; many academic papers stubbornly apply this estimation process to handle many DGP issues and multiple equations propositions. Another important reason to refrain from the application of GMM within this research is the fact that GMM estimators have problems with the estimation of weak instruments. This point is a very important argument to justify the use of fixed effects vector decomposition model within this study. This approach is novel and contrary to the usage of GMM within the majority of the academic papers in ER microstructure markets.

The econometric literature encompassing the problem to estimate the effects of time-varying regressors and/or weak instruments can be certainly found in the works of Kripfganz and Schwarz (2013); Mitze (2010); Plumber and Troeger (2007 and 2011); Atkinson and Cornwell (2012); and Plumber and Troeger (2007) (this latter issue was critically assessed and debated in a recent symposium on FEVD by Greene 2011 and Breush et al. 2011). Among the fixed effects vector decomposition (FEVD) models, this study chooses the Atkinson and Cronwell model. The benefits and drawbacks of these FEVDS models are explained below. They support the choice of estimation procedure within this empirical investigation.

First, proposing a two-stage procedure, Kripfganz and Schwarz (2013) estimate in a first step the coefficients of the time varying regressors. Subsequently, they regress in a second step the first step residuals on the time-invariant regressors. This approach is promising, but even when they claim that their proposed approach can be applied to any first step methodology (that estimates consistently the time-varying coefficients without depending on coefficient estimates from the time-invariant variables), they have also limited their study to several GMM models together with the quasi-maximum likelihood estimator (QML). Therefore, the drawbacks to use this approach within this study comprise the following:

a) The approach highly depends on the precision of the first-step estimates.
b) The low performance when regressors are weekly exogenous. (This is the more likely case for the variables proxying the strategic component, the variables from the market structure, and the economic variables.)
c) The lack of theoretical progress or econometric evidence using other estimates in the framework apart from GMM and QML.

Second and very important for this empirical investigation, and another alternative to tackle the estimation of IV, is the augmented Fixed Effect Model (FEM) proposed by Plumber and Troeger (2007). It allows for the essential estimation of time-invariant variables in this study on strategy. Very conveniently, for the estimation of the variables of this empirical investigation, the idea behind the Plumber and Troeger's Fixed Effect Vector Decomposition (FEDV) model is to conduct a FEM in the first step to calculate estimates of the time varying variables. Afterwards, they recover the residuals as a proxy for the unobserved individual effects. This approach regresses the residual against the time-invariant variables to calculate the parameter estimates. In opposition to this model, Greene (2011) argues that Plumber and Troeger used a wrong variance-covariance matrix resulting in a systematically small standard error. However, the underestimation of standard errors can be corrected by several bootstrapping techniques available in Atkinson and Cornwell (2006). Indeed, the main benefits of using within this study Plumber and Troeder's FEDV, together with the approach proposed by Atkinson and Cornwell, is the robustness of the model. It allows for the possibility of recovering the estimates from the time-invariant survey variables and economic variables.

More precisely, this research also benefits from the fixed-effects (FE) model's ability to control for unobserved heterogeneity. In effect, the unobserved units' ability is the more likely scenario within the ER estimation procedure. During this process to control the unobserved heterogeneity, any time-invariant regressors (such as the survey variables or economic time-invariant variables) are removed together with unobserved effects when FE is conducted. Nonetheless, this can be solved by applying the Hausman and Taylor's (1981) second step regression of the FE estimator, and the time means of the time-invariant variables. As a result, the partial effects of the time-invariant variables covered within this study can be estimated.

Particularly, the estimation process proposed by Atkinson and Cornwell (2014) includes:

a) A panel data environment that it is appropriate in the context of the currency pairs examined in this empirical investigation.
b) The consideration of instrumental variables' estimation, which is a key feature for some variables within this research such as order flow.

c) Alternatives for bootstrapping the estimators of the second-step covariance matrix. This is very relevant for this research because it supplies robust standard errors to the estimates, and therefore, thoroughness to carry on the ER determination analysis.

d) Importantly, the wild bootstrapping which it performs is almost always better than other techniques at different levels of endogeneity, weak and strong instruments, and time and cross-sectional length. Their study highlights the supremacy of the wild method with weak instruments, strong endogeneity, and small *N*. This is the most probable scenario in this research; weak instruments (calculated from survey data), strong endogeneity (a correlation between the parameter or variable and the error term), a small *N* (currency pairs), and a large *T* (time frequency).

This study follows the same panel-data models considered by Atkinson and Cornwell:

$$y_{it} = x_{it}\beta + z_i\gamma + \xi_{it}, \;\; i = 1, \dots, N; \quad t = 1, \dots, T$$

$$\xi_{it} = c_i + e_{it}$$

y_{it}: Dependent variable

x_{it}: Vector of time-varying regressors (*1 x K*)

z_i: Vector of time-invariant regressors (*1 x G*)

c_i: Unobserved fixed effect for the cross-section unit

e_{it}: Error term

β: Coefficient for the time-varying regressors (*Kx1*)

γ : Coefficient for the time-invariant regressors (*G x 1*)

i: Units or individuals

t: Time frequency

Indeed, this study has chosen the Atkinson and Cornwell estimation procedure due to their particular interest in estimating γ, because some strategic component features and the economic time-invariant variables significance are tested in γ. As noted before, the model allows for endogeneity between x_{it} and z_i with regard to c_i. The model takes advantage of the robustness of the FE estimator, in that the approach to estimate γ begins with a first-step FE estimator of β which is consistent even for endogeneity of x_{it} with regard to c_i. However, an assumption in the model is that x_i and z_i are exogenous with respect to the error term e_i. In this connection, the use of IV within this research diminishes the effect of this strong assumption on the error.

Before explaining the model panel 2SLS assumptions in detail, it is important to briefly review the panel data and fixed effects model on the assumptions. They are indeed highly relevant for the DGP in this research. First, the assumptions of panel models comprise of the following:

a) $E(e_{it}) = 0$; and $(c_i) = 0$; panel data models assumes linearity in the parameters β, the individual-specific effect c_i; and the error term e_{it}.

b) $\{X_i, y_i\}_{i=1}^{N}$ i.i.d.; the observations are cross-sectionally independent (in this research the individuals are the currency pairs), but not necessarily across time; this implies the random sampling of the units.

c) $E(e_{it} | X_i, c_i) = 0$, there is strict exogeneity; e_{it} is assumed uncorrelated with the explanatory variables and the unobserved effects at past, present, and future *t* periods. This strong assumption forbids lagged dependent variables.

d) The assumptions regarding the variance comprise:

e) $V(e_{it}|\, X_i, c_i) = \sigma_e^2 I$; $\sigma_e^2 > 0$ and finite; the error is homoscedastic with no serial correlation.

f) $V(e_{it}|\, X_i, c_i) = \sigma_{e,it}^2$; $\sigma_{e,it}^2 > 0$ and finite; $Cov\left(e_{it,}e_{is,}|\, X_i, c_i\right) = 0\ \forall\ s \neq t$; there is no serial correlation.

g) $V(e_{it}|\, X_i, c_i) = \Omega_{e,i}(X_i)$. The variance of the error is positive definite (p.d.) and finite.

Second and adding to the above, the assumptions of the fixed effects (FE) model include:

a) No need of the random effects' assumption $E(c_i|\, X_i) = 0$, therefore, the unobserved effects can be correlated with the explanatory variables. In other words, there is no independence assumption.

b) $V(c_i|\, X_i) = \sigma_c^2$; $\sigma_c^2 < \infty$; in other words, FE assumes homoscedasticity of the individual specific effect.

c) $V(c_i|\, X_i) = \sigma_{c,i}^2(X_i) < \infty$; FE assumes heteroskedasticity of the cross-sectional units of individual specific effect.

d) $rank\left(\ddot{X}\right) = K < NT$ and $E(\ddot{x}_i'\ddot{x}_i)$ is positive definite and finite. This means that the explanatory variables are not perfectly collinear; all the explanatory variables have non-zero variance over the time for a given individual. Therefore, this implies that the explanatory variables cannot include constant or time-invariant variables.

The fixed effects estimator of β is unbiased under a), b), c) and h) in small samples. Moreover, under d) and normally distributed idiosyncratic errors, β is normally distributed in small samples. Under d) and allowing for heteroskedasticity and serial correlation of an unknown form the asymptotic variance of β can be computed with the cluster-robust covariance estimator. This is advisable to find the cluster-robust standard errors for FE, as in practice the economic variables are often serially correlated violating d).

Briefly, the first-step FE estimator follows the traditional model:

$$\hat{\beta}_{FE} = (\sum_i X_i' Q_i X_i)^{-1} \sum_i X_i' Q_i y_i \tag{6}$$

$Q_i = I_T - j_T(j'_T j_T)^{-1} j'_T$; It is the projection that time de-means the data.

The second-step takes $\hat{\beta}_{FE}$ and computes individual or group level residuals:

$$\hat{\delta}_i = \bar{y}_i - \bar{x}_i \hat{\beta}_{FE} \tag{7}$$

Finally, it is estimated:

$$\hat{\delta}_i = z_i \gamma + u_i \tag{8}$$

For

$$u_i = \bar{\xi}_i - \bar{x}_i(\hat{\beta}_{FE} - \hat{\beta}) \tag{9}$$

$$\bar{\xi}_i = c_i + \bar{e}_i \tag{10}$$

The over-bar designates the sample-period mean for unit i.

Also, the model of Atkinson and Cornwell assumes that the endogenous elements of the time-invariant variables are uncorrelated with the error and also it presupposes that the resulting second-step error is not correlated to the error of the endogenous elements of the time invariant-variables.

Finally, Atkinson and Cornwell adapt the wild heteroskedasticity-robust procedure to bootstrap standard errors in the first-step regression. They demonstrate that this procedure is unbiased and consistent for both exogeneity and endogeneity. This is a very important advantage for this study because the explanatory variables in the model may have a recursive causal relation, for example between order flow and price returns, or correlated assets with price returns.

5.8. Secondary data

Dukascopy is the source of Forex tick data; this is the real-time transactions measured in milliseconds (e.g. 02 January 2013 12:00:05:458). The company activities are divided between the Swiss Foreign Exchange Marketplace (SWFX), and the Dukascopy Swiss Forex Bank. The benefits of this source of data related with this empirical investigation include:

a) One benefit is that the Swiss FX market supplies direct access to the largest spot liquidity of Electronic Communication Platforms (ECNs), which it is available for institutional organisations and professional traders. This is an advantage because the quoted prices and transactions are more accurate, and therefore the reliability of the data is relatively high compared to other ECNs.

b) The SWFX gathers the cooperation of banks, institutional investors, FX market places and technology providers. SWFX with its ECN has no dealing desk and offers a STP (Straight-Through processing) execution. There are other advantages as many ECN have dealing desks that generate a lack of transaction transparency. Nonetheless, the SWFX is obligated to hold a certain number of small executed trades in their balanced sheets, until they are big enough to fit into the minimum trading size of the interbank market.

c) The SWFX displays the clients' bid and offers orders, variable spreads, and competitive quotes placed by several institutions in the market. These provide reliability and validity regarding the mid points prices to generate the variable price returns, and also consistency in the spread variable.

Perhaps the most important limitation of the source of data in this research, it is that the dataset is not an interdealer dataset from EBS or Reuters. However, given the large liquidity of Dukascopy, the mid-points prices from Dukascopy are an excellent indicator of the market price.

Each currency pair dataset of tick data from Dukascopy contains 5 columns encompassing:

a) The date in milliseconds with GMT and without Day Saving Time (DST).
b) The best bid price.
c) The best ask price.
d) The ‘bid volume’ or the volume available at the best bid price on the market.
e) The ‘ask volume’ or the volume available at the best ask price.

The data comprises a total of 11 months from 01 January 2013 to 30th November 2013. In order to manage a one year database in a frequency of tick by tick, the use of the hardware memory needs to be planned carefully, especially the usage of RAM. Implicitly and adding to the agents’ incomplete information assumption, computational hardware and technical methods are a barrier to the small agents in the market. Given the hardware resources at hand, the data is aggregated in many other higher frequencies (i.e. 1 minute and 10 minutes). The estimations used either 1 minute or 10 minutes data frequencies depending on the estimation objective or the hardware capacity required by certain estimation methods.

The Chapter 6 ‘Panel Fixed Effects’ uses one minute frequency. As diverse statistical issues such as cointegration, unit roots, and cross-sectional dependency affects the data, diverse type of fixed effects estimators were evaluated. In some cases, it was necessary to test sections of the data to compute the regressions or the diagnostics.

The Chapter 7 uses 10 minutes data frequency. The results were compared used sections of the data set in 1 minute frequency, and the results are similar.

The following are the methods to aggregate the data from tick to other high frequencies:

a. For the variable exchange rates, it is used the closing price in the selected time frequency.
b. The positive and negative order flows were aggregated (summed up) in the respective time frequency.
c. The real-time macroeconomic conditions index was aggregated using the mean of the variable in the given time frequency.
d. The rollovers were aggregated using the mean of the observations in the time frequency.
e. The trading strategy variables were averaged to avoid colinearity among these variables.

The data were gathered for the major currency pairs and other currencies, and transformed to the USD base if needed. The selected currency pairs of this research are the 7 Majors, especially, because the gathered macroeconomic announcements dataset covers mostly these currencies.

The Table 61 report the data available from SWFX. Specifically, the Chapter on Panel Fixed Effects uses the majors, which are the most transacted and liquid currencies in the Forex market. As noted in the column Majors in the Table 61, the majors comprise 7 currencies.

Table 61. Gathered dataset currency pairs

	Majors	Crosses	Metals	Exotic
1	AUDUSD	AUDCAD	XAGUSD	AUDSGD
2	EURUSD	AUDCHF	XAUUSD	CADHKD
3	GBPUSD	AUDJPY		CHFPLN
4	NZDUSD	AUDNZD		CHFSGD
5	USDCAD	CADCHF		EURDKK
6	USDCHF	CADJPY		EURHKD
7	USDJPY	CHFJPY		EURHUF
8		EURAUD		EURMXN
9		EURCAD		EURPLN
10		EURCHF		EURRUB
11		EURGBP		EURSGD
12		EURJPY		EURTRY
13		EURNOK		EURZAR
14		EURNZD		HKDJPY
15		EURSEK		MXNJPY
16		GBPAUD		NZDSGD
17		GBPCAD		SGDJPY
18		GBPCHF		USDBRL
19		GBPJPY		USDDKK
20		GBPNZD		USDHKD
21		NZDCAD		USDHUF
22		NZDCHF		USDRUB
23		NZDJPY		USDTRY
24		USDNOK		ZARJPY
25		USDSEK		
26		USDSGD		

The first column aims to indicate the number of currencies in the groups that will be reported in the next columns. The second column encompasses the U.S. dollar

(USD) as the base currency together with Australian Dollar (AUD), Euro (EUR), British Pound (GBP), New Zealand Dollar (NZD), Canadian Dollar (CAD), Swiss Franc (CHF), and Japanese Yen (JPY). The third column reports the currency that crosses with the available data at Dukascopy. This latter column reports other currencies whose base is another currency apart from the USD. It additionally comprises the Norwegian Krone rates (NOK) and Swedish Krona (SEK). The fourth column includes the Silver Ounce (XAG) and Gold Ounce (XAU) as priced in the USD. Finally, the fifth column includes the exotic pairs, among them those that remain to be specified are the Turkish Lira (TRY) Russian ruble (RUB), Hungarian forint (HUF), Hong Kong Dollar (HKD), Danish Krone (DKK), Brazilian real (BRL), Singapur dollar (SGD), Mexican peso (MXN), South African rand (ZAR), and Polish zloty (PLN).

This empirical investigation has chosen these seven currencies for the following reasons:

a) Very importantly, the data quality (reliability, validity, and time consistency) is higher for the prices of these currencies.
b) The transactions with these currencies comprise 86.6% of the market.
c) The data can generate the sequence of prices and transactions accurately, in other words, the variables price returns and order flow can be constructed from the gathered dataset.
d) The common knowledge information (macroeconomic announcements) quality is only gathered for the seven currency pairs or majors.

The dependent variable of the model (price returns) and the order flow estimation procedure is addressed in the paragraphs below.

5.9. Price Returns (dependent variable *r*)

The dependent variable, price returns, is calculated as $R_t = ln(S_t/S_{t-1})$, where R_t is the return in time *t;* S_t is calculated using the quotes mid-points as shown in the previous literature. In order to compute the returns the logarithm (*ln*) of the division between the current spot price S_t over the previous quotes mid-point S_{t-1} has been applied. This estimation makes it necessary to drop the first observation because obviously the return is undetermined in this case.

As a result of the formula above, it has generated *2,393,775* observations (minutes), and the data is not balanced, as the observations range from 341,673 to 342,088 observations for each of the seven currency pairs.

The Table 62 reports the results of the Shapiro-Wilk test for normality for the variable exchange rate returns (*r*). The sample period is from January 1st, 2013 22:00 to November 29th, 2013 21:59.

Table 62. Exchange rates returns *r*, Shapiro-Wilk W test for normal data

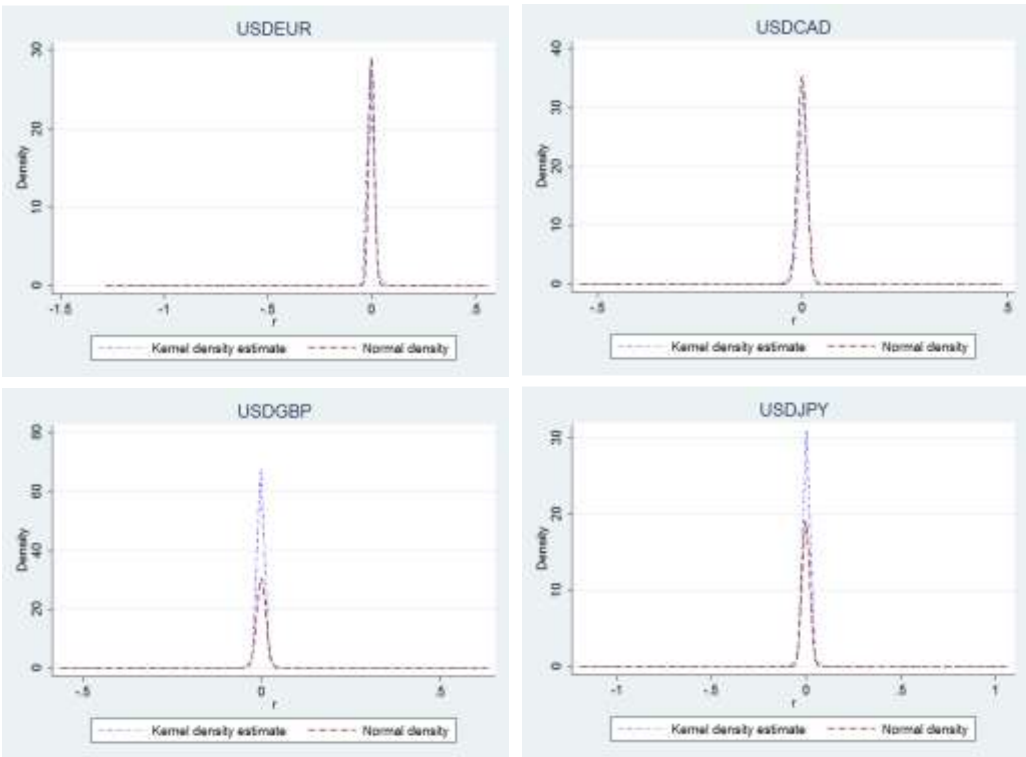
The first column 'Pair' informs the seven currency pairs of choice within this empirical investigation. The currency pairs that are reported with numbers from 1 to 7 are respectively EURUSD GBPUSD, JPYUSD, CADUSD, AUDUSD, CHFUSD, and NZDUSD. These are the seven main transacted currencies in the world. The second column shows the encompassed number of observations. The third column presents the critical value of the W statistic for the Shapiro-Wilk test. The fourth column displays the critical value of the V statistic. The fifth column reports the z statistic. Finally, the sixth column shows the significance level of the z statistic or the p-value. The p-values reject the null of normality.

Pair	Obs	W	V	z	Prob>z
1	341890	0.80529	1.30	26.805	0.0000
2	342061	0.79823	1.30	26.907	0.0000
3	342069	0.82459	1.20	26.51	0.0000
4	341673	0.81646	1.20	26.637	0.0000
5	342088	0.82501	1.20	26.503	0.0000
6	342059	0.80456	1.30	26.816	0.0000
7	341928	0.83732	1.10	26.296	0.0000

Table 62 reports the Shapiro-Wilk test for normal data (the null hypothesis is data normality). Even though the returns (*r*) were calculated using a logarithm, the test shows in the sixth column that the null hypothesis is clearly rejected. The latter are using other transformation methods for this non-normal data.

The issue can be observed in the Figure 13. As an example, it shows the *r* kernel density compared with the normal distributions for 4 exchange rates returns.

Figure 13. Kernel density and normal density for the returns of USDEUR, USDCAD, USDGBP, and USDJPY



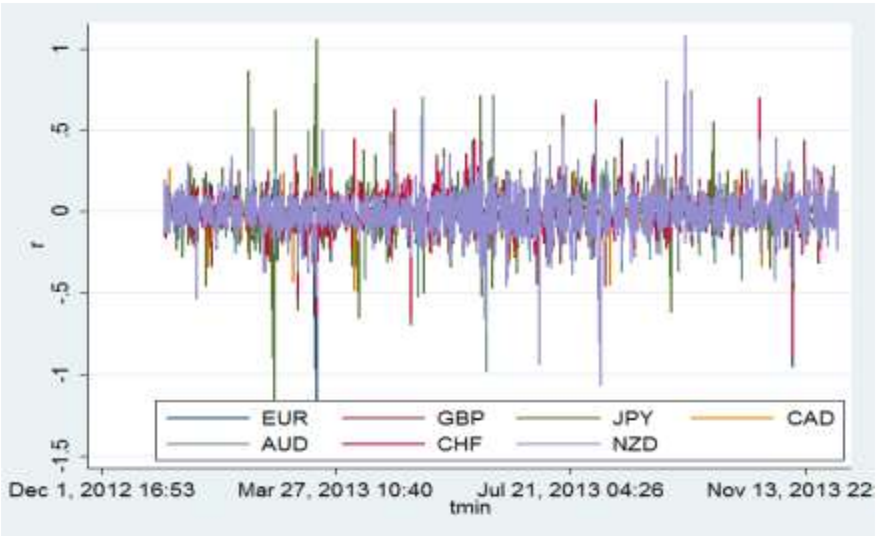
This figure reports the Kernel density estimate (blue line) and the normal density (red line) for the price returns *r* (horizontal axis) of USDEUR, USDCAD, USDGBP, and USDJPY. The vertical axis represents the density.

In the Figure 13, it shows the fat tails of the distribution of returns. Also, for USDGBP and USDJPY the high kurtosis in the distribution is evidenced.

The non-normality of the returns *r* affects the fixed effects estimation within this empirical investigation, because the commented assumption b) does not hold given the Shapiro-Wilk test results. In effect, the normality assumption b) is desirable to obtain a good performance of the estimators, and for reasons of the interpretation. However, it is not essential for the fixed effects models (nor for the random effects models) (Clarke et al. 2010). Indeed, this is a limitation in this research that might be solved with a more sophisticated non-linear fixed effects model. Even though, the limitation brings about a slight estimation bias.

The returns look stationary (see Figure 14). However, the results will be appropriately tested in the on Fixed Effects. In the Figure 14, it is also evidenced that the great sigma returns. Indeed, there are many observations that are superior to the 0.5 returns; this brings about the commented fat tails in the distributions of the exchange rates returns.

Figure 14. Spot price returns (*r*) at one minute frequency



The sample period is from January 1st, 2013 22:00 to November 29th, 2013 21:59. The figure shows in the vertical axis the sample variable *r* (spot price returns) at a 1 minute frequency (horizontal axis). All currency pairs were transformed to denote the price in USD. Therefore, the returns are expressed in percentage of dollars. The seven currency pairs are drawn in different colors and include Euro (EUR), British

Pound (GBP), Japanese Yen (JPY), Canadian Dollar (CAD), Australian Dollar (AUD), Swiss Franc (CHF), and New Zealand Dollar (NZD).

5.10. Order Flow (explanatory variable *o*) Estimation

Complete transactions datasets are often unavailable to researchers or they simply do not exist. Therefore, I consider an alternative method for estimating order flow from incomplete trading data. The method's details are available in Evans (2011, p.365) and are explained below.

The estimation simply identifies the direction of each transaction based on the change in prices from one tick to the other. The direction of the trade order flow is then estimated by subtracting the quantity of seller initiated transactions from the quantity of buyer initiated transactions within a specific period of time. For example, the most basic algorithm empirically defined as the 'Tick test' separates the buying initiated and the selling initiated if the transaction price in the time (*t)* is higher than the transaction price in the moment (t-1), and this is seller initiated when this calculation is negative. Sometimes added to this, a second algorithm from Lee and Ready (1991) judges the direction against the comparison between the transaction prices with the quotes mid-point. Evans (2011, p.365) provides a rationale based on the sequential trading model for these algorithms.

The process to identify the direction of the transactions follows the following algorithm:

Conditional case 1: the quotes' mid-price change from time *t-1* to time *t* is greater than zero, and then direction is positive or 1.

Conditional case 2: the quotes' mid-price change from time *t-1* to time *t* is less than zero, and then direction is negative or -1.

The remaining undetermined cases are ticks with no change in the quotes, mid-point quotes, or available broker volumes (although it may be due to the changes in the available inventories, but at this point the change of available bid volume equals the change of available ask volume, which again is an undetermined case). Therefore, these ticks might be considered as simple quotes, and if not, the quantity transacted is assumed to be very low as neither the inventories or prices have changed.

By means of STATA 12 SE, the conditional cases above were applied individually to the seven currency pairs of choice within this empirical research. All currency pairs that are dollar based (e.g. USDJPY, USDCHF) were transformed to be based in terms of the U.S. dollars.

The Table 63 reports the Shapiro-Wilk test (the null hypothesis is data normality) for the seven ER order flows. The results clearly reject the null of normality; even though, the order flows (*o*) were transformed using logarithm, z-score, min-max, softmax and sigmoid techniques. The test shows in the sixth column that the null is clearly rejected.

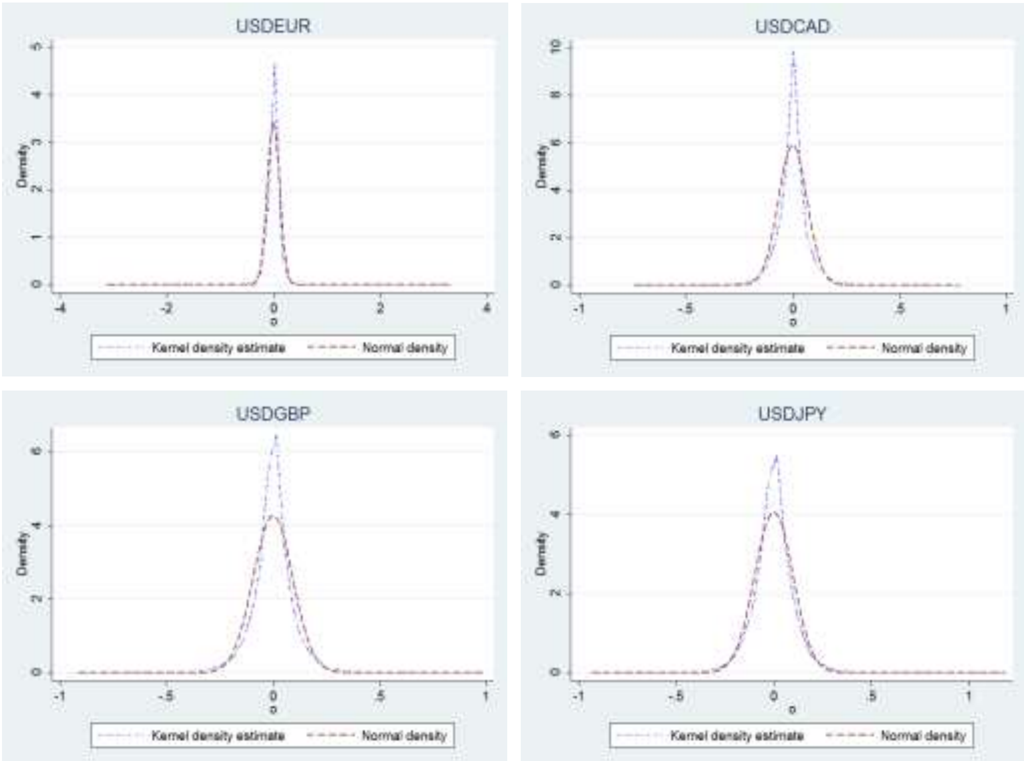
Table 63. Shapiro-Wilk test for the seven ER order flows

This table reports the results of the Shapiro-Wilk test for normality for the variable order flow (*o*). The sample period is from January 1st, 2013 22:00 to November 29th, 2013 21:59. The first column 'Pair' informs the seven currency pairs of choice within this empirical investigation. The currency pairs reported with numbers from 1 to 7 are respectively EURUSD GBPUSD, JPYUSD, CADUSD, AUDUSD, CHFUSD, and NZDUSD. These are the seven main transacted currencies in the world. The second column shows the encompassed number of observations. The third column presents the critical value of the W statistic for the Shapiro-Wilk test. The fourth column displays the critical value of the V statistic. The fifth column reports the z statistic. Finally, the sixth column shows the significance level of the z statistic or the p-value. The p-values reject the null of normality.

Pair	Obs	W	V	z	Prob>z
1	341890	0.83961	11000.00	26.256	0.0000
2	342061	0.96373	2385.842	22.043	0.0000
3	342069	0.97388	1717.855	21.112	0.0000
4	341673	0.9485	3385.308	23.034	0.0000
5	342088	0.97098	1908.921	21.411	0.0000
6	342059	0.95957	2659.7	22.351	0.0000
7	341928	0.96091	2570.657	22.254	0.0000

The non-normality issue can also be observed in the Figure 14. As an example, it shows the *r* kernel density of the order flows compared with the normal distributions.

Figure 14. Kernel density and normal density for the order flows of USDEUR, USDCAD, USDGBP, and USDJPY

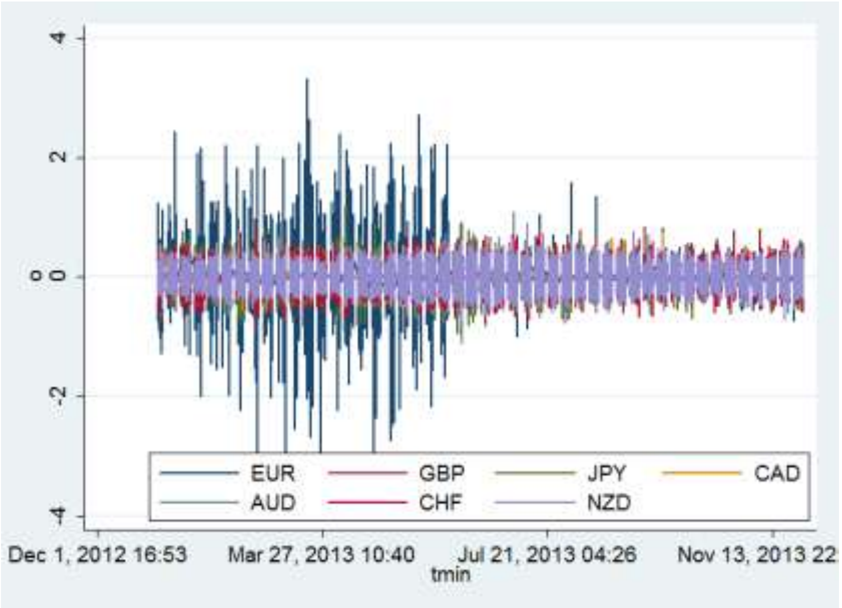


The Figure 14 reports the Kernel density estimate (blue line) and the normal density (red line) for the order flows *o* (horizontal axis) of USDEUR, USDCAD, USDGBP, and USDJPY. The vertical axis represents the density.

The non-normality of the order flows *o* affects the panel data estimation within this empirical investigation, because the commented assumption b) does not hold. In effect, the normality assumption b) is desirable to obtain a good performance of the estimators and for reasons of the interpretation. However, it is not essential for fixed effects models (nor for random effects models) (Clarke 2010). Indeed, this might be solved for a more sophisticated non-linear fixed effects model; even though, the limitation of non-normality brings about a slight estimation bias.

On the other hand, the order flows look stationary (Figure 15). However, the stationarity will be appropriately tested in the Chapter on Fixed Effects. In the Figure 15, it is also evidenced the great variance of the order flows of the USDEUR order flows (in blue colour). Indeed, there are many observations that cross the range (-2, 2).

Figure 15. Order flows (*o*) at one minute frequency



The sample period is from January 1st, 2013 22:00 to November 29th, 2013 21:59. The figure shows in the vertical axis the sample variable *o* (order flow) at a 1 minute frequency (horizontal axis). Therefore, the order flows are expressed in terms of units. The seven order flows are drawn in different colors and include order flows for the Euro (EUR), British Pound (GBP), Japanese Yen (JPY), Canadian Dollar (CAD), Australian Dollar (AUD), Swiss Franc (CHF), and New Zealand Dollar (NZD).

5.11. Macroeconomic conditions (explanatory variables *a* and *b*)

As commented in the Chapter 2 Literature Review, one of the most important problems is that the ER seems to be disconnected from the macroeconomic conditions (i.e. the ‘ER disconnect puzzle’). The literature on ER microstructure markets confirm that the macroeconomic announcements (and even non-economic information) are impounded directly to the ER through the quoted prices by dealers, and indirectly through the order flows. Under this context, this empirical investigation follows the research of Evans and Lyons (2002) regarding the generation of an indicator of the real macroeconomic conditions.

The macroeconomic conditions are measured by the economic announcements (or economic fundamentals) from different entities in the market such as Central Banks, Governments and other third party institutions. Empirically, the Forex agents review the calendar of economic releases in a contemporaneous fashion, and decide whether or not they place their buy or sell market orders. This empirical investigation uses a rich and daily updated economic calendar dataset from www.forexstreet.com, in order to construct the proxy for the USD macroeconomic conditions (variable *a*), and the macroeconomic conditions related to the foreign currency (variable *b*).

Monthly, the gathered data averages 642 economic calendar releases per country. For this reason, it is inconvenient to report all the variables details. However, the complete list of macroeconomic releases is presented in Appendix 4. The countries and regions from which the economic releases were gathered encompass: Australia, Canada, European Monetary Union, France, Germany, Italy, Japan, New Zealand, Portugal, Spain, Switzerland, United Kingdom, and the United States of America. The following paragraphs reports the essential economic announcements for the ER.

5.11.1. Essential economic releases for the USD, EUR, GBP, JPY, CAD, AUD, CHF, and NZD

The Bullet points below report the most volatile economic releases for the currency pairs of the heading based-dollar. First, the essential U.S. economic releases include:

a) Gross Domestic Product Annualized

b) Personal Consumption Expenditures Prices (QoQ)

c) Nonfarm Payrolls

d) Unemployment Rate

e) Consumer Price Index (YoY)

f) Consumer Price Index Ex Food and Energy (YoY)

g) Retail Sales (MoM)

h) Consumer Confidence

i) Durable Goods Orders

According to the gathered dataset within this research the expected economic releases with high-volatility for the European Union include:

a) ZEW Survey - Economic Sentiment Germany

b) ZEW Survey - Economic Sentiment European Monetary Union

c) Unemployment Rate s.a. Germany

d) Unemployment Rate European Monetary Union

e) Unemployment Change Germany

f) Retail Sales (YoY) European Monetary Union

g) Retail Sales (MoM) European Monetary Union

h) Producer Price Index (YoY) Germany

i) Producer Price Index (YoY) European Monetary Union

j) Harmonised Index of Consumer Prices (YoY) Germany

k) Gross Domestic Product w.d.a (YoY) Germany

l) Gross Domestic Product s.a. (YoY) European Monetary Union

m) Gross Domestic Product s.a. (QoQ) European Monetary Union

n) Gross Domestic Product s.a (QoQ) Germany

o) Gross Domestic Product n.s.a (YoY) Germany

p) ECB Interest Rate Decision European Monetary Union

q) Consumer Price Index (YoY) Germany

r) Consumer Price Index (YoY) European Monetary Union

s) Consumer Price Index - Core (YoY) European Monetary Union

Furthermore, among the economic releases in the dataset for the United Kingdom, it is expected to obtain great ER volatility in the following economic announcements:

a) BoE Asset Purchase Facility

b) BoE Interest Rate Decision

c) BOE MPC Vote Cut

d) BOE MPC Vote Hike

e) BOE MPC Vote Unchanged

f) Claimant Count Change

g) Consumer Inflation Expectations

h) Consumer Price Index (YoY)

i) Core Consumer Price Index (YoY)

j) Gross Domestic Product (QoQ)

k) Gross Domestic Product (YoY)

l) ILO Unemployment Rate (3M)

m) NIESR GDP Estimate (3M)

n) Retail Sales (YoY)

o) Retail Sales ex-Fuel (YoY)

It is also expected that there will be a high implied volatility within the following economic releases of the Japanese economy:

a) BoJ Interest Rate Decision

b) Gross Domestic Product (QoQ)

c) Gross Domestic Product Annualized

d) National Consumer Price Index (YoY)

e) National CPI Ex Food, Energy (YoY)

f) National CPI Ex-Fresh Food (YoY)

g) Tankan Large Manufacturing Outlook

Moreover, the Canadian economic announcements that presumably may generate the most important volatility to CAD include:

a) Bank of Canada Consumer Price Index Core (YoY)

b) BoC Interest Rate Decision

c) Consumer Price Index (YoY)

d) Gross Domestic Product (YoY)

e) Net Change in Employment

f) Unemployment Rate

Following this up further, the most influential Australian economic releases towards the AUD may comprise:

a) Consumer Price Index (YoY)

b) Employment Change s.a.

c) Gross Domestic Product (QoQ)

d) Gross Domestic Product (YoY)

e) RBA Interest Rate Decision

f) Unemployment Rate s.a.

The Swiss economic announcements that often cause the highest volatility to CHF comprise of the following:

a) Gross Domestic Product (YoY)
b) SNB Interest Rate Decision

Finally, the calendar events from New Zealand that generates the highest volatility in the market include:

a) Consumer Price Index (QoQ)
b) Consumer Price Index (YoY)
c) Gross Domestic Product (QoQ)
d) RBNZ Interest Rate Decision

The data was transformed to avoid figures written with ‘K’ for thousands and ‘M’ for millions. Also, figures with percentages were expressed in the decimal form. Moreover, certain releases include qualitative analysis; this empirical investigation focuses its efforts only in quantitative releases. Examples of this type of releases comprise of the following:

a) Fed Chairman Bernanke Speaks
b) FOMC Meeting Minutes
c) G7 Meetings
d) FOMC Statement

More Specifically within this study, the economic releases dataset comprise the following data:

a) Date and exact disclosing time (in minutes).
b) Name of the fundamental or economic news.

c) Country where the information was originated. (In this study there are eight countries, i.e. U.S. and the seven countries related to the researched currencies.)

d) Expected volatility of the data release (0 stands for countries' holidays and 1 to 3 for the expected release volatility, with 3 being the highest expected volatility).

e) Actual economic release (final announcement expressed quantitatively).

f) Previous economic release, including revisions of the last release if applicable.

g) Forecasted or consensus on the economic release.

5.11.2. Estimation procedure of the real macroeconomic conditions

The macroeconomic releases are followed by traders, and they change their views and expectations on the macroeconomic situation in a real time basis. The estimation of the real-time macroeconomic conditions includes the Kalman Filter, a novel procedure applied by Evans and Lyons (2009) and Evans (2010).

The formulation of the real- time estimate follows the equation below, where *R* is the real time estimate of M1 (money supply) for a particular country, in the month *m* and a day of that month *d*. M1 equals the expected value of *R* in the month *m* given the public information only known at the day *d* or Ω_{d} (Evans 2011, p396).

$$\mathrm{R}_{\mathrm{m|d}} = \mathrm{E}[R_m \,|\Omega_{\mathrm{d}}]$$

Contrary to Evans (2010 and 2011) and Evans and Lyons (2009), this empirical investigation applies the equation to different time frequencies. For the specification of $\mathrm{R}_{\mathrm{m|d}}$, the information Ω_{d} comprises the information gathered for the USD, EUR, GBP, JPY, CAD, AUD, CHF, and NZD (the data was commented at the beginning of this section). Moreover, the estimation involves the use of the algorithm 'Kalman Filter' explained in Harvey (1990) and also in Evans (2005).

The Kalman's Filter algorithm describes how inferences are made from partial observations of a system with reference to the real state of a dynamic system. Particularly, in this research the one minute (mn) changes in M1 (ΔR_{mn}) equals the sum of the macroeconomic developments (during one minute) related to M1 (i.e. ΔR_i) or more formally:

$$\Delta \mathrm{R}_{\mathrm{mn|d|m}} = \sum_{i=1}^{t|mn} \Delta R_i$$

Where $\Delta \mathrm{R}_{\mathrm{mn|d,m}}$ is the increment in the macroeconomic conditions given the minute, the day and the month, which is equal to the sum of all the increments from 1 to *t* ticks within the minute *mn*.

The Kalman's filter algorithm solves two problem related to the real-macroeconomic conditions index:

a) It allows to compute $\mathrm{R}_{\mathrm{m|d}} = \mathrm{E}[R_m \,|\Omega_{\mathrm{d}}]$
b) The parameters can be estimated using maximum likelihood from time series.

Following this further, I select the state and observation equation where $\Delta \mathrm{R}_{\mathrm{mn|d|m}}$ depends only on the contribution of the last month. Adapting the work of Evans (2005) to the dynamics of this research the state model (state equation) follows the matrix equation:

$$\begin{bmatrix} r_t^Q \\ \Delta^{Q(1)}x_t \\ \Delta^{Q(2)}x_t \\ r_t^M \\ \Delta^{M(1)}x_t \\ \Delta^{M(2)}x_t \\ \Delta x_{mn} \end{bmatrix} = \begin{bmatrix} 1-\ \delta_t^Q & 0 & 0 & 0 & 0 & 0 & 1 \\ \delta_t^Q & 1-\delta_t^Q & 0 & 0 & 0 & 0 & 0 \\ 0 & \delta_t^Q & 1-\delta_t^Q & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1-\delta_t^M & 0 & 0 & 1 \\ 0 & 0 & 0 & \delta_t^M & 1-\delta_t^M & 0 & 0 \\ 0 & 0 & 0 & 0 & \delta_t^M & 1-\delta_t^M & 0 \\ 0 & 0 & 0 & 0 & \emptyset_1 & 0 & 0 \end{bmatrix} \times \begin{bmatrix} r_{t-1}^Q \\ \Delta^{q(1)}x_{t-1} \\ \Delta^{q(2)}x_{t-1} \\ r_{t-1}^M \\ \Delta^{M(1)}x_{t-1} \\ \Delta^{M(2)}x_{t-1} \\ \Delta x_{mn-1} \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ e_t \end{bmatrix}$$

Where r_t^Q and r_t^M are three partial sums defining the cumulative minute by minute contributions to M1 from quarterly, monthly, and daily periods; $\Delta^{Q(1)}x_t$ is the quarterly M1 growth is the completed quarter; as the reporting lag of the final version of M1 is more than a quarter ; therefore, $\Delta^{Q(2)}x_t$ is M1 from two quarters back. The rationale is similar for $\Delta^{M(1)}x_t$ and $\Delta^{M(2)}x_t$, the main difference is that these terms measure the monthly contribution of monthly macroeconomic variables releases. The model dynamics is completed by the minute by minute contributions on minute *mn of* Δx_{mn} as a weighted average of the minute by minute contributions over the last *k* completed minutes, and an error term e_t. [1]

The dummy variables δ indicate the daily dynamics of r_t^Q and r_t^M, thus they take the value of 1 for the first day of the month or a quarter as follows:

$$\delta_t^M = \begin{cases} 1 \text{ if } t = \mathrm{M}(\tau, \mathrm{j}) + 1, for\ j = 1, 2, 3 \\ \quad\quad 0 \quad otherwise \end{cases}$$

$$\delta_t^Q = \begin{cases} 1 \text{ if } t = \mathrm{Q}(\tau) + 1 \\ 0 \quad otherwise \end{cases}$$

The matrix above denote a system of equations is applicable to the Kalman state-space form:

$Z_t = \mathbb{A}_t Z_{t-1} + \mathbb{B}_t U_t$ (State equation)

$y_t = \mathbb{C}_t Z_t + \mathbb{D}_t V_t$ (Observation equation)

Where, U_t and V_t are shocks vectors with mean zero and $\mathbb{E}[U_t V_t'] = 0$. Z_t is a state vector of variables on time *t* that describes the time-macroeconomic conditions. The vector of variables y_t (observation equation) relates observations to Z_t and a vector of observation shocks V_t. $\mathbb{A}, \mathbb{B}, \mathbb{C},$ and $\mathbb{D}$ have time-deterministic processes (they are functions of *t* and non-dependant on any shock.

[1] A more detailed of the real time inference can be found in Evan (2005, pp 127 - 144)

The real-time estimates of M1 are calculated in two steps using the state-space form. First, the parameters of the model are calculated using maximum likelihood estimates. Second, the calculated parameters are used to compute the real-time estimates of M1. The sample likelihood function is generated in a recursive loop by applying the filter to the matrix above.

5.11.3. Data characteristics

The U.S. macroeconomic releases are the same for all the currencies studied within this empirical investigation, because all the exchange rates are expressed and determined based on USD. Therefore, the computed proxy of the U.S. real-macroeconomic conditions is also the equal for all the other currencies. For this reason, the Shapiro-Wilk test for normality is also equal for the seven currencies. The Table 64 reports the results for the Shapiro-Wilk test for the U.S. real macroeconomic conditions (*a*).

Table 64. U.S. real-macroeconomic conditions (*a*), Shapiro-Wilk normality test

Shapiro-Wilk W test for normal data

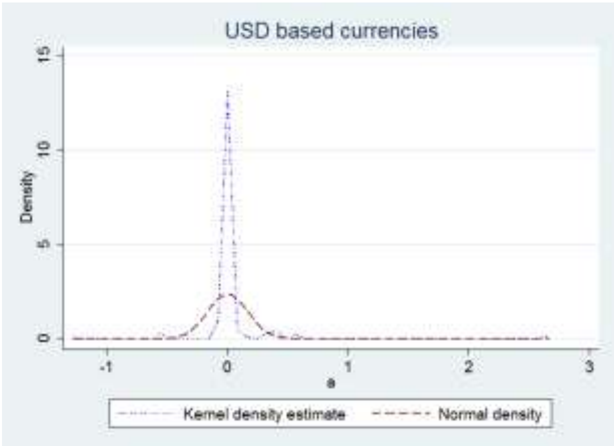
Variable	Obs	W	V	z	Prob>z
a	766	0.35863	317.400	14.107	0.00000

The table reports the results of the Shapiro-Wilk test for normality for the variable U.S. real macroeconomic conditions (*a*); the first column informs the variable. The sample period is from January 1st, 2013 22:00 to November 29th, 2013 21:59. The second column shows the encompassed number of observations. The third column presents the critical value of the W statistic for the Shapiro-Wilk test. The fourth column displays the critical value of the V statistic. The fifth column reports the z statistic. Finally, the sixth column shows the significance level of the z statistic or the p-value. The p-values reject the null of normality.

As reported in the Table 64, the results indicate that the observations for *a* are also non-normally distributed. The Figure 16 confirm the results, the red line corresponds to the normal distribution, and the doted blue line shows the distribution of the variable *a*. The results evidence that the variable *a* has a very high kurtosis and fat tails.

Figure 16. Kernel density and normal density for the U.S. real macroeconomic conditions

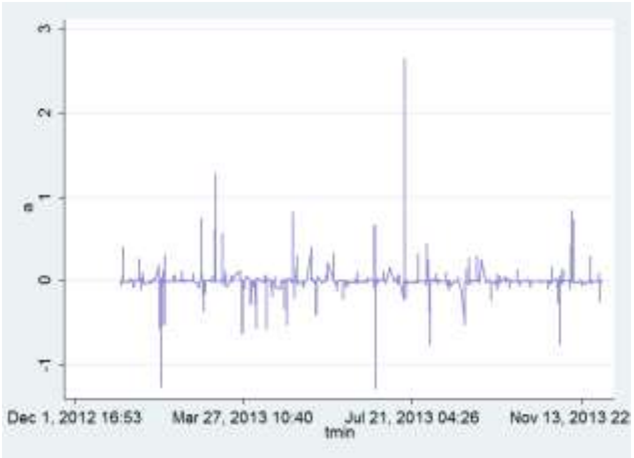
The figure reports the Kernel density estimate (blue line) and the normal density (red line) for the real-macroeconomic conditions *a* (horizontal axis). The vertical axis represents the density.



The non-normality of the variable *a* negatively affects the panel data estimation within this empirical investigation, because the commented assumption b) of the panel models is violated. However, as reviewed for the variables returns *r* and order flow *o*, the normality assumption b) is desirable to obtain good performance of the estimators and for reasons of the interpretation. However, it is not essential for fixed effects models (nor for random effects models) (Clarke 2010). Indeed, this is a limitation through this research, that may be solved for a more sophisticated non-linear fixed effects model. Even though, the limitation of non-normality brings about a slight estimation bias.

Moreover, the variable *a* looks stationary (Figure 17). Nonetheless, the stationarity will be appropriately tested in the Chapter on Fixed Effects.

Figure 17. Real-macroeconomic conditions (*a*) at one minute frequency



The sample period is from January 1st, 2013 22:00 to November 29th, 2013 21:59. The figure shows in the vertical axis the sample variable *a* (real-macroeconomic conditions) at 1 minute frequency (horizontal axis).

Furthermore, the Shapiro-Wilk test for normality reports that the non-U.S. real-macroeconomic conditions *b* (i.e. Europe, United Kingdom, Japan, Canada, Australia, Switzerland, and New Zealand) are non-normal (See Table 65).

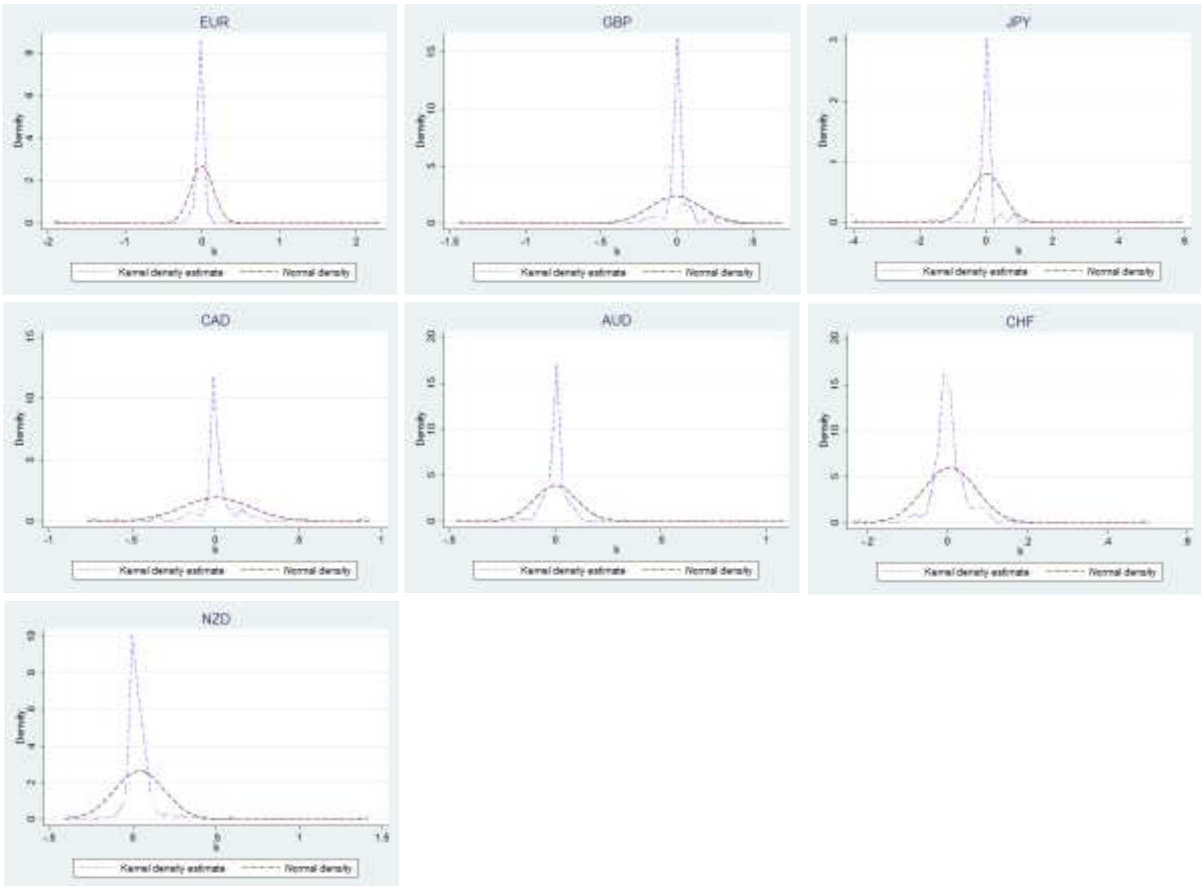
Table 65. Shapiro-Wilk test for the variable related to macroeconomic conditions

The table reports the results of the Shapiro-Wilk test for normality for the variable non-U.S. real-macroeconomic conditions (*b*). The sample period is from January 1st, 2013 22:00 to November 29th, 2013 21:59. The first column 'Pair' informs the seven countries within this empirical investigation (i.e. Europe, United Kingdom, Japan, Canada, Australia, Switzerland, and New Zealand respectively). The second column shows the encompassed number of observations for the variable non-U.S. real-macroeconomic conditions. The third column presents the critical value of the W statistic for the Shapiro-Wilk test. The fourth column displays the critical value of the V statistic. The fifth column reports the z statistic. Finally, the sixth column shows the significance level of the z statistic or the p-value. The p-values reject the null of normality.

Pair	Obs	W	V	z	Prob>z
1	846	0.34244	356.157	14.45	0.000
2	254	0.58508	76.31	10.093	0.000
3	265	0.27447	138.515	11.505	0.000
4	123	0.72703	26.822	7.379	0.000
5	226	0.54152	76.101	10.029	0.000
6	109	0.65522	30.596	7.625	0.000
7	144	0.49286	56.982	9.146	0.000

The non-normality issue can be also observed in the Figure 18. It shows the variable *b* Kernel density compared to the normal distribution.

Figure 18. Kernel density and normal density for the non-U.S. real macroeconomic conditions

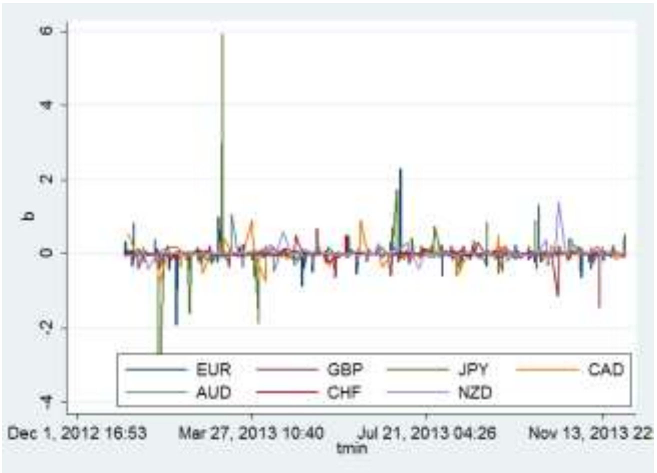


The figure reports the Kernel density estimate (blue dot line) and the normal density (red dash line) for the real-macroeconomic conditions *b* (horizontal axis). The variable is different for all the studied currency pairs related their respective countries (i.e. Europe, United Kingdom, Japan, Canada, Australia, Switzerland, and New Zealand respectively).

However, even when normality is desirable for the panel data assumptions, it is not essential for the fixed effects models (nor for random effects models) (Clarke 2010).

Furthermore, the non-U.S. real-macroeconomic conditions *b* looks also stationary for each currency pair (see Figure 19). However, the appropriate tests will be conducted in the Chapter on Fixed effects.

Figure 19. Real-macroeconomic conditions (*b*) at one minute frequency



The sample period is from January 1st, 2013 22:00 to November 29th, 2013 21:59. The figure shows in the vertical axis the sample variable *b* (foreign macroeconomic conditions) at a 1 minute frequency (horizontal axis). The variable corresponds to the macroeconomic releases from Europe (EUR), United Kingdom (GBP), Japan (JPY), Canada (CAD), Australia (AUD), Switzerland (CHF), and New Zealand Dollar (NZD).

5.12. Estimation of the rollover rates (explanatory variable s)

When trading currencies, market agents require that they receive the purchased currency two days after the transaction date. Nonetheless, if market agents simultaneously close the existing position at the daily close rate and re-enter the position at the new day opening rate (i.e. rolling over the position), the agents deliberately extend the settlement period by one day. In fact, many agents are concerned about profiting in the market rather than taking delivery of the purchased currency. In reality, Forex transactions encompass the process of borrowing one currency to buy another. Therefore, earning and paying interest is a habitual market singularity.

At the closing price of every trading day, agents pay (receive) interest if the borrowed currency has a superior (inferior) interest rate relative to the purchased currency. If the agents are not willing to receive or pay interest, they need to close out their trading positions just before 5pm ET. Briefly, the rollovers are interest rates related to currencies. All exchange rates have two rollovers or swap interest rates, one for the currency base and the other for the foreign currency. Moreover, the rollovers have a calendar of payments. Wednesdays habitually pay 3 times the interest rate differential.

bbalibor is known as 'London InterBank Offered Rate'. This indicator is reported for ten currencies with 15 maturities; therefore, 150 rates are generated each business day.

This study uses the libor rates at which banks have often lent money among themselves. Moreover, the libor rates are multiplied by the calendar rollovers (calendar of interest differential payments). Particularly the source of the data is the daily bbalibor 1month for USD, EUR, CAD, GBP, NZD, CHF, AUD, and JPY. This rate benchmarks the average rate at which a bank can receive unsecured currency funding in the London interbank market for a given period. Therefore, bbalibor rates are a calculated average of submissions from LIBOR contributor banks. The data was obtained from the intercontinental Exchange Benchmark Administration Ltd for the same sample period.

Furthermore, the daily rollover rates differentials s is calculated from the difference between the foreign rollover rate s_f and the USD rollover rate s_{usd}, and this result is multiplied by the implied number of payments q in the trading day *t*. The formula is presented below:

$$s = (s_f - s_{usd}) * q_t$$

The Table 66 confirms that *s* is non-normally distributed. (The Prob>z is less than 0.0000 for all the daily rollover differentials.) Moreover, the Figure 20 reports the variable *s* and the normal density. The main implication of this Figure is that *s* is non-normally distributed. This research unsuccessfully conducted transformations using z-score, min-max, softmax and sigmoid techniques, in order to bring the variable *s* probability distribution close to a normal distribution.

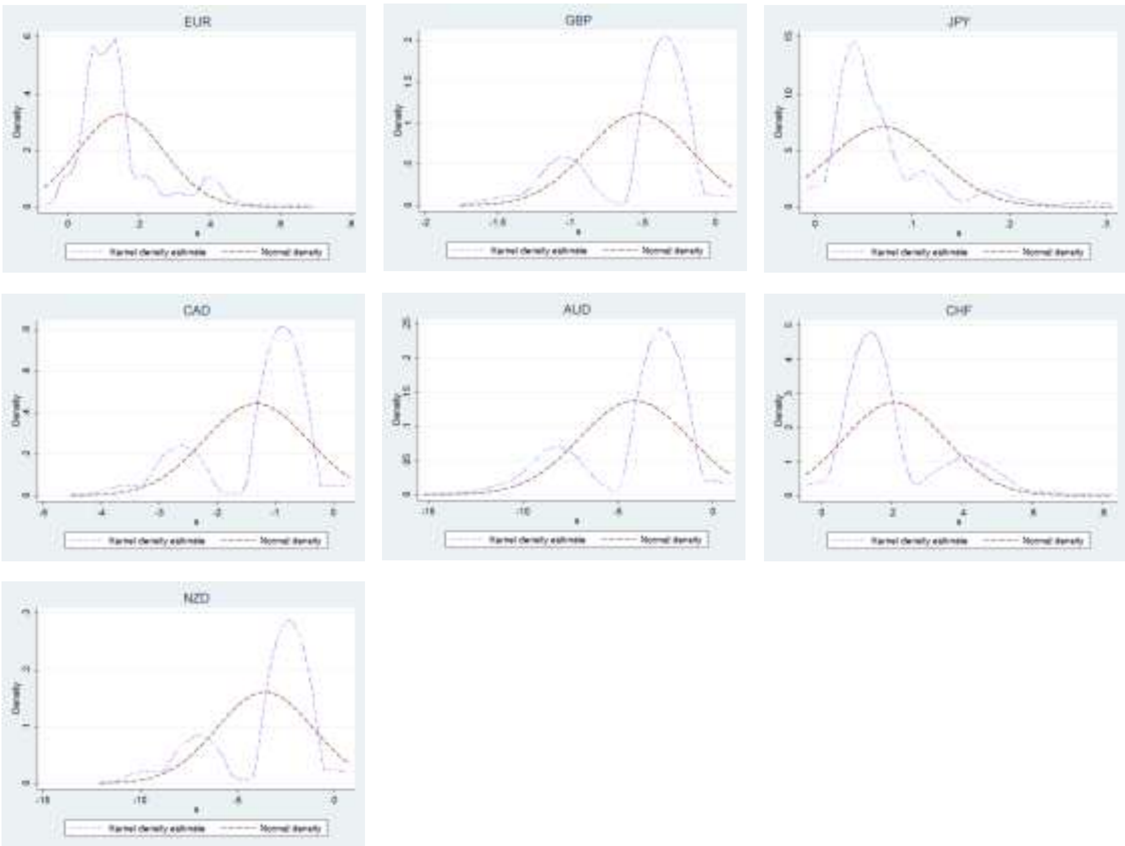
Table 66. Shapiro-Wilk test for each daily rollover differential (variable *s*)

Pair	Obs	W	V	z	Prob>z
1	191	0.82294	25.378	7.423	0.00000
2	190	0.72446	39.314	8.426	0.00000
3	190	0.79801	28.819	7.713	0.00000
4	190	0.69965	42.853	8.624	0.00000
5	186	0.75319	34.57	8.122	0.00000
6	190	0.7934	29.478	7.765	0.00000
7	185	0.72395	38.486	8.366	0.00000

The table reports the results of the Shapiro-Wilk test for normality for the daily rollover rates differentials (s). The sample period is from January 1st, 2013 22:00 to November 29th, 2013 21:59. The first column 'Pair' informs the seven variables *s* for the exchange rates studied in this empirical investigation (i.e. EURUSD, GBPUSD, JPYUSD, CADUSD, AUDUSD, CHFUSD, and NZDUSD respectively). The second column shows the encompassed number of observations for the variable non-U.S. real-macroeconomic conditions. The third column presents the critical value of W statistic for the Shapiro-Wilk test. The fourth column displays the critical value of the V statistic. The fifth column reports the z statistic. Finally, the sixth column shows the significance level of the z statistic or the p-value. The p-values clearly reject the null of normality.

Figure 20. Kernel densities estimates of the daily rollovers rate differentials

The figure reports the Kernel density estimate (blue dot line) and the normal density (red dash line) for the daily rollover differentials *s* (horizontal axis). The variable is different for all the studied currency pairs.

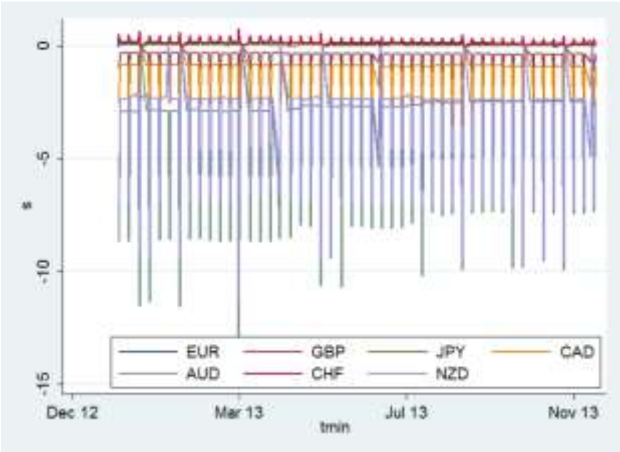


The variable *s* fits the fixed effects assumptions. Even when non-normality for *s* is evidenced, the normality assumption is not essential for fixed effects models (Clarke 2010). In fact, this limitation brings about a slight estimation bias in the fixed effects context.

Furthermore, the daily rollover difference *s* looks stationary for each of the currency pairs studied in this study (see Figure 21). However, the suitable test on this matter will be conducted in the Chapter on Fixed effects.

Figure 21. Daily rollover rates differentials at 1 minute frequency

The sample period is from January 1st, 2013 22:00 to November 29th, 2013 21:59. The figure shows in the vertical axis the sample variable *s* (daily rollover rate differential) at 1 minute frequency (horizontal axis). The variable corresponds to seven exchange rates: EURUSD, GBPUSD, JPYUSD, CADUSD, AUDUSD, CHFUSD, and NZDUSD.



5.13. Descriptive statistics variables *r o a b s*

Adding to the Shapiro Wilk tests, the kernel densities and the variable patterns, the Table 67 reports further information about the sample variables. For example, it reports the number of observations (*N*) per exchange rate (Pair) and variable (i.e. *r, o*, *a*, *b, s*). The number of observations per currency pair returns is around *342.000*. This is equal to the number of generated order flows. The skewness of the returns *r* is different for each currency pair, but the standard deviations are similar.

Table 67. Summary statistics

The table reports in the first column the currency pairs (i.e. 1:EURUSD, 2:GBPUSD, 3:JPYUSD, 4:CADUSD, 5:AUDUSD, 6:CHFUSD, and 7:NZDUSD. The second column shows the number of observations *N*, and the mean, skewness, kurtosis and standard deviation (sd). The remaining columns inform the variables returns (*r*), order flow (*o*), the U.S. macroeconomic conditions (*a*), the foreign macroeconomic conditions (*b*), and the daily rollovers differentials (*s*).

Pair	stats	r	o	a	b	s
1	N	341890	341890	800	909	191
	mean	8.62E-06	0.000691	0.003686	-0.00173	0.148756
	skewness	-2.628	0.021693	4.847012	2.870899	1.661151
	kurtosis	360.9243	48.03786	104.7876	123.861	5.770416
	sd	0.013604	0.116453	0.164335	0.143444	0.122626
2	N	342061	342061	800	280	190
	mean	2.03E-06	0.000153	0.003686	-0.00757	-0.52687
	skewness	0.627178	0.013083	4.847012	-3.92228	-1.1557
	kurtosis	124.8798	6.015364	104.7876	36.25232	3.166859
	sd	0.012989	0.093386	0.164335	0.159326	0.35704
3	N	342069	342069	800	288	190
	mean	-4.9E-05	-0.00089	0.003686	0.017316	0.069915
	skewness	0.367404	-0.0176	4.847012	4.368812	1.831766
	kurtosis	124.2856	5.710505	104.7876	101.5546	6.497942
	sd	0.020746	0.098193	0.164335	0.478227	0.056573
4	N	341673	341673	800	132	190
	mean	-1.9E-05	0.000158	0.003686	0.006941	-1.32866
	skewness	-0.39396	0.046128	4.847012	0.44947	-1.14756
	kurtosis	97.87025	7.313585	104.7876	11.73792	3.136785
	sd	0.011209	0.067562	0.164335	0.1994	0.898001
5	N	342088	342088	800	236	186
	mean	-3.9E-05	-0.00015	0.003686	-0.00016	-4.12608
	skewness	0.088979	-0.03168	4.847012	4.7686	-1.13648
	kurtosis	129.2726	5.875647	104.7876	60.32261	3.295634
	sd	0.018107	0.090595	0.164335	0.100368	2.888337
6	N	342059	342059	800	126	190
	mean	2.87E-06	-0.00027	0.003686	0.004961	0.205931
	skewness	0.25296	0.005541	4.847012	3.701855	1.308515
	kurtosis	115.7752	6.45472	104.7876	35.91974	4.127331
	sd	0.016131	0.083118	0.164335	0.061788	0.145541
7	N	341928	341928	800	154	185
	mean	-5.73E-06	0.000504	0.003686	0.036246	-3.5786
	skewness	0.009039	0.030264	4.847012	5.572206	-1.11426
	kurtosis	95.90011	6.190215	104.7876	53.68273	3.13837
	sd	0.021033	0.081555	0.164335	0.145577	2.47489

Importantly, the results show that variables fit with the fixed effects assumption h) (i.e. $rank(\ddot{X}) = K < NT$ and $E(\ddot{x}_i'\ddot{x}_i)$ is positive definite and finite). In other words, all the explanatory variables are not perfectly collinear, and they have non-zero variance. They are not constant or time invariant-variables.

Moreover, the Table 68 shows the correlations among variables. The results show significant correlations of the exchange rates returns r with o, a , and b (order flow, U.S. macroeconomic conditions, and foreign macroeconomic conditions, respectively). However, r is not significantly correlated with s (the daily rollover rate differential). The results fit the explained fixed effects assumption e) (i.e. no need of the assumption $E(c_i | X_i) = 0$). In other words, the unobserved effects can be correlated with the explanatory variables, or the explanatory variables can significantly correlate. The fixed effects estimator is not bias given even at high levels of endogeneity. Therefore, in this aspect the variables fit the fixed effects assumptions.

Table 68. Variables correlation

	r	o	a	b	s
r	1.0000				
o	0.7435*	1.0000			
a	-0.3276*	-0.1791*	1.0000		
b	0.1793*	0.0600	0.2188	1.0000	
s	0.0024	0.0101	.	-1.0000	1.0000

In the table, *r, o, a, b,* and *s* stand for exchange rate returns; order flow; U.S. macroeconomic conditions; foreign macroeconomic conditions; and daily rollover rates differentials, respectively. The stars correspond to the correlation significant to a 5% level.

Finally, the Table 69 shows a FEM. The purpose is to report the dimensions of the data (The remaining output is explained in the following Chapter on Fixed Effects). The output informs that *N* is small (number of groups equals 7). On the other hand, *T* is large (total number of observations equals 2,393,768). Moreover, the average observations per group equal 341,966.9. However, the exchange rates and order flows have 340,000 observations each, and there are less observations for the real time estimates of the macroeconomic conditions and the variable rollovers (They are about 5,000 observations). Given the complexity of some estimations (i.e. when inverting the matrixes is not plausible because the RAM capabilities, the sample must be tested in sections that in most of the cases are less than 5,000 observations.

Table 69. Dimensions of the data using FEM

R-sq:			
within	0.5567	Obs	2.393.768
between	0.6339	Groups	7
overall	0.5567	Prob >F	0

	coef	Std. Err.	t	P>|t|
o	1.354684	0.000079	1724.5400	0.0000
a	-0.120783	0.000902	-133.9100	0.0000
b	0.060506	0.001093	55.3800	0.0000
s	0.004214	0.001834	2.3000	0.0220
cons	-0.000009	0.000008	-1.1300	0.2590

The table presents a fixed effects' (within) regression between the exchange rate returns *r* as dependent variable, and order flow *o;* U.S. macroeconomic conditions *a*; foreign macroeconomic conditions *b*; and rollover rate differential *s*. Importantly for this chapter, the table reports the dimensions of the data in the heading. Moreover, it also indicates the number of observations (2,393,768), and seven the number of groups (i.e. EURUSD; GBPUSD; JPYUSD; CHFUSD; CADUSD; AUDUSD; and NZDUSD rates). It also informs that the group variable is *p* (i.e. the currency pairs or the exchange rates). The remaining features will be explained in detail in the next chapter.

Appendix – Chapter 5

Complete list of Australian macroeconomic releases within the research sample:

- AiG Performance of Services Index
- ANZ Job Advertisements
- Building Permits (MoM)
- Building Permits (YoY)
- CB Leading Indicator
- Company Gross Operating Profits (QoQ)
- Construction Work Done
- Consumer Inflation Expectation
- Current Account Balance
- Export Price Index (QoQ)
- Exports
- Fulltime employment
- HIA New Home Sales (MoM)
- Import Price Index (QoQ)
- Imports
- Investment Lending for Homes
- National Australia Bank's Business Conditions
- New Motor Vehicle Sales (MoM)
- New Motor Vehicle Sales (YoY)
- Private Capital Expenditure
- Private Sector Credit (MoM)
- Private Sector Credit (YoY)
- Producer Price Index (QoQ)
- Producer Price Index (YoY)
- RBA Commodity Index SDR (YoY)
- RBA Foreign Exchange Transaction
- RBA trimmed mean CPI (QoQ)
- RBA trimmed mean CPI (YoY)
- TD Securities Inflation (MoM)
- TD Securities Inflation (YoY)
- Wage Price Index (QoQ)
- Wage Price Index (YoY)
- Westpac Consumer Confidence
- Westpac Consumer Confidence Index
- Westpac Leading Index (MoM)
- AiG Performance of Construction Index
- AiG Performance of Mfg Index
- Consumer Price Index (QoQ)
- Gross Domestic Product (QoQ)
- Home Loans
- House Price Index (QoQ)
- House Price Index (YoY)
- National Australia Bank's Business Confidence
- National Australia Bank's Business Confidence (QoQ)
- Part-time employment
- Retail Sales s.a. (MoM)
- Trade Balance
- Consumer Price Index (YoY)
- Employment Change s.a.
- Gross Domestic Product (YoY)

- RBA Interest Rate Decision
- Unemployment Rate s.a.

Complete list of Canadian macroeconomic releases within the research sample:

- Canadian portfolio investment in foreign securities
- Capacity Utilization
- Consumer Price Index - Core (MoM)
- Exports
- Foreign portfolio investment in Canadian securities
- Imports
- Industrial Product Price (MoM)
- International Merchandise Trade
- Labor Productivity (QoQ)
- Manufacturing Shipments (MoM)
- New Housing Price Index (MoM)
- Participation rate
- Raw Material Price Index
- Retail Sales ex Autos (MoM)
- Wholesale Sales (MoM)
- Bank of Canada Consumer Price Index Core (MoM)
- Building Permits (MoM)
- Consumer Price Index (MoM)
- Current Account
- Gross Domestic Product (MoM)
- Gross Domestic Product Annualized (QoQ)
- Housing Starts s.a (YoY)
- Ivey Purchasing Managers Index
- Ivey Purchasing Managers Index s.a
- New Housing Price Index (YoY)
- Retail Sales (MoM)
- Bank of Canada Consumer Price Index Core (YoY)
- BoC Interest Rate Decision
- Consumer Price Index (YoY)
- Gross Domestic Product (YoY)
- Net Change in Employment
- Unemployment Rate

Complete list of Canadian macroeconomic releases within the research sample:

- Consumer Price Index (MoM)
- Exports (MoM)
- Foreign Currency Reserves
- Imports (MoM)
- Producer and Import Prices (MoM)
- Producer and Import Prices (YoY)
- Consumer Price Index (YoY)
- Employment Level (QoQ)
- Gross Domestic Product (YoY)
- Gross Domestic Product s.a. (QoQ)
- Industrial Production (QoQ)
- Industrial Production (YoY)
- KOF Leading Indicator
- Real Retail Sales (YoY)
- SECO Consumer Climate (3m)

- SVME - Purchasing Managers' Index
- Trade Balance
- UBS Consumption Indicator
- Unemployment Rate s.a (MoM)
- ZEW Survey - Expectations
- SNB Interest Rate Decision

Complete list of European macroeconomic releases within the research sample:

- 10-y Bond Auction Italy
- 10-y Bond Auction France
- 10-y Bond Auction Italy
- 10-y Obligaciones Auction Spain
- 12-Month Letras Auction Spain
- 18-Month Letras Auction Spain
- 2-y Bond Auction Spain
- 2-year Notes auction Germany
- 30-y Bond Auction Germany
- 30-y Bond Auction Spain
- 3-Month Letras Auction Spain
- 3-y Bond Auction Italy
- 3-y Bond Auction Spain
- 5-y Bond Auction Italy
- 5-y Bond Auction Spain
- 6-Month Letras Auction Spain
- 9-Month Letras auction Spain
- Budget France
- Business Climate European Monetary Union
- Business Climate France
- Business Confidence Italy
- Business Confidence Portugal
- Construction Output s.a (MoM) European Monetary Union
- Construction Output w.d.a (YoY) European Monetary Union
- Consumer Confidence France
- Consumer Confidence Italy
- Consumer Confidence Portugal
- Consumer Price Index - Harmonized (YoY) Greece
- Consumer Price Index (EU Norm) (MoM) Italy
- Consumer Price Index (EU Norm) (YoY) Italy
- Consumer Price Index (EU norm) final (MoM) France
- Consumer Price Index (EU norm) final (YoY) France
- Consumer Price Index (MoM) Italy
- Consumer Price Index (MoM) Portugal
- Consumer Price Index (MoM) Spain
- Consumer Price Index (YoY) Greece
- Consumer Price Index (YoY) Italy
- Consumer Price Index (YoY) Portugal
- Consumer Price Index (YoY) Spain
- Consumer Spending (MoM) France
- Current Account (YoY) Greece
- Current Account Balance Portugal
- Current Account Balance Spain
- Current Account France
- Current Account n.s.a European Monetary Union
- Current Account n.s.a. Germany

- Current Account s.a European Monetary Union
- Economic Sentiment Indicator European Monetary Union
- Employment Change (QoQ) European Monetary Union
- Employment Change (YoY) European Monetary Union
- Exports (MoM) Germany
- Exports, EUR France
- Factory Orders s.a. (MoM) Germany
- Global Trade Balance Italy
- Global Trade Balance Portugal
- Gross Domestic Product - Estimated (QoQ) Spain
- Gross Domestic Product - Estimated (YoY) Spain
- Gross Domestic Product (QoQ) France
- Gross Domestic Product (QoQ) Italy
- Gross Domestic Product (QoQ) Portugal
- Gross Domestic Product (QoQ) Spain
- Gross Domestic Product (YoY) Italy
- Gross Domestic Product (YoY) Portugal
- Gross Domestic Product (YoY) Spain
- Gross Domestic Product n.s.a (YoY) Greece
- HICP (MoM) Spain
- HICP (YoY) Spain
- House Price Index (QoQ) Spain
- ILO Unemployment France
- Import Price Index (MoM) Germany
- Import Price Index (YoY) Germany
- Imports (MoM) Germany
- Imports, EUR France
- Individual Investment (Current Year) France
- Industrial Confidence European Monetary Union
- Industrial Orders n.s.a (YoY) Italy
- Industrial Orders s.a (MoM) Italy
- Industrial Output (MoM) France
- Industrial Output Cal Adjusted (YoY) Spain
- Industrial Output s.a. (MoM) Italy
- Industrial Output w.d.a (YoY) Italy
- Industrial Production (YoY) Greece
- Industrial Production s.a. (MoM) European Monetary Union
- Industrial Production s.a. (MoM) Germany
- Industrial Sales n.s.a. (YoY) Italy
- Industrial Sales s.a. (MoM) Italy
- Inflation ex-tobacco (MoM) France
- M3 Money Supply (3m) European Monetary Union
- M3 Money Supply (YoY) European Monetary Union
- Markit Manufacturing PMI France
- Markit Manufacturing PMI Greece
- Markit Manufacturing PMI Italy
- Markit Manufacturing PMI Spain
- Markit Services PMI France
- Markit Services PMI Spain
- Nonfarm Payrolls (QoQ) France
- Private loans (YoY) European Monetary Union
- Producer Price Index (MoM) Germany
- Producer Price Index (MoM) Italy
- Producer Price Index (YoY) Greece
- Producer Price Index (YoY) Italy

- Producer Price Index (YoY) Spain
- Producer Prices (MoM) France
- Public Deficit/GDP Italy
- Real GDP Growth Germany
- Retail Sales (MoM) European Monetary Union
- Retail Sales (YoY) Greece
- Retail Sales (YoY) Spain
- Retail Sales n.s.a (YoY) Italy
- Retail Sales s.a. (MoM) Italy
- Trade Balance EU Italy
- Trade Balance EUR France
- Trade Balance n.s.a. European Monetary Union
- Trade Balance non-EU Italy
- Trade Balance s.a. European Monetary Union
- Trade Balance Spain
- Unemployment Change Spain
- Unemployment Rate (MoM) Greece
- Unemployment Rate (QoQ) Greece
- Unemployment Rate Portugal
- Unemployment Survey Spain
- Wage Inflation (MoM) Italy
- Wage Inflation (YoY) Italy
- Wholesale Price Index (MoM) Germany
- Wholesale Price Index (YoY) Germany
- 10-y Bond Auction Germany
- Consumer Confidence European Monetary Union
- Consumer Price Index (MoM) European Monetary Union
- Consumer Price Index (MoM) Germany
- Factory Orders n.s.a. (YoY) Germany
- Gfk Consumer Confidence Survey Germany
- Gross Domestic Product (YoY) France
- Gross Domestic Product n.s.a (YoY) Germany
- Gross Domestic Product w.d.a (YoY) Germany
- Harmonised Index of Consumer Prices (MoM) Germany
- IFO - Business Climate Germany
- IFO - Current Assessment Germany
- IFO - Expectations Germany
- Industrial Production n.s.a. w.d.a. (YoY) Germany
- Industrial Production w.d.a. (YoY) European Monetary Union
- Labour cost European Monetary Union
- Markit Manufacturing PMI European Monetary Union
- Markit Manufacturing PMI Germany
- Markit PMI Composite European Monetary Union
- Markit Services PMI European Monetary Union
- Markit Services PMI Germany
- Markit Services PMI Italy
- Producer Price Index (MoM) European Monetary Union
- Producer Price Index (YoY) Germany
- Retail Sales (MoM) Germany
- Retail Sales (YoY) Germany
- Sentix Investor Confidence European Monetary Union
- Services Sentiment European Monetary Union
- Trade Balance s.a. Germany
- Unemployment Italy
- Unemployment Rate European Monetary Union

- ZEW Survey - Current Situation Germany
- ZEW Survey - Economic Sentiment European Monetary Union
- ZEW Survey - Economic Sentiment Germany
- Consumer Price Index - Core (YoY) European Monetary Union
- Consumer Price Index (YoY) European Monetary Union
- Consumer Price Index (YoY) Germany
- ECB Interest Rate Decision European Monetary Union
- Gross Domestic Product s.a (QoQ) Germany
- Gross Domestic Product s.a. (QoQ) European Monetary Union
- Gross Domestic Product s.a. (YoY) European Monetary Union
- Harmonised Index of Consumer Prices (YoY) Germany
- Producer Price Index (YoY) European Monetary Union
- Retail Sales (YoY) European Monetary Union
- Unemployment Change Germany
- Unemployment Rate s.a. Germany

Complete list of British macroeconomic releases within the research sample:

- 10-y Bond Auction
- 30-y Bond Auction
- Average Earnings excluding Bonus (3Mo/Yr)
- Average Earnings including Bonus (3Mo/Yr)
- BBA Mortgage Approvals
- BoE Asset Purchase Facility
- BoE Interest Rate Decision
- BOE MPC Vote Cut
- BOE MPC Vote Hike
- BOE MPC Vote Unchanged
- BRC Retail Sales Monitor - All (YoY)
- BRC Shop Price Index (MoM)
- CB Leading Economic Index
- CBI Distributive Trades Survey - Realized (MoM)
- CBI Industrial Trends Survey - Orders (MoM)
- Claimant Count Change
- Claimant Count Rate
- Consumer Credit
- Consumer Inflation Expectations
- Consumer Price Index (MoM)
- Consumer Price Index (YoY)
- Core Consumer Price Index (YoY)
- Current Account
- DCLG House Price Index (YoY)
- Gfk Consumer Confidence
- Goods Trade Balance
- Gross Domestic Product (QoQ)
- Gross Domestic Product (YoY)
- Halifax House Prices (3m/YoY)
- Halifax House Prices (MoM)
- Hometrack Housing Prices s.a (MoM)
- ILO Unemployment Rate (3M)
- Index of Services (3M/3M)
- Industrial Production (MoM)
- Industrial Production (YoY)
- M4 Money Supply (MoM)
- M4 Money Supply (YoY)

- Manufacturing Production (MoM)
- Manufacturing Production (YoY)
- Markit Manufacturing PMI
- Markit Services PMI
- Mortgage Approvals
- Nationwide Housing Prices n.s.a (YoY)
- Nationwide Housing Prices s.a (MoM)
- Net Lending to Individuals (MoM)
- NIESR GDP Estimate (3M)
- PMI Construction
- PPI Core Output (MoM) n.s.a
- PPI Core Output (YoY) n.s.a
- Producer Price Index - Input (MoM) n.s.a
- Producer Price Index - Input (YoY) n.s.a
- Producer Price Index - Output (MoM) n.s.a
- Producer Price Index - Output (YoY) n.s.a
- Public Sector Net Borrowing
- Retail Price Index (MoM)
- Retail Price Index (YoY)
- Retail Sales (MoM)
- Retail Sales (YoY)
- Retail Sales ex-Fuel (MoM)
- Retail Sales ex-Fuel (YoY)
- RICS Housing Price Balance
- Rightmove House Price Index (MoM)
- Rightmove House Price Index (YoY)
- Total Business Investment (QoQ)
- Total Business Investment (YoY)
- Total Trade Balance
- Trade Balance; non-EU

Complete list of Japanese macroeconomic releases within the research sample:

- Adjusted Merchandise Trade Balance
- All Industry Activity Index (MoM)
- Annualized Housing Starts
- Bank lending (YoY)
- BoJ Interest Rate Decision
- BSI Large Manufacturing (QoQ)
- Capacity Utilization
- Capital Spending
- Coincident Index
- Construction Orders (YoY)
- Consumer Confidence Index
- Corporate Service Price (YoY)
- Current Account n.s.a.
- Domestic Corporate Goods Price Index (MoM)
- Domestic Corporate Goods Price Index (YoY)
- Eco Watchers Survey: Current
- Eco Watchers Survey: Outlook
- Exports (YoY)
- Foreign bond investment
- Foreign investment in Japan stocks
- Gross Domestic Product (QoQ)
- Gross Domestic Product Annualized

- Gross Domestic Product Deflator (YoY)
- Housing Starts (YoY)
- Imports (YoY)
- Industrial Production (MoM)
- Industrial Production (YoY)
- Jobs/applicants ratio
- JP Foreign Reserves
- Labor Cash Earnings (YoY)
- Large Retailer's Sales
- Leading Economic Index
- Machinery Orders (MoM)
- Machinery Orders (YoY)
- Merchandise Trade Balance Total
- Monetary Base (YoY)
- Money Supply M2+CD (YoY)
- National Consumer Price Index (YoY)
- National CPI Ex Food, Energy (YoY)
- National CPI Ex-Fresh Food (YoY)
- Nomura/ JMMA Manufacturing Purchasing Manager Index
- Overall Household Spending (YoY)
- Retail Trade (YoY)
- Retail Trade s.a (MoM)
- Tankan Large All Industry Capex
- Tankan Large Manufacturing Index
- Tankan Large Manufacturing Outlook
- Tankan Non - Manufacturing Index
- Tankan Non - Manufacturing Outlook
- Tertiary Industry Index (MoM)
- Tokyo Consumer Price Index (YoY)
- Tokyo CPI ex Food, Energy (YoY)
- Tokyo CPI ex Fresh Food (YoY)
- Trade Balance - BOP Basis
- Unemployment Rate
- Vehicle Production (YoY)
- Vehicle Sales (YoY)

Complete list of New Zealand macroeconomic releases within the research sample:

- ANZ Activity Outlook
- ANZ Business Confidence
- ANZ Commodity Price
- Building Permits s.a. (MoM)
- Business NZ PMI
- Consumer Price Index (QoQ)
- Consumer Price Index (YoY)
- Current Account - GDP Ratio
- Current Account (QoQ)
- Electronic Card Retail Sales (MoM)
- Electronic Card Retail Sales (YoY)
- Employment Change
- Exports
- Food Price Index (MoM)
- Gross Domestic Product (QoQ)
- Gross Domestic Product (YoY)
- Imports

- Labour cost index (QoQ)
- Labour cost index (YoY)
- M3 Money Supply (YoY)
- Manufacturing sales
- NZIER Business Confidence (QoQ)
- Producer Price Index - Input (QoQ)
- Producer Price Index - Output (QoQ)
- RBNZ Inflation Expectations (YoY)
- RBNZ Interest Rate Decision
- REINZ House Price Index (MoM)
- Retail Sales (QoQ)
- Retail Sales ex Autos (QoQ)
- Terms of Trade Index
- Trade Balance (MoM)
- Trade Balance (YoY)
- Unemployment Rate
- Visitor Arrivals (YoY)
- Westpac consumer survey

Complete list of U.S. macroeconomic releases within the research sample:

- 10-Year Note Auction
- 2-Year Note Auction
- 30-Year Bond Auction
- 3-Month Bill Auction
- 3-Year Note Auction
- 4-Week Bill Auction
- 52-week Bill auction
- 5-Year Note Auction
- 6-Month Bill Auction
- 7-Year Note Auction
- Average Weekly Hours
- Capacity Utilization
- Challenger Job Cuts (YoY)
- Chicago Purchasing Managers' Index
- Consumer Price Index Core s.a
- Consumer Price Index n.s.a (MoM)
- Continuing Jobless Claims
- Core Personal Consumption Expenditure - Price Index (MoM)
- Core Personal Consumption Expenditures (QoQ)
- Current Account
- Dallas Fed Manufacturing Business Index
- EIA Crude Oil Stocks change
- EIA Natural Gas Storage change
- Employment cost index
- Existing Home Sales (MoM)
- Export Price Index (MoM)
- Export Price Index (YoY)
- IBD/TIPP Economic Optimism (MoM)
- Import Price Index (MoM)
- Import Price Index (YoY)
- ISM New York index
- Kansas Fed manufacturing activity

- MBA Mortgage Applications
- NAHB Housing Market Index
- New Home Sales Change (MoM)
- NFIB Business Optimism Index
- Nonfarm Productivity
- NY Empire State Manufacturing Index
- Pending Home Sales (MoM)
- Personal Consumption Expenditures - Price Index (MoM)
- Personal Consumption Expenditures - Price Index (YoY)
- Producer Price Index (MoM)
- Producer Price Index ex Food & Energy (MoM)
- Redbook index (MoM)
- Redbook index (YoY)
- Richmond Fed Manufacturing Index
- S&P/Case-Shiller Home Price Indices (YoY)
- Total Net TIC Flows
- Total Vehicle Sales
- Unit Labor Costs
- Wholesale Inventories
- ADP Employment Change
- Average Hourly Earnings (MoM)
- Average Hourly Earnings (YoY)
- Building Permits (MoM)
- Business Inventories
- CB Leading Indicator (MoM)
- Chicago Fed National Activity Index
- Construction Spending (MoM)
- Consumer Credit Change
- Consumer Price Index (MoM)
- Consumer Price Index Ex Food & Energy (MoM)
- Core Personal Consumption Expenditure - Price Index (YoY)
- Durable Goods Orders ex Transportation
- Existing Home Sales Change (MoM)
- Factory Orders (MoM)
- Gross Domestic Product Annualized
- Gross Domestic Product Price Index
- Housing Price Index (MoM)
- Housing Starts (MoM)
- Industrial Production (MoM)
- Initial Jobless Claims
- ISM Non-Manufacturing PMI
- ISM Prices Paid
- Markit Manufacturing PMI
- Monthly Budget Statement
- Net Long-Term TIC Flows
- New Home Sales (MoM)
- Pending Home Sales (YoY)
- Personal Consumption Expenditures Prices (QoQ)
- Personal Income (MoM)
- Personal Spending
- Philadelphia Fed Manufacturing Survey
- Producer Price Index (YoY)
- Producer Price Index ex Food & Energy (YoY)
- Retail Sales ex Autos (MoM)
- Reuters/Michigan Consumer Sentiment Index

- Trade Balance
- Consumer Confidence
- Consumer Price Index (YoY)
- Consumer Price Index Ex Food & Energy (YoY)
- Durable Goods Orders
- Fed Interest Rate Decision
- Fed Pace of MBS Purchase Program
- Fed Pace of Treasury Purchase Program
- ISM Manufacturing PMI
- Nonfarm Payrolls
- Retail Sales (MoM)
- Unemployment Rate

CHAPTER 6. PANEL FIXED EFFECTS

This chapter discusses the calculation process of the fixed effects estimator for the model of exchange rates (ER) determination. This chapter explores the fixed effects econometric methods that have been developed for large *N* (groups) and large *T* (time). The data allows for a more explicit treatment of the following:

a) The heterogeneity across units.

b) The dynamics, including the treatment of unit roots.

c) The cross-section dependence from the special interaction or unobserved common factors.

More specifically, this chapter determines whether time and the groups' fixed effects are necessary. Furthermore, it will test the normality assumption of the residuals of a first basic fixed effects estimator, and also heteroskedasticity tests will be conducted, as well as a variable omitted bias test (Ramsey test). These latter tests are not essential as it is commonly found that there will be a certain degree of variable omitted bias within the economic field. These tests are calculated to describe the exchange rate's characteristics. Contrary to this the calculation of panel unit roots and tests are essential. These tests are highly important because they can generate spurious regression problems. These results generate the necessity of dynamic fixed effects specifications, which are also covered in this chapter.

Chapter 4 explained the specification of the model. The equation model is presented below again as the following:

$$LnP_t^k - LnP_{t-1}^k = \lambda_1 O_t^k + \lambda_2 A_t^d + \lambda_3 B_t^k + \lambda_4 \Delta\left(S_t^{\mathrm{d}} - S_t^k\right) + \zeta_t^k \qquad (4)$$

Where:

$LnP_t^k - LnP_{t-1}^k$ is the logarithm of the spot price in time t for the currency *k*. The exchange rate returns is *R*.

O_t^k is the order flow in time *t* for the currency *k*.

A_t^d is the U.S. real time macroeconomic index.

B_t^k is the foreign real time macroeconomic index.

$\lambda_2 \Delta\left(R_t^{\mathrm{d}} - R_t^k\right)$ is the interest rate differential *S*. R_t^{d} is the interest rate for U.S. dollars. R_t^k is the interest rate for the foreign currency.

In detail, this study first determines the importance of time effects, using OLS and time dummies for the group units (exchange rates). Therefore, time dummies are generated from the time variable *T*. However, given the technical limitations, the pooled OLS with time fixed effects are computed just for a subset of *1440* time observations.

Subsequently, the Wald test for composite linear hypothesis on the parameters of the most recently fit model is computed. The Wald test is applied to confirm whether an effect exists or not in the sample. It basically conducts an *F* test within the variable lists of linear restrictions applied to the fit model. In this case, the Wald test either confirms or does not confirm the need for the time effects within the ER regression (see Table 70).

Table 70. Wald test for the pooled OLS with time Fixed effects

The table reports the results of the Wald test where *dum2* to *dum1440* represents the *1,440* time dummies. Below the dummies is reported the *F* statistic. In brackets there are the degrees of freedom *k* (*1,439*) and the dimensions of the data *d* (8633). The *F* statistic equals *1.79,* and the *Prob* > *F* (*1*.79) informs whether or not to reject the null hypothesis of joint significance.

1	dum2	= 0
2	dum3	= 0
3	dum4	= 0
...		
1437	dum1438	= 0
1438	dum1439	= 0
1439	dum1440	= 0
F(1439, 8633)	= 1.79	
Prob> F	= 0.0000	

In the Table 70, the null is rejected given that clearly *Prob* > *F* is less than *0.05.* Therefore, the need to control for time effects is confirmed. In other words, the results show that time is a significant variable, and that a panel regression with time *T* and cross-section (groups) N is reasonable. Technically, these results suggest the rejection of the null hypothesis of joint insignificance (the Wald test results are significant as the *F statistic* equals 1.79 and the probability of non-rejection is less than 5%).

Moreover, a panel fixed effects or the within estimator (see the Table 71) is conducted. The within estimator also independently indicates the need for currency pairs effects (group effects). In other words, the null hypothesis ($u_{i=}0$) is rejected due to a significant *F* statistic. Therefore, this illustrates the need for exchange rates' fixed effects.

Table 71. Fixed Effects with time dummies

This table presents a fixed effects' regression with time dummies. The exchange rate returns *r* is the dependent variable. The remaining variables *o, a, b,* and *s* represent the order flows, the U.S. real macroeconomic conditions, the foreign real macroeconomic conditions, and the daily rollovers rate differential, respectively. Given that the use of dummies restrict the number of observations in the regression, variable *a* is reported as omitted because of collinearity. Importantly for this section the existence of group effects (within exchange rates *p*) have been confirmed. The *F* statistic (*11.92*) and the *Prob > F* equal to *0.000* reports that all coefficients in the model are different from zero, therefore, showing that the currency pairs fixed effects is an important feature. The Equation model is shown as $LnP_t^k - LnP_{t-1}^k = \lambda_1 O_t^k + \lambda_2 A_t^k + \lambda_3 B_t^k + \lambda_4 S_t^k + \lambda_4 DUM + \zeta_t^k$, where $LnP_t^k - LnP_{t-1}^k$ is the logarithm of the spot price in time *t* for the currency *k*, and in other words, where $LnP_t^k - LnP_{t-1}^k$is the exchange rate returns *R*. O_t^k is the order flow *O* at time *t* for the currency *k* at 7 different price volatilities. The variable *A* represents the real macroeconomic conditions of U.S. The variable *B* represents the foreign macroeconomic conditions related to the currency pair based on the US dollar. *S* is the interest rate differential. DUM are the time (*T*) dummies. The coefficients λ_1 to λ_4 are related to the explanatory variables.

R-sq:		Obs	10074
within	0.6659	Groups	7
between	0.4803	F(1442, 8625)	11.92
overall	0.6611	Prob >F	0

	coef	Std. Err.	t	P>|t|
o	0.104681	0.001248	83.9100	0.0000
a	0.000000	omitted		
b	1.099267	0.089179	12.3300	0.0000
s	-0.049472	0.071762	-0.6900	0.4910
dum2	-0.000009	0.006024	1.6400	0.1010
dum3	0.002009	0.006020	0.3300	0.7390
dum4	0.001395	0.006021	0.2300	0.8170
...				
dum1438	-0.001955	0.006020	-0.3200	0.745
dum1439	0.025716	0.006020	0.4300	0.669
dum1140	0.003771	0.006021	0.6300	0.531
cons	-0.002957	0.004257	-0.6900	0.487

The Table 72 reports the time dummies (*dum2* to *dum1440*). However, the coefficients are non-significant due to data generating process issues. The Fixed Effects estimator assumes that there is a different intercept in the regression equation for individual group/time. Depending on the type of effects (group vs. time), three models can be generated: a fixed group effect model, a fixed time effect model, and a fixed group and time effects model. The results support the fixed group and time effects model.

Again, a Wald test is conducted using the covariance matrix of the regression above. The results confirm independently the need for time fixed effects.

Table 72. Wald test for the Pooled Fixed Effects with time dummies

The table reports the results of the Wald test. *dum2* to *dum1440* represent the *1,440* time dummies. Below, the *F* statistic is reported. In brackets there are the degrees of freedom *k* (*1,439*) and the dimension of the data *d* (*8,625*). The *F* statistic equals *1.56,* and the *Prob > F* (*0.000*) informs whether or not to reject the null hypothesis of joint significance. In the table, the null is rejected as clearly it is shown that *Prob > F* is less than *0.05.* Therefore, it confirms the existence and the necessity of the time effects.

1	dum2	= 0
2	dum3	= 0
3	dum4	= 0
…	…	
1437	dum1438	= 0
1438	dum1439	= 0
1439	dum1440	= 0
F(1439, 8633)	= 1.56	
Prob>F	= 0.000	

Having established the need for time and group effects, the fixed effects estimation is computed below in order to analyse the output in detail and the error assumptions.

Table 73. Fixed Effects regression

The table presents a fixed effects' regression. The *R-sq* reports the R-square or the amount of variance of the returns *r,* as explained by *o, a, b,* and *s.* The exchange rate returns *r* is the dependent variable. The remaining variables *o, a, b,* and *s* are the order flows, the U.S. real macroeconomic conditions, the foreign real macroeconomic conditions, and the daily rollovers rate differential, respectively. The equation model is shown as $LnP_t^k - LnP_{t-1}^k = \lambda_1 O_t^k + \lambda_2 A_t^k + \lambda_3 B_t^k + \lambda_4 S_t^k + \zeta_t^k$, where $LnP_t^k - LnP_{t-1}^k$ is the logarithm of the spot price in time *t* for the currency *k,* and in other words where $LnP_t^k - LnP_{t-1}^k$is the exchange rate returns *R.* O_t^k is the order flow *O* at a time *t* for the currency *k* at 7 different price volatilities. The variable *A* represents the real macroeconomic conditions of the U.S. The variable *B* represents the foreign macroeconomic conditions related to the currency pair based on the US dollar. *S* is the interest rate differential. The coefficients λ_1 to λ_4 are related to the explanatory variables.

R-sq:		Obs	2393768
within	0.5567	Groups	7
between	0.6339	F(4, 2393757)	751495
overall	0.5567	Prob >F	0
corr (u_i, Xb)	-0.005		

	coef	Std. Err.	t	P>|t|
o	0.135468	0.000079	1724.5400	0.0000
a	0.120783	0.000902	133.9100	0.0000
b	-0.605064	0.001093	-55.3800	0.0000
s	0.004214	0.001834	2.3000	0.0220
cons	-0.000009	0.000008	-1.1300	0.2590

rho	0.000235
sigma_u	0.000537
sigma_e	0.011085

Importantly, it is confirmed that there are the existence of group effects (within exchange rates *p*). The *F* statistic (7*.94*) and the *Prob > F* equal to *0.000* reports that all coefficients in the model are different from zero. Moreover, the table shows that the currency pairs' effects are an important feature. The *corr*(*u_i, Xb*) indicates that the errors u_i are negatively correlated with the regressors in the fixed effects model (-*0.0050). rho* is the intra-class correlation (*0.0002348*). In other words, it signifies that *0.0002348* of the variance is due to differences across panels. *Sigma_u* and *sigma_e* are the standard deviations of residuals across groups, and the standard deviations of the overall error term respectively.

The column *Coef* indicates how much the *r* changes when individually each of the explanatory variables increase by one unit. The sign of the coefficients indicate a positive relationship between *o, a,* and *s* with the returns *r.* The column Std Err reports the standard errors of the coefficients. The column *t* shows the *t-values*; they test the hypothesis that each coefficient is different from zero. To reject the null hypothesis, the *t-value* has to be greater than *1.96* (at a 95% confidence level). Therefore, the variables *o, a, b,* and *s* have a significant impact on the *r*. The column *p>|t|* informs the coefficients' significance.

The Shapiro-Wilk test for normality is performed to determine if the residuals follow a normal distribution (see the Table 74). As a result, it is confirmed that residuals are not normally distributed (*Prob>z* is equal to *0.00000*). As explained in Chapter 4, this implies violation of the assumption d) regarding the variance and normally distributed idiosyncratic errors. This issue generates bias in the standard errors. Under these circumstances, the asymptotic variance of β can be computed with the cluster-robust covariance estimator. In other words, under d), the cluster-robust allows for heteroskedasticity and serial correlation of an unknown form. This is probably because neither the dependent variable nor the logs of the dependent variable follow a normal distribution.

Table 74. Fixed Effects Residuals and Shapiro-Wilk normality test

The table reports the results of the Shapiro-Wilk test for normality for the residuals *e2FE* of the FE regression above. The sample period is from January 1st, 2013 22:00 to November 29th, 2013 21:59. The first column 'Variable' informs the observed variable *e2FE*. The second column shows the encompassed number of observations. The third column presents the critical value of the W statistic for the Shapiro-Wilk test. The fourth column displays the critical value of the V statistic. The fifth column reports the z statistic. Finally, the sixth column shows the significance level of the z statistic or the *p-value*. Here, the *p-value* rejects the null of normality.

Shapiro-Wilk test for normal daata

Variable	Obs	W	V	z	Prob>z
e2FE	2,393,768	0.69478	44,000.00	30.306	0.0000

Before proceeding to perform the heteroskedasticity test, the Ramsey test is performed in order to determine if the model suffers from an omitted variables bias. The results in the Table 75 show that the *Ramsey F* statistic is significant *(0.000).* This means that there are omitted variable bias issues. However, this result is expected due to the large set of information conveyed by the ER prices and the underlying microstructure. The results are presented in the Table 75.

Table 75. Ramsey RESET test

The table reports the Ramsey Reset test for the FE regression. The table reports the F statistic 293.79, and the degrees of freedom k together with the dimensions of the sub-sample (i.e. 3, 25,896).

Ramsey RESET test using powers of the fitted values of r
Ho: Model has no ommitted variables
F (3, 25896) = 293.79
Prob>F = 0.0000

The Ramsey test is performed with just over a subsample of *30.299* observations due to technical limitations. The *Prob > F* equals *0.0000,* therefore, the model is significant. This means rejection of the null hypothesis. In other words, the model has omitted variable bias issues.

Significantly, the possible existence of heteroskedasticity is a major concern in the application of panel data. A set of random variables is heteroscedastic if its sub-populations have different within variance. Generally, economic theories have assumed that the errors are homoskedastic. Moreover, if homeskedastic and heteroskedastic-robust standard errors have similar notions, it is indeed preferable to use the heteroskedasticity-robust standard errors. If they differ, however, the decision is still made to use the more reliable ones that allow for heteroskedasticity. The cluster-robust standard errors are more reliable in any case.

In order to present the dataset characteristics, this study performs the Breusch-Pagan and Cook-Weisberg test for heteroskedasticity. The results presented in the Table 76 are significant (*0.0000*). The χ^2 statistic equals *5,476.49*. In other words, it indicates that heteroskedasticity is a problem.

Table 76. Fixed Effects and Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

The table reports the Breusch-Pagan test for heteroskedasticity. The null hypothesis is constant variance (homoskedasticity).

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
H0: Constant variance
Variables: fitted values of *r*

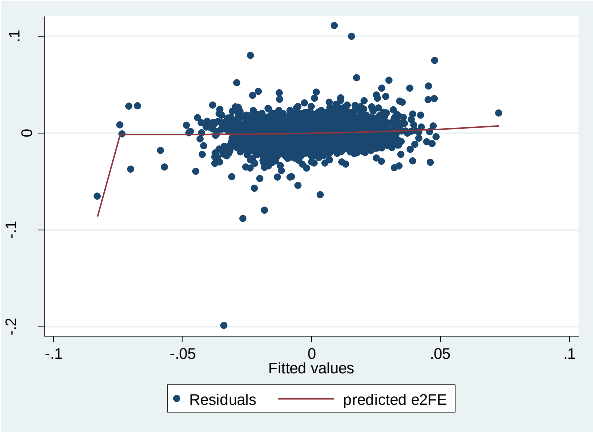
Chi2(1)	= 5476.49
Prob>Chi2	= 0.0000

The Table reports the χ^2 statistic (*5,476.49*). The results *Prob > chi2* are significant (*0.0000*). This means rejection of the null hypothesis. In other words, the results indicate the presence of heteroskedasticity.

In order to provide a clear idea of the heroskedastic errors, this issue is portrayed in the Figure 22. Clearly, the residuals still have a pattern and therefore, a non-constant variance.

Figure 22. Residuals vs. Fitted values

The figure portrays the FE regression residuals with dots. The red line represents the predicted values of the residuals. It is observed that there is a pattern in the predicted values, therefore the residuals are not homoskedastic.



As a result, this study computes the FE Robust Standard Deviations. This removes the heteroskedasticity and one type of autocorrelation. The cluster or the robust standard deviation generate a consistent estimate of the asymptotic variance. The 'robust' option in Stata deals with $\mathrm{E}(u_{it}^2) = \sigma_i^2$ and $\mathrm{E}(u_{it}^2) = \sigma_t^2$. Not deliberately, the last case also corrects the autocorrelation of the following type: $u_{it} = \rho u_{i,t-1} + e_{it}$.

The serial correlation is tested by the Arellano Bond test. This test shows the presence of autocorrelation at least for the lags *2* to *4* in the dependent variable. The results are presented in the Table 77.

Table 77. Arellano-Bond - serial correlation test

The table reports the Stata calculation for the Arellano-Bond test for autocorrelation. The null hypothesis is a serial correlation. The Table reports that some of the first differences are significant (*Prob > z less than 0.05*). This means that the null hypothesis serial correlation should be accepted.

Arellano-Bond test for AR(1): z =	0.28	Pr > z = 0.7813
Arellano-Bond test for AR(2): z =	2.22	Pr > z = 0.0265
Arellano-Bond test for AR(3): z =	3.12	Pr > z = 0.0018
Arellano-Bond test for AR(4): z =	2.55	Pr > z = 0.0107

The issue of heteroskedastic errors is confirmed by means of the decomposition of the IM-test of Cameron and Travedi, that is adding tests for both skewness and kurtosis.

Table 78. Cameron-Travedi - decomposition of IM test

The table reports the Cameron-Travedi test for heteroskedasticity. The null hypothesis is constant variance (homoskedasticity).

Cameron & Trivedi's decomposition of IM-test

Source	χ2	df	P
Heteroskedasticity	33,446.79	13	0.0000
Skewness	286.27	4	0.0000
Kurtosis	4.53	1	0.0332
Total	33,737.59	18	0.0000

The Table 78 reports that the *Prob > z* are significant (*less than 0.05*). This means rejection of the null hypothesis of homoskedasticy.

On the other hand, an issue can be found in the Panel Data when cross-section dependence is high. The implications here show that there is little improvement in efficiency from the panel estimators relative to a single time-series. Among others, the sources of cross-section dependence include:

d) Spatial spillovers (e.g. between exchange rate prices in different countries)

e) That there may be interaction effects through trade

f) An influence of groups through possible common unobserved factors

This study conducts the CD-test of cross-sectional independence, which tests the null of cross-sectional independence by means of the Average correlation coefficients and Pesaran (2004) CD test. The results in Table 79 indicate the rejection of the null hypothesis. In other words, the results suggest cross-section dependence (between exchange rates) with a CD-test of 396.73 and *p-value* of *0.000*.

Table 79. Fixed Effects and CD-test cross-sectional Independence

The table reports the CD-test of cross-section independencce for the FEM. The first column shows the variable name e2FE (the residuals of the performed FEM). The table also reports the group variable *p* (exchange rates), the number of groups (seven currency pairs), and the average number of observations. It also informs the CD-test statistic and the *p-value*. The Table reports a *p-value* as significant (*less than 0.05*). This means rejection of the null hypothesis of cross-sectional independence.

Average correlation coefficients and CD test (Pesaran 2004)
Variable: e2FE
Group variable: currency pairs based dollar
Groups: 7

Variable	CD-test	p-value	corr	abs (corr)
e2FE	396.73	0.0000	0.148	0.148

Null hypothesis: cross-section independence CD ~ N(0,1)

Having established the cross-sectional dependence, the order of integration is studied using the Maddala and Wu (1999) and the Pesaran (2007) panel unit root tests for multiple variables and lags based on Dickey-Fuller and augmented Dickey-Fuller regressions for models with and without a trend term. Due to the large quantity of observations, and the derived technical issues to manage large datasets, the test results below account for 40,238 observations from 01 April 2013 to 04 April 2013, with the number of residual series tested set to 6; the results indicate that the series suffer a high order of integration. Similar results are obtained using other time periods.

Table 80. Fixed Effects Model and Maddala-Wu (1999) panel unit root tests

The table reports the Maddala and Wu (1999) panel unit root test. It assumes heterogeneity in the autoregressive coefficient of the Dickey-Fuller regression, and ignores cross-section dependence in the data. The first column reports the residuals of the fixed effects estimator. The second column informs the analised lags. Based on the Fisher-principle, the third column indicates the chi-squared statistic. The fourth column reports the *p-values* of the calculated statistic. Clearly, the *p-values* indicate a strong presence of panel unit roots.

Maddala and Wu (1999) Panel Unit root test (MW)	
Variable:	e2FE
Group variable:	p
Number of groups:	7
Observations:	40,231

Specification without trend			Specification with trend		
e2Fe lags	Chi2	p-value	e2Fe lags	Chi2	p-value
0	0.000	1.000	0	0.000	1.000
1	0.000	1.000	1	0.000	1.000
2	0.000	1.000	2	0.000	1.000
3	0.000	1.000	3	0.000	1.000
4	0.000	1.000	4	0.000	1.000
5	0.000	1.000	5	0.000	1.000
6	0.000	1.000	6	0.000	1.000

This study also computed the Pesaran (2007) panel unit root test. However, the results report missing values due to the Maddala and Wu test reports *p-values* equal to 1. This indicates the strong presence of panel unit roots.

6.1. A choice of FE model

The fixed- effects (within estimator) denote a particular estimator for the coefficients in the regression model (ability). Panel Fixed effects generate time-independent effects for each unit possibly correlated with the regressors. As stated above, the panel exchange rates series suffer from:

- Heteroskedasticity
- Cross-sectional dependence
- Problems arising with co-integration and unit roots

The choice of FE model specification is a key decision to deal with these issues. The possible solutions to the unit roots issue encompass:

a) OLS estimation for variables in first differences
b) Heterogeneous parameter models. They include:
    - Mean Group (MG) estimator (Pesaran and Smith 1995) with either linear group-specific trend or the weighted matrix models
    - MG estimator with cross-sectionally demeaned data
c) Dynamic equation models. They comprise of:
    - Pooled mean group (PMG)
    - PMG by mean of groups
    - PMG by fixed effects model (FEM)

The following sections analyse in detail the results from these models. The aim is to remove the unit roots issue because it may bring about spurious regression problems.

6.1.1. OLS estimation for variables in first differences

A first possible solution to the issues that have been discussed is the OLS estimation for variables in first differences. If the variable series are *I(1)* in their levels, they are then *I(0)* in first difference, and therefore, there is no spurious regression. Yet, the regression model may be seriously affected from misspecification. This can result in problems with the computation of dummy variables especially when *T* tends to be infinite. This is the case with the dataset in this study.

Table 81. OLS estimation for variables in first differences

The table presents an OLS regression in first differences. The exchange rate returns r is the dependent variable. The variables o, a, and b represents the order flows, the U.S. the real macroeconomic conditions, the foreign real macroeconomic conditions, and the daily rollovers rate differential, respectively. The equation model shows $LnP_t^k - LnP_{t-1}^k = \lambda_1 O_t^k + \lambda_2 A_t^k + \lambda_3 B_t^k + \lambda_{\mathrm{t+3}} DUM_t + \zeta_t^k$, where $LnP_t^k - LnP_{t-1}^k$ is the logarithm of the spot price in time t for the currency k, and in other words, $LnP_t^k - LnP_{t-1}^k$is the exchange rate returns R. O_t^k is the order flow O at a time t for the currency k at 7 different price volatilities. The variable A represents the real macroeconomic conditions of the U.S. The variable B represents the foreign macroeconomic conditions related to the currency pair based on the US dollar. DUM are the time (T) dummies. The coefficients λ_1 to λ_3 are related to the explanatory variables. $\lambda_{\mathrm{t+3}}$ represents all the coefficients for each time dummy.

First-differenced IV regression

Group Variable:		p	Wald chi2 (5761)	73,064.96
Time variable:		t	Prob>chi2	0.0000
Observations:		40,155		
Groups:		7		
	within	between	overall	
R-sq:	0.6278	0.0012	0.6275	

D.r	Coef.	Std. Err	z	P>|z|
o	0.104538	0.00055	189.94	0.0000
a	Ommited			
b	0.437668	0.033618	13.02	0.0000
dum2	0.003763	0.042946	0.88	0.3810
dum3	0.003453	0.006074	0.57	0.5700
dum4	0.003831	0.007439	0.52	0.6060
…				
dum5756	0.009167	0.326543	0.03	0.9780
dum5757	0.010009	0.326571	0.03	0.9760
dum5758	0.007355	0.326600	0.02	0.9820
dum5759	0.01189	0.326628	0.04	0.9710
dum5760	0.013094	0.326656	0.04	0.9680
Sigma_u	0.000280			
sigma_e	0.011363			
rho	0.000608			

Instrumented: o, a, b

Instruments: dum2 to dum5760, o, a, b

The table presents an OLS estimation for variables in first differences. Here the time dummies indicate a levels-evolution, not growth rates. Indeed, this process extracts time dummy coefficients of a regression in first differences; and therefore, represents levels of evolution (means) of unobserved common factors across all groups (exchange rates).

Given the capabilities of Stata, 5760 time dummies (i.e. from 01 Apr 2013 00:00:00 to 04 Apr 2013 23:59:59) are analysed. The first part of the table provides information about the names and quantities of the groups and observations. The *R-sq* reports the R-square or the amount of variance of the returns *r,* explained by *o, a, b,* and *s.* The Chi-square statistic (73064.*96*) and the *Prob > Chi2* equal to *0.0000* reports that all coefficients in the model are different from zero. Again, it shows that the currency pairs' effects are an important feature.

The *corr*(*u_i, Xb*) indicates that the errors u_i are negatively correlated with the regressors in the OLS in first differences (*-0.0111).* In the first column, the prefix Dr informs that the variable is estimated in first differences. The exchange rate returns *r* is the dependent variable. The remaining variables *o, a, and b,* are the order flows, the U.S. real macroeconomic conditions, and the foreign real macroeconomic conditions, respectively. Beforehand, the daily rollovers rate differential *s* was dropped as it is not significant. Moreover, *a* is omitted due to collinearity. This means that the U.S. real macroeconomic conditions have a constant pattern within the period of time observed.

The coefficients in the second column provide a positive and a negative relation of the order flows *o,* and the foreign macroeconomic releases *b* with the exchange returns. The sign results were as expected; a positive order flow generates a positive return and a negative real macroeconomic conditions index generates a positive return.

The column Std Err reports the standard errors of the coefficients. The column *z* shows the *z-values,* as they are used to test the hypothesis that each coefficient is significant. To reject the null hypothesis, the *z-value* has to produce a *P>*|*z*| greater than

0.05. *rho* is the intra-class correlation (*0.00060766*). In other words, it shows that *0.00060766* of the variance is due to differences across panels. *Sigma_u* and *sigma_e* are the standard deviations of residuals across groups, and the standard deviations of the overall error term respectively.

Again, the Shapiro-Wilk test for normality is performed on the residuals of the OLS for variables in first differences. The results indicate that they do not follow a normal distribution (see the Table 82, *Prob>z* is equal to *0.00000*). This implies violation of the assumption d) regarding the variance and normally distributed idiosyncratic errors.

Therefore, violation of assumption d) poses a problem of efficiency in terms of bias in the standard errors. Under these circumstances, the asymptotic variance of β can be computed with the cluster-robust covariance estimator. In other words, under d), cluster-robust allows for heteroskedasticity and a serial correlation of an unknown form.

Table 82. OLS with variables in first differences and the Shapiro-Wilk normality test

The table reports the results of the Shapiro-Wilk test for normality for the residuals of the OLS with variables in first differences *eFD*. The sample period is from 01 April 2013 00:00:00 to 04 April 2013 23:59:59. The first column 'Variable' informs the observed variable *eFD*. The second column shows the encompassed number of observations. The third column presents the critical value of the W statistic for the Shapiro-Wilk test. The fourth column displays the critical value of the V statistic. The fifth column reports the z statistic. Finally, the sixth column shows the significance level of the z statistic or the *p-value*. Here, the *p-value* rejects the null of normality.

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
eFD	40,155	0.84742	2,384.06	21.484	0.0000

The test results on ommited variables keep failing greatly for this stimation process (see Table 83). However, as mentioned earlier, this result is expected in economic research on exchange rates.

Table 83. Ramsey Reset test - OLS estimation for variables in first differences

The table reports the Ramsey Reset test for the OLS estimation for variables in first differences.

Ramsey RESET test using powers of the fitted values of r	
Ho: Model has no ommitted variables	
F (3, 34390)	= 137.54
Prob>F	= 0.0000

The table reports the *F* statistic (137.54), and the degrees of freedom *k* together with the dimensions of the sub-sample (i.e. *3*, *34390*). The Ramsey test is performed with just over a subsample due to technical limitations. The *Prob > F* equals *0.0000*, therefore, the model is significant. This means rejection of the null hypothesis. In other words, the model has omitted variable bias issues.

The results regarding the autocorrelation are better than the fixed effects regression for the first lag *AR(1)* (see the Table 84). A process AR(1) can be corrected with the use of robust or cluster standard errors. However, the results in the Table 84 suggest the presence of AR(3) and AR(4) processes.

Table 84. First differences serial correlation

Arellano-Bond test for AR(1): z =	-89.90	Pr > z = 0.0000
Arellano-Bond test for AR(2): z =	-0.90	Pr > z = 0.3690
Arellano-Bond test for AR(3): z =	-3.00	Pr > z = 0.0027
Arellano-Bond test for AR(4): z =	3.38	Pr > z = 0.0007

The table reports the Arellano-Bond test for autocorrelation. The null hypothesis is serial correlation. The Table 84 reports that some first differences are significant (*Prob > z less than 0.05*). This means that the null hypothesis of serial autocorrelation shall be accepted. Obviously, the results suggest a Pr > z greater than *0.05*. This violates the panel model assumption of no autocorrelation.

The Breush-Pagan heteroskedasticity results keep resultantly high. The outcome of the OLS estimation for variables in first differences is better than the fixed effects.

Indeed, the chi-square statistic decreased in the OLS in first differences; however, the results still indicate an heteroskedasticity issue. The results are presented in the Table 85 for informative and comparative purposes. Certainly, as explained before, the robust standard deviations are always preferable even when there is no clear evidence of heteroskedasticity.

Table 85. OLS with variables in first differences – the Heteroskedasticity test

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
H0: Constant variance
Variables: fitted values of *r*

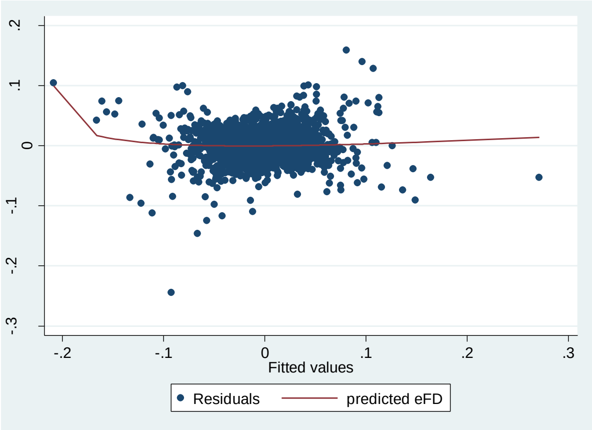
Chi2(1)	= 592.89
Prob>Chi2	= 0.0000

The table reports the Stata command for the Breusch-Pagan test for heteroskedasticity. The null hypothesis is constant variance (homoskedasticity). The Table reports the χ^2 statistic (*592.49*). The results *Prob > chi2* are still significant (*0.0000*). This means rejection of the null hypothesis. In other words, the results indicate the presence of heteroskedasticity. Other alternatives used to test hetteroskedasticity include the White (1980) general test for heteroskedasticity. However, this test is considered a special case of the Breush-Pagan test, where the errors may be non-normally distributed. There are many other tests for heteroskedasticity (e.g. the Goldfeldt-Quant test); they are not used here as the results using the Breush-Pagan approach clearly detect the issue.

Moreover, in the Figure 23 are portrayed the residuals. This helps to observe the issue of heteroskedasticity. Clearly, the errors still show a persistent systematic relation, and therefore a non-constant variance.

Figure 23. First differences residuals

The figure portrays the FE regression residuals with dots. The red line represents the predicted values of the residuals. It is observed that there is a pattern in the predicted values; therefore, the residuals are not homoskedastic.



The test of cross-sectional independence still reject the null hypothesis. However, the statistic is less than that calculated in the previous model, that is a CD-test of *-51.92* and *p-value 0.000*. This implies that the improvement in the estimators' efficiency, by conducting the OLS with variables in the first differences model, is small.

Table 86. OLS with variables in first differences and CD-test cross-sectional Independence

The table reports the CD-test of cross-section independencce for the OLS estimation with variables in first differnces. The first column shows the variable name eFD (the residuals of the performed OLS with variables in first differences). The table also reports the group variable *p* (exchange rates), the number of groups (seven exchange rates), the average number of observations, and information on whether the panel is balanced. It also informs the CD-test statistic and the *p-value*. The Table reports a *p-value* significant (*less than 0.05*).

Average correlation coefficients and CD test (Pesaran 2004)
Variable: e2FE
Group variable: currency pairs based dollar
Groups: 7

Variable	CD-test	p-value	corr	abs (corr)
e2FE	-51.92	0.0000	-0.15	0.166

Null hypothesis: cross-section independence CD ~ N(0,1)

The results above mean rejection of the null hypothesis of cross-sectional independence.

The Maddala –Wu and Pesaran (2007) unit root test indicates persistency of the unit roots issue (the results are presented in the Table 87). This is a serious problem as it can generate spurious regression issues. As solution, the heterogeneous parameter models are going to be reviewed in the following section.

Table 87. OLS with variables in first differences and Maddala-Wu (1999) panel unit root tests

The table reports the Maddala and Wu (1999) panel unit root test. It assumes heterogeneity in the autoregressive coefficient of the Dickey-Fuller regression and ignores cross-section dependence in the data. The first column reports the residuals of the fixed effects estimaator. The second column informs the analised lags. Based on the Fisher-principle, the third column indicates the chi-squared statistic. The fourth column reports the *p-values* of the calculated statistic. Clearly, the *p-values* indicate a strong presence of panel unit roots.

Maddala and Wu (1999) Panel Unit root test (MW)

Variable:	e2FE
Group variable:	p
Number of groups:	7
Observations:	20,126

Specification without trend			Specification with trend		
e2Fe lags	Chi2	p-value	e2Fe lags	Chi2	p-value
0	0.000	1.000	0	0.000	1.000
1	0.000	1.000	1	0.000	1.000
2	0.000	1.000	2	0.000	1.000
3	0.000	1.000	3	0.000	1.000
4	0.000	1.000	4	0.000	1.000
5	0.000	1.000	5	0.000	1.000
6	0.000	1.000	6	0.000	1.000

6.2. Heterogeneous parameter models

Heterogeneous panel data models are those in which all parameters vary across individuals. Habitually, panel models assume parameter homogeneity even though the evidence indicates heterogeneity. These models address the issue of cross-sectional dependence. This is an issue in the models studied above.

One approach to estimate to solve cross-sectional dependency is the Mean Group estimator (MG) (Pesaran and Smith 1995), in which both *N* and *T* are large. This estimation procedure is explained in the next section.

6.2.1. Mean group estimator

The MG estimator allows different intercepts, slope coefficients, and error variances across groups. The estimator emphasises variable non-stationary, cross-section dependence, and parameter heterogeneity in terms of parameter slope and time-invariant effects. The empirical model is the following:

Assume that the (k + 1) x 1 vector $\delta_i = (\alpha_i, \beta_i')'$ indicates that it contains slopes and intercepts.

Define the heterogeneous model as $y_i = W_i\delta_i + u_i$ **(5)**

Where y_i is a *T* x 1 vector, and W_i is a vector *T* x (k + *1*).

Then random parameters are assumed. This means $\delta_i = \delta + \eta_i$; where $E(\eta_i) = 0$; $E(\eta_i\eta_j') = \Omega$ or $E(\eta_i\eta_j') = 0$, for $i = j$; and that $E(\eta_i/W_i) = 0$

The MG estimator computes OLS for each group as follows:

$$\hat{\delta}_i = (W_i'W_i)^{-1}W_i'y_i \qquad \textbf{(6)}$$

The procedure then calculates the average $\bar{\delta} = \frac{\sum_i \hat{\delta}_i}{N}$

And then MG estimates the (k+1) x (k+1) covariance matrix Ω as follows:

$$\widehat{\Omega} = \sum_{\mathrm{i}}(\hat{\delta}_i - \bar{\delta})(\hat{\delta}_i - \bar{\delta})'/(N-1) \qquad \textbf{(7)}$$

Of course, estimators using means are sensitive to outliers; the MG procedure; however, can use the robust option which reduces the effect of outliers.

As variables in the model are *I(1)*, the Pesaran and Smith (1995) Mean group (MG) estimator might be a good option because it allows the potential heterogeneity across currency pairs (heterogeneous slope coefficients across *N*). In other words, this model might specify the correct cointegrating relationship. Under these circumstances, coefficients represent averages across groups, which are computed as unweighted means. The estimators stress the importance of non-stationarity, cross-section dependence, and parameter heterogeneity. The model smoothing the effect of outliers by means of a weighted matrix is presented in Table 88.

Table 88. Mean group estimator – outlier robust / weighted matrix

The table reports the Mean Group (MG) estimation using the outlier robust standard deviations (weighted matrix). The first column also reports the group-specific trend and the regression as constant. Importantly, the daily rollovers' differential *s* is not significant, and therefore it was removed from the regression. The coefficients are reported in the second column, and the third column the robust standard deviations. The fourth and fifth columns report the *z* statistic and their respective significance level. Importantly, the group-specific linear trend is not significant.

Mean Group estimator (Pesaran 1995)

Coefficients represent averages across groups

Group variable: currency pair

Groups:	7
Observations:	2,393,768
Wald chi2(3)	105.35
Prob>chi2	0.0000

r	coef.	Std. Err.	z	P>|z|
o	0.139635	0.016232	8.60	0.0000
a	0.126408	0.024255	5.21	0.0000
b	-0.210015	0.102595	-2.05	0.0410
trend	0.000000	0.000000	-0.16	0.8700
cons	-0.000028	0.000013	-2.12	0.0340

The coefficients indicates averages across the variable exchange rates *p*. The table also reports the number of observations and the number of groups. The Chi-square statistic (105.35) and the *Prob > Chi2* equal to *0.0000* inform that all coefficients in the model are different from zero. The first column of the table reports the variables used in the regression (i.e. exchange rate returns *r*; Order Flow *o;* real-time U.S.

macroeconomic index *a*; real-time foreign macroeconomic index *b*). The Pesaran and Smith (1995) MG estimator models the time-variant unobservable factors with a linear trend. This means that the unobservable common factors are not significant for this dataset.

The individual results for the curreny pairs *N* are listed in the Table 89. Importantly, the significance levels confirm the idea that the trend is not significant among group-specific coefficients.

Table 89. Individual results for the linear MG estimator

The estimation uses the variables exchange rate returns *r*, Order Flow *o*, US macroeconomic index *a*, and foreign macroeconomic index *b*. The columns 2 to 3 report the coeficients and standard deviations for each group. Intuitive levels of significance level $P>|z|$ are presented before the coefficients.

Mean Group Estimator (Group-Specific Coefficients)

	Group 1		Group 2		Group 3		Group 4	
	coef.	std. err.	coef.	std. err.	coef.	std. err.	coef.	std. err.
o	*** 0.0920	0.0012	*** 0.1042	0.0002	*** 0.1567	0.0002	*** 0.1282	0.0002
a	*** 0.0664	0.0018	*** 0.1153	0.0018	*** 0.2251	0.0030	*** 0.0511	0.0015
b	*** -0.0206	0.0019	*** -0.2284	0.0032	0.0014	0.0017	*** -0.4009	0.0031
trend	0.0000	0.0000	0.0000	0.0000	*** 0.0000	0.0000	0.0000	0.0000
cons	*** -0.0001	0.0000	0.0000	0.0000	*** -0.0002	0.0000	0.0000	0.0000

	Group 5		Group 6		Group 7	
	coef.	std. err.	coef.	std. err.	coef.	std. err.
o	*** 0.1536	0.0002	*** 0.1489	0.0002	*** 0.2028	0.0003
a	*** 0.1293	0.0024	*** 0.1804	0.0022	*** 0.1231	0.0028
b	*** -0.7145	0.0074	-0.0202	0.0147	*** -0.2079	0.0070
trend	0.0000	0.0000	*** 0.0000	0.0000	*** 0.0000	0.0000
cons	-0.0003	0.0000	0.0000	0.0000	0.0000	0.0000

*** $P|z|<0.01$ ** $P|z|<0.05$ * $P|z|<0.10$

The results in the Table 89 are a detailed continuation of the MG estimation presented previously. This detailed estimation results report the individual coefficients for the linear MG estimation, as the MG estimator assumes unobserved common factors with heterogeneous factor loadings. In other words, MG models these unobservables with a linear trend. Thus, the regression above is estimated for each group member *N* (groups 1 to 7 in the table), and includes an intercept to calculate fixed efects, and a linear trend to capture time-variant unobservables. The table reports the averaged coefficients across groups.

The MG estimator uses demeaned variables in a model with country-specific linear trends. However, an issue arises when cross-sectional common evolution on the data is imposed, as it introduces more dependencies across the cross-section. Therefore, an important increase in the CD-test of cross-sectional independence is expected. The results are presented in the Table 90.

Table 90. CD-test cross-sectional Independence MG estimator

The table reports the CD-test of cross-section independencce for the MG estimation. The first column shows the variable name eMG (the residuals of the performed MG estimation). The table also reports the group variable *p* (exchange rates), the number of groups (seven exchange rates), the average number of observations, and information on whether the panel is balanced. It also informs the CD-test statistic and the *p-value*.

Average correlation coefficients and CD test (Pesaran 2004)
Variable: e2FE
Group variable: currency pairs based dollar
Groups: 7

Variable	CD-test	p-value	corr	abs (corr)
e2FE	469.41	0.0000	0.175	0.175

Null hypothesis: cross-section independence CD ~ N(0,1)

The Table reports a *p-value* significant (*less than 0.05*). This means rejection of the null hypothesis of cross-sectional independence. The results show that the MG estimation increases the cross-sectional dependence issues compared to the OLS in first differences previously presented.

The model improves slightly, but keeps failing to solve the unit root problem. The residuals are presented in the Appendix of Chapter 6. Contrary to the assumption, those results keep portraying a clear tendency in the residuals.

Table 91. MG- Maddala-Wu and Pesaran panel unit root tests

The table reports the Maddala and Wu (1999) panel unit root test. It assumes heterogeneity in the autoregressive coefficient of the Dickey-Fuller regression and ignores cross-section dependence in the data. The first column reports lags of the residuals of the fixed effects estimator. Based on the Fisher-principle, the second column indicates the chi-squared statistic. The fourth column reports the p-values of the calculated statistic.

Maddala and Wu (1999) Panel Unit root test (MW)

Variable:	eMG
Group variable:	p
Number of groups:	7
Observations:	20,142

Specification without trend			Specification with trend		
eMG lags	Chi2	p-value	eMG lags	Chi2	p-value
0	0.000	1.000	0	0.000	1.000
1	0.000	1.000	1	0.000	1.000
2	0.000	1.000	2	0.000	1.000
3	0.000	1.000	3	0.000	1.000
4	0.000	1.000	4	0.000	1.000
5	135.660	0.000	5	0.000	1.000
6	537.516	0.000	6	0.000	1.000

Clearly, the *p-values* indicate strong presence of panel unit roots.

6.2.2. The *MG* estimator with cross-sectioanlly 'demeaned' data

The assumptions of the MG estimator with cross-sectionally demeaned data relax the evolution over time of the cross-section with the advantage that it permits a non-linear evolution instead of linear (trend). Technology is believed to be common across all currency pairs within this model. However, the results are not presented here because the model still suffers from cross-dependence (CD-test = *-379.61*; *p-value 0.000*). The panel unit root test has similar results to the unweighted MG. The results are presented in Appendix – Chapter 6.

6.3. Dynamic equation models

The estimators presented above do not correct the problem of co-integration in the dataset. Therefore, the use of these estimators is not valid because they cannot resolve potential issues of spurious regression. The solution is the use of a more dynamic specification. Error-correction dynamic specifications calculate the co-integrating vector and correct the unit roots issue. Moreover, the dynamic equation estimators gather the signals of ‘true’ parameter estimates when the inclusion of several lags is not suitable in the macro panel.

A further disadvantage of the heterogeneous parameter estimations, as discussed above, is the fact that they may increase the cross-sectional dependence issue. Contrary to this the dynamic equation models have the advantage of pooling the long run estimates and correcting the cross-sectional dependence issue.

The Models below assume that there is an autoregressive distributive lag (ARDL) dynamic panel specification, which is traditionally parameterised into the following error correction equation:

$$\Delta y_{it} = \phi_i\left(y_{i,t-1} - \theta_i' x_{it}\right) + \sum_{j=1}^{p-1} \lambda_{ij}^* \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij}'^* \Delta x_{i,t-j} + \mu_i + \epsilon_{it} \qquad \textbf{(8)}$$

With $\phi_i = -(1 - \sum_{j=1}^{p} \lambda_{i,j})$; $\theta_i = \sum_{j=0}^{q} \delta_{i,j}/(1 - \sum_k \lambda_{ik})$; $\lambda_{ij}^* = -\sum_{m=j+1}^{p} \lambda_{im}$;

For j=1,2,…,p-1; and $\delta_{ij}^* = -\sum_{m=j+1}^{q} \delta_{im}$; for j=1,2,…,q-1.

Where x_{it} are the regressors for groups i, μ_i are the fixed effects, $\lambda_{i,j}$ are the scalar coefficients of the lagged regressors, and $\delta_{i,j}$ are coefficients vectors. The parameter ϕ_i represents the corrected speed of adjustment of the error. Specifically, if the parameter ϕ_i equals zero there is no evidence of long-run relationship in the error. The parameter θ_i' represents the long-term relationship between the variables. T must have enough size to compute an estimator for each individual group.

The assumptions of the model include:

a) The errors are independently distributed across i and t, with zero means, and variances $\sigma_i^2 > 0$, and finite fourth-order moments. Increasing the lags order on x_{it} and $y_{i,t}$ are conducive for satisfying the assumption related to the independence of the disturbance (Pesaran et al. 1999).

b) Disturbances are distributed independently of the regressors, x_{it}. This assumption is important for consistent estimators in the short-run; however, Pesaran et al. (1997) argues that it can be allowed for dependence in the long run estimation, as far as x_{it} is autoregressive on the finite-order.

c) For equation 8, the roots of $\sum_{j=1}^{p} \lambda_{i,j} z^j = 1$, i=1,2,…N are outside the unit circle. This assumption makes $\phi_i < 0$; and therefore, it highlights the long run relation between x_{it} and $y_{i,t}$. Pesaran, Shin, and Smith (1999) provide a framework to test this assumption.

d) There is long run homogeneity on X_{it}, defined by $\theta_i = \theta$, $i = 1,2, \dots, N$. Therefore, θ is the same across groups.

PMG tests of homogeneity of error variances and short (long) run coefficients can be conducted using the Likelihood Ratio. However, this study uses the Hausman test (Hausman 1978) as an alternative method (Pesaran et al. 1999). The MG estimator is consistent, but inefficient if the slope homogeneity holds. Under long run homogeneity the PMG are consistent and efficient. This is the main reason why the research for this thesis uses the Hausman test, as the effect of the heterogeneity in the long run can be determined using the Hausman test between MG and PMG (Pesaran 1996).

Therefore, the paragraphs below compare three dynamic equation models that correct the co-integration issue. The Breush-Pagan test is then conducted in order to choose the most efficient dynamic specification.

6.3.1. Pooled Mean Group (PMG)

Pesaran, Shin and Smith (1997, 1999) proposed the Pooled Mean Group (PMG) estimator. The procedure constrains the long-run coefficients (to be equal across groups as in the Fixed Effects estimator); this allows the short run coefficients, the intercept and error variances to differ over groups.

Since the latter equation 8 is nonlinear in the parameters, the model needs to be resolved by the maximum likelihood (ML) method to estimate the parameters.

The Pesaran, Shin and Smith (1999) Pooled Mean Group (PMG) estimator is presented in the Table 92. This approach is appealing to this research because it was designed as a half-way between pooled and heterogeneous parameter estimators, which of course addresses the problem of cross-dependency. It also corrects the problem of serial correlation in the form of co-integration and unit roots. In other words, the long-run (LR) relationship is assumed to be common, and the short- run (SR) and error correction parameters are allowed to differ across groups; these might be the behaviour of the exchange rates series.

Since PMG employs the error correction model (ECM) specification, the co-integration is not an issue. Nonetheless, the drawback consists in the assumption of cross-section independence, which has been a persistent problem in the models tested beforehand by means of the CD-test.

In the Table 92, the LR outcome is the long-run error-correcting the relationship between the returns *r* (dependent variable), the order flows *o*, the U.S. real-time macroeconomic variable *a*, and the foreign real-time macroeconomic variable *b.* The SR results are the heterogeneous short-run and adjustment parameters. Indeed, LR acts as a coefficient on the newly-created error correction term. The latter implies an iterative procedure to achieve the best fit in which LR is computed, the coefficients are included, and the whole model is estimated with heterogeneous SR, and an error- correction term. Afterwards it is evaluated by means of maximizing the log likelihood (LL) in order to find the best model. The SR results presented in the Table 92 are averages across *N* (currency pairs).

Table 92. Pooled Mean Group (PMG)

The long run coefficients indicates pooled regression and averages across the variable exchange rates. Contrary, the short run coefficients are allowed to differ over units. The table also reports the number of observations, the number of groups, and other sample information. The first column of the table reports the variables used in the regression (i.e. exchange rate returns *r*; order flow *o;* real-time U.S. macroeconomic index *a*; real-time foreign macroeconomic index *b*). The shortrun coefficients were calculated using first differences. Importantly, the daily rollovers' differential *s* is not significant, and therefore it was removed from the regression. In the second and third column are reported the intuitive p-values and the coefficients. The fourth column illustrates the robust standard deviations.

Pooled Mean Group (PMG) Regression

Groups:	7 exchange rates
Observations:	2,390,123
Log Likelihood:	7,597,015

Long Run			
Dr.	P>|z|	Coef.	Std. Err.
o	***	0.128561	0.000113
a	***	0.110252	0.001217
b	***	-0.124274	0.001770

Short Run			
	P>|z|	Coef.	Std. Err.
Long Run	***	-0.90109	0.017314
o	***	0.134965	0.000113
a	***	0.113949	0.001217
b	***	-0.174591	0.001770
cons		-0.000014	0.000018

*** P>|z|<0.01   ** P>|z|<0.05   * P>|z|<0.1

Importantly, all the explanatory variables in the table are significant. The coefficients signs denote an inverse relation between *r* and *b,* and a direct relation between *r* and *a.* This means that positive U.S. macroeconomic news bring about positive returns, and positive foreign macroeconomic news generate negative returns on the dollar based currencies.

Interestingly, all short run estimates are significant with the exception of the constants for two currency pairs. Indeed, within the PMG model, the intercepts, the short term slope coefficients, and error variances are all relaxed to differ across groups, but the model constrains the LR coefficients to be the same across groups in a FEM fashion.

Table 93. Detailed PMG results – pooled estimator

Pooled Mean Group (PMG) Regression
Groups: 7 exchange rates
Observations: 2,390,123
Log Likelihood: 7,597,015

Long Run

Dr.	P>|z|	Coef.	Std. Err.
o	***	0.128561	0.000113
a	***	0.110252	0.001217
b	***	-0.124274	0.001770

Exchange Rate 1

	P>|z|	Coef.	Std. Err.
ec	***	-0.81751	0.001685
o	***	0.107853	0.000104
a	***	0.082977	0.001418
b	***	-0.062276	0.001600
cons	***	-0.000066	0.000015

Exchange Rate 2

Dr.	P>|z|	Coef.	Std. Err.
ec	***	-0.89349	0.001685
o	***	0.115012	0.000120
a	***	0.099784	0.001404
b	***	-0.163307	0.002392
cons		-0.000016	0.000015

Exchange Rate 3

Dr.	P>|z|	Coef.	Std. Err.
ec	***	-0.88493	0.001719
o	***	0.143535	0.000180
a	***	0.171220	0.002180
b	***	-0.053865	0.001442
cons	**	0.000056	0.000024

Exchange Rate 4

Dr.	P>|z|	Coef.	Std. Err.
ec	***	-0.93872	0.001705
o	***	0.128169	0.000134
a	***	0.075993	0.001205
b	***	-0.257007	0.002319
cons	***	-0.000036	0.000012

Exchange Rate 5

Dr.	P>|z|	Coef.	Std. Err.
ec	***	-0.93228	0.001668
o	***	0.141056	0.000158
a	***	0.113673	0.001782
b	***	-0.436387	0.005192
cons		-0.000014	0.000019

Exchange Rate 6

Dr.	P>|z|	Coef.	Std. Err.
ec	***	0.953191	0.001715
o	***	0.138666	0.000159
a	***	0.139679	0.001664
b	***	-0.080805	0.010487
cons	**	0.000038	0.000018

Exchange Rate 7

Dr.	P>|z|	Coef.	Std. Err.
ec	***	-0.88753	0.001669
o	***	0.170470	0.000210
a	***	0.114315	0.002060
b	***	-0.168488	0.005072
cons	***	-0.000059	0.000022

*** P>|z|<0.01 ** P>|z|<0.05 * P>|z|<0.1

The long run coefficients indicates pooled regression and averages across the variable exchange rates *p.* They are presented in the first panel of results. The remaining panels show the detailed short run coefficients (for the seven studied exchange rates). The first equation (ec) presents the normalized cointegrating vector. The table also reports the number of observations, the number of groups, and other sample information. Each panel reports in the first column the intuitive significance levels, and in the second column the short run coefficients, and the variables used in the regression (i.e. exchange rate returns *r*; Order Flow *o;* real-time U.S. macroeconomic index *a*; real-time foreign macroeconomic index *b*). The second column also reports the regression constant.

Importantly, the daily rollovers' differential *s* are not significant, and therefore it was removed from the regression. The coeffient signs are the same for all currencies in LR and SR. The fourth column provides information for the robust standard deviations. Importantly, all the explanatory variables in the table are significant. The coefficients signs denote an inverse relation between *r* and *b*, and a direct relation between *r* and *a.* This means that positive U.S. macroeconomic news bring about positive returns, and positive foreign macroeconomic news generate negative returns on the dollar based currencies.

The short run conditional estimates are used in the model as an innovation to estimate the long run coefficient vector. Very importantly, in order to the fit the results within the first step of the panel 2SLS, the estimated covariance matrix for all estimated parameters can be recovered Pesaran et al. (1999).

The model solves the existing co-integration and cross section dependence problems that were found in the series. However, as commented in the assumptions, the

PMG model assumes slope homogeneity. In effect, it assumes long run elasticities to be equal in the cross-sections. Indeed, this can be the case within the field of exchange rates determination. When the assumption is 'true', the pooling across currency pairs generates efficient and consistent estimates. However, if not or when the 'true' slope is heterogeneous, the PMG pooled estimates are inconsistent. For this reason, the Table 94 reports the PMG by mean-group (MG) estimates (*N* unweighted estimates), as this estimator is consistent whether or not there is slope heterogeneity. This permits a comparison of both the models by the Hausman test as advised in Pesaran (1999).

Table 94. PMG by mean of groups (MG) - unweighted process

The table reports the results of the PMG by Mean Group estimates. The long run coefficients indicates the mean group regression and averages across the groups (exchange rates *p*). Long run results are presented in the first panel. The remaining panels show the short run coefficients. The first column of the table reports the variables used in the regression (i.e. exchange rate returns *r*; Order Flow *o;* real-time U.S. macroeconomic index *a*; real-time foreign macroeconomic index *b*). The second column reports the intuitive significant levels. The rollovers' differential *s* were removed as they are not significant. The third column reports the coefficients. The coefficient signs are the same in LR and SR. The third column illustrates the robust standard deviations. The fourth and fifth columns report the *z* statistic and their respective significance level.

Mean group approach - Pooled Mean Group (PMG) Regression
Groups: 7 exchange rates
Observations: 2,390,123
Log Likelihood: 7,597,015

Long Run

Dr.	P>|z|	Coef.	Std. Err.
o	***	0.142639	0.014153
a	***	0.138109	0.023239
b	**	-0.235665	0.102257

Short Run

	P>|z|	Coef.	Std. Err.
Long Run	***	-0.94789	0.008776
o	***	0.141427	0.013995
a	***	0.126836	0.022841
b	**	-0.227514	0.098409
cons		-0.000012	0.000024

*** P>|z|<0.01 ** P>|z|<0.05 * P>|z|<0.1

Importantly, all the variables in the table above are significant. The coefficients signs denote an inverse relation between *r* and *b*, and a direct relation between *r* and *a.* This means that positive U.S. macroeconomic news brings about positive returns, and positive foreign macroeconomic news generate negative returns on the dollar based currencies.

By comparing the PMG and PMG by MG (tables above), it is noted that the estimated long run coefficients are statistically significant and equally signed.

Nonetheless, the pooled mean-group estimates of *b* are considerably different in magnitude (PMG -0.1242741 *vs. PMG by MG -0.235664*). The speed of estimate adjustment (estimates at the short run) also reports noteworthy differences for *b*. The Table 95 reports the Hausman test with a non-significant χ^2 statistic equal to *3.63*. The decision is not rejection of the null hypothesis of non-systematic difference between both methods. Under this circumstance, the PMG estimator is preferred because of its efficiency. As a result, the assumption of LR slope homogeneity is supported in the exchange rates (majors).

Table 95. Hausman test between PMG vs. PMG-MG

The table reports the Breusch-Pagan test for heteroskedasticity. The table reports the variables *o*, *a*, and *b*. The regression coefficients of both regressions are on the second and third column. The fourth column reports the difference between coefficients. The fifth column reports the standard error.

Hausman test between MG and PMG estimators

H0: Difference in coefficients is not systematic

	(b) MG	(B) PMG	b-B	S.E.
L.o	0.142639	0.128561	0.014078	0.014875
L.a	0.138109	0.110252	0.027857	0.024396
L.b	-0.23566	-0.12427	-0.11139	0.107464

b: consistent under Ho and Ha

B: inconsistent under Ha, efficient under Ho

Chi2(3) = 3.63

Prob>Chi2 = 0.3045

The heteroskedasticity test is conducted to compare the coefficients of the PMG and PMG by MG estimators. The Table reports a non-significant χ^2 statistic equal to

3.63. The results *Prob > chi2* si not significant (*0.3045*). This means it has rejected the null hypothesis of non-systematic difference between coefficients. Moreover, as the pooled mean group estimator is asymptotically more efficient, the result indicates that the PGM estimation is preferable.

The PMG assumes equal coefficients of the co-integrating vector across panels in the long run. However, imposing short run equal coefficients may improve the estimation efficiency. Specifically, the Pooled Mean Group by the Fixed Effects Model (PMG by FEM) further restricts the short run coefficients to be equal. In other words, PMG by FEM constrains the speed of adjustment coefficient to be equal. Moreover, PMG by FEM estimates the model allowing *N* specific intercepts.

In the cases when PMG by FEM is statistically similar to PMG or PMG by MG estimates, the PMG by FEM estimators are more efficient and preferable as the speed of adjustment coefficient is equal across panels. However, if the estimates are different, PGM by FEM suffers from a simultaneous equation bias, because of the endogeneity involving the error term and lagged dependent variable.

The Table 96 shows the PGM by FEM results. Again, the Hausman test is conducted. This test is important as it is useful to calculate and assess whether endogeneity is an important issue in the dataset.

Table 96. PGM by FEM – constant speed of adjustment coefficient

The table reports the results of the PMG by FEM. The long run coefficients indicate a mean group regression and averages across the variable exchange rates p (first panel of results). The other panel show the short run coefficients. The first column reports the explanatory variables used (i.e. exchange rate returns r; Order Flow o; real-time U.S. macroeconomic index a; real-time foreign macroeconomic index b). The second column reports the intuitive significance levels. The third column reports the long and short run coefficients. The first column also reports the regression constant. The daily rollovers' differential *s* was non-significant, and therefore it was dropped from the regression previously. The PMG by FEM estimation also present a non-significant b. In the second column are reported the coefficients. The coefficient signs are the same in LR and SR. The fourth column illustrates the robust standard deviations.

Fixed Effects approach - Pooled Mean Group (PMG) Regression

Groups:	7 exchange rates
Observations:	2,390,123
Log Likelihood:	7,597,015

Long Run

Dr.	P>|z|	Coef.	Std. Err.
o	***	0.136529	0.016217
a	***	0.129220	0.026132
b		-0.064848	0.055669

Short Run

	P>|z|	Coef.	Std. Err.
Long Run	***	-0.95271	0.01269
o	***	0.135883	0.013995
a	***	0.120449	0.022841
b		-0.060485	0.098409
cons	***	-0.000016	0.000024

*** P>|z|<0.01 ** P>|z|<0.05 * P>|z|<0.1

The coefficients' signs denote a direct relation of *r* with *o* and *a* . This means that positive U.S. macroeconomic news bring about positive returns. Positive foreign macroeconomic news is non-significant on the dollar based currencies.

The PMG by FE coefficients are signed as expected. However, the foreign real-time macro variable *b* is not significant with this model. Indeed, when it has imposed an equal speed of adjustment across panels in the short run the foreign real-time macro variable *b* is not significant.

The results reported in the Table 97 indicate that the simultaneous equation bias is minimal for these data. Therefore, it is concluded that the fixed effects model is preferred over the mean-group model.

This thesis uses the Hausman test even when it has been criticised when it has been necessary to use it to decide between random and fixed effects (Clark et al. 2010). In this study; however, the Hausman test is not used to decide between random or fixed effects, but to decide between short term homogeneous or heterogeneous velocity of adjustment between PMG by MG and PMG by FE.

Table 97. Hausman test between PMG by MG and PGM by FEM

The table reports the Breusch-Pagan test for heteroskedasticity. The first column reports the variables *o*, *a*, and *b*. The regression coefficients of both regressions are in the second and third column. The fourth column reports the difference between coefficients. The fifth column reports the standard errors.

Hausman test between PMG by MG and PMG by FE estimators

H0: Difference in coefficients is not systematic

	(b) MG	(B) PMG	b-B	S.E.
L.o	0.142639	0.13653	0.00611	1.441413
L.a	0.138109	0.12922	0.00889	2.3669
L.b	-0.23566	-0.06485	-0.17082	10.41523

b: consistent under Ho and Ha

B: inconsistent under Ha, efficient under Ho

Chi2(3) = 0.0000

Prob>Chi2 = 1.0000

The heteroskedasticity test is conducted to compare the coefficients of the PMG by MG, and PMG by FE estimators. The Table above reports a non-significant χ^2 statistic (*3.63*). The test is non-significant (*0.3045*). This means rejection of the null hypothesis of a non-systematic difference between coefficients. Moreover, as the pooled mean group estimator is asymptotically more efficient, the result indicates that PGM by FE is preferable.

Lastly, the Table 98 shows the PGM by FEM after removing *b;* this suggests evidence on the constant speed of adjustment coefficients.

Table 98. Pooled Group Mean by Fixed Effects Method – final results.

Fixed Effects approach - Pooled Mean Group (PMG) Regression
Groups: 7 exchange rates
Observations: 2,390,123
Log Likelihood: 7,597,015

Long Run

Dr.	P>|z|	Coef.	Std. Err.
o	***	0.136558	0.016217
a	***	0.128643	0.026132

Short Run

	P>|z|	Coef.	Std. Err.
Long Run	***	-0.95267	0.012652
o	***	0.135907	0.015524
a	***	0.119913	0.025375
cons	***	-0.000015	0.000000

*** P>|z|<0.01 ** P>|z|<0.05 * P>|z|<0.1

The Table 98 shows the results of the PMG by FE. The long run coefficients indicates mean group regression and averages across the variable exchange rates *p*. They are presented in the first panel of results. The other panels show details on the short run coefficients. The first column of the table reports the explanatory variables (i.e. exchange rate returns *r*; Order Flow *o;* real-time U.S. macroeconomic index *a*). The second column reports the intuitive significance level. Importantly, neither the foreign macroeconomic measure *b* nor the daily rollovers' differential *s* are significant; and therefore, these variables were removed from the regression. In the third column are reported the coefficients. The coefficient signs are the same in both the long and short run. The fourth column provides information for the robust standard deviations. The fourth and fifth columns report the *z* statistic and their respective significance level. Importantly, all the variables in the table are significant. The coefficients signs denote an inverse relation between *r* and *b*; and a direct relation between *r* and *a*. This means that positive U.S. macroeconomic news bring about positive returns, and positive foreign macroeconomic news generate negative returns on the dollar based currencies.

6.4. Empirical Findings

The results presented in this chapter are innovative and important because they bring about the following findings:

a) They confirm the robustness of the Portfolio Shift Model in the exchange rates determination.
b) Order flow is confirmed significant; this supports the theories attributing to this variable a key aggregative and informational mechanism in the exchange rates determination.
c) Exceptionally, this chapter provides supportive evidence of the importance of the real-time macroeconomic conditions (Evans 2010). The contribution of this study is to find that real-time macroeconomic conditions are also significant at very high frequencies (1 minute frequency).
d) This study did not find a significant relationship between exchange rates and interest rate differentials.
e) This chapter uses PMG by FE to solve co-integration problems found in the dataset.

The following paragraphs explain this findings and contributions further.

The empirical results show that currency flows determines the ER. Specially, the results stress the importance of the applied portfolio shift model (Evans and Lyons, 2002a and 2002b), and the usefulness of modelling the agent heterogeneity to explain the exchange rates. In this connection, the process of aggregation of dispersed information, which determines the order flow, is found to be highly important.

The empirical findings confirm the previous evidence on agents' economic heterogeneity in the Forex market (e.g. Frechette and Weaver 2001). Indeed, order flow is a variable that conveys economic information for the market agents. Very importantly, the results presented in this chapter are new in the literature, and they suggest a solution to ‘the ER disconnect puzzle’. At very high frequencies, this study evidences a significant relationship (connection) between the real-time macroeconomic index (Evans 2010) and the ER. The index was calculated using a Kalman Filter, and can be a key topic of future research.

These results also support previous solutions to the notion of an ER disconnect puzzle (the fact that ER appears to be disconnected from observable news and fundamentals). Indeed, this study shows that the real macroeconomic conditions (both foreign and U.S.) are significant variables at a very high frequency (1 minute). Previous literature has demonstrated that macroeconomic releases are important at high frequencies (daily frequencies) as in Evans (2010); the findings of this chapter suggests that US macroeconomic releases are important at very high frequencies (1 minute), and this point is important as there are no previous MMM literature evidencing this point.

This study also provides evidence that the foreign macroeconomic conditions *b* are significant in the short run when the heterogeneous speed of adjustment in the coefficients is allowed. The importance of the U.S. macroeconomic conditions clearly dominates the long and short run.

The daily rollovers *s* are apparently significant in the initial fixed effects regression. However, the results are not the same in the heterogeneous parameter models or dynamic models. This indicates that co-integration and unit roots generated spurious regression results relative to *s*. This result is contrary to Burnside, Eichembaum and Rebelo (2009).

The sign of the coefficients are in line with the work of Evans and Lyons (2005) and Evans (2010). He studied the Forex returns at high frequency dynamics (daily) and the developments in macroeconomics. In addition to the evidence of Evans, this study supplies empirical evidence supporting the existence of the link between macroeconomics and order flow. As in Evans (2010), this research also estimates the price returns based on order flow and macroeconomic variables. The most important findings comprise:

a) The long run and short run coefficients are similar. The long run coefficients have a slightly greater influence on price returns.
b) The PMG by FEM estimation shows that order flow accounts for a *0.1365* variation in excess for price returns at a 1 minute frequency (in the long run).
c) The PMG by FEM estimation shows that the developments in U.S. macroeconomics account for *0.1292* variation in excess for price returns at a 1 minute frequency (in the long run). Overall, the positive U.S. economic news strengthens the USD generating exchange rate based-dollar depreciation.
d) The explanatory power is higher than traditional models, including the most recent monetary models with central banks reaction functions.
e) It makes available a solution to the ER disconnect puzzle or the apparent disconnection between exchange rates and fundamentals.
f) Contrary to Reitz, Schmidt, and Taylor (2011), the results indicate that order flow may convey information for short run speculative strategies.

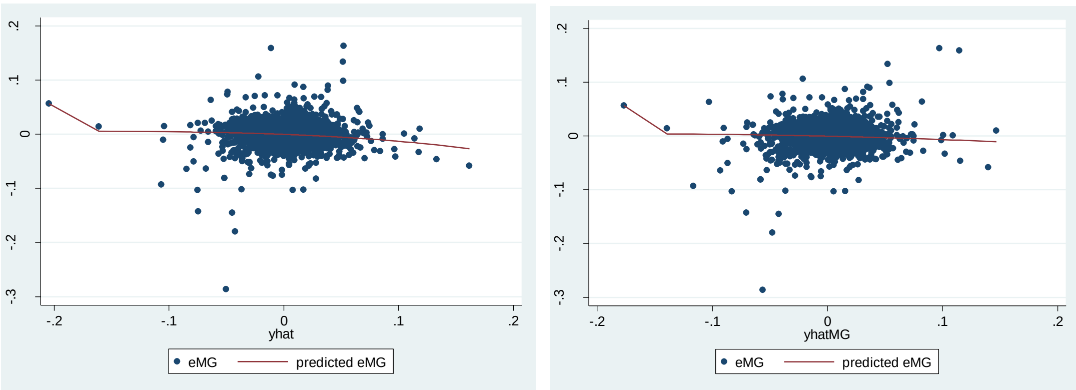
The PMG by FEM regression is the first step regression for the Panel 2SLS estimation (i.e. its covariance matrix). The panel 2SLS is the applied estimation method to test the time-invariant variables. The source of time-invariant variables within this research is the cross-sectional survey variables and economic time invariant variables. These variables are related to the topic of strategy discussed in this research. The next chapter will address the combined results from the survey and the time series.

Having presented in detail the estimation procedure used to choose the PMG by FEM, the next chapter reports only the indispensable procedures and post-estimation tests of the PMG by FEM estimation.

Appendix – Chapter 6

Figure 24. MG (trend and weighted) - residuals vs. fitted residuals

The figure portrays the regression residuals. The first panel presents the PMG by MG with its trends and the second panel the PMG by MG without its trends. The red line represents the predicted values of the residuals.



A pattern in the predicted values can be observed, and therefore the residuals are not homoskedastic.

Table 99. *MG* with cross-sectionally demeaned data

The table reports the Mean Group (MG) estimation using cross-sectionally demeaned data. The coefficients indicates averages across the variable exchange rates *p*. The table also reports the number of observations and the number of groups. The Chi-square statistic (123.35), and the *Prob > Chi2* equal to *0.0000* show that all the coefficients in the model are different from zero. The first column of the table reports the variables used in the regression (i.e. exchange rate returns *r*; Order Flow *o;* real-time U.S. macroeconomic index *a*; real-time foreign macroeconomic index *b*). Importantly, the daily rollovers' differential *s* is not significant, and therefore it was removed from the regression. In the second column the coefficients are reported. The third column relays the robust standard deviations. The fourth and fifth columns report the *z* statistic and their respective significance level.

Mean Group estimator (Pesaran 1995)	
Coefficients represent averages across groups	
Group variable: currency pair	
Groups:	7
Observations:	2,393,768
Wald chi2(3)	123.66
Prob>chi2	0.0000

r	coef.	Std. Err.	z	P>|z|
o	0.118240	0.016232	8.60	0.0000
a	0.530435	0.113637	5.21	0.0000
b	-0.137253	0.055828	-2.05	0.0140
cons	0.000000	0.000028	-2.12	0.9060

The results present a specially high coefficient for *a*. The results of the postestimation tests show that this regression does not solve the co-integration issue. Therefore, the high results for *a* (and the other coefficients) are very likely to be spurious.

These results were tested for co-integration using the Maddala and Wu (1999) panel unit root test. It assumes heterogeneity in the autoregressive coefficient of the Dickey-Fuller regression, and ignores the cross-section dependence in the data. Based on the analysed lags and the Fisher-principle, the chi-squared statistic indicates a strong presence of panel unit roots.

CHAPTER 7. COMBINED RESULTS

This chapter examines a central point of this research: whether trading management strategies influence exchange rate determination. This chapter entirely focuses on this research objective as it highlights the relationship between microstructure, strategy and exchange rate (ER) determination. The results obtained from a cross-sectional study, and through fixed effects estimation (Chapters 4, 5, and 7 respectively) will also be combined here. Furthermore, the later sections will estimate the volatility in an intermediate step in order to:

a) Analyse the volatility tolerance as a strategic objective.
b) Disaggregate order flows by the different levels of price volatility according to identified control groups (CG).
c) Generate the trading strategy variables, and estimate their significance using a Panel Second Step Least Square regression (Panel 2SLS).

The notion of time-invariant variables encompasses those variables with very low variance. This study applies an alternative estimation procedure to recover the coefficients of the time-invariant variables, using the Panel 2SLS (Atkinson and Cornwell, 2014). The use of the Panel 2SLS estimator is suitable given the time-invariant nature of the trading strategy variables. As reviewed in the previous chapter, the PMG by fixed effects is the selected within estimator method used for the first step[2]. The second step uses the approach of Atkinson and Cronwell (2014) to recover the coefficients of the trading variables in the model specification.

[2] This study confirmed in the chapter on Fixed Effects that PMG by FE is the most efficient estimator

The approach in this chapter combines time-invariant data (cross-sectional data from a survey), and time-variant ER rates data (secondary data). The cross-sectional data is a key source of information for the generation of control-groups and trading strategy variables. The trading management strategies (time-invariant variables) are assigned to each control group. This empirical investigation generates control groups using (a) an ER volatility and (b) the Forex ‘market hours’ (the times at which the major markets are opened and closed). This is because the survey findings suggest strategy heterogeneity in terms of ER volatility. The following sections will explain further the variables generation process and the estimation results.

7.1. The variable generation process using exchange rate (ER) volatility

This section empirically estimates and analyses the agents’ distinctive levels of volatility tolerance and trading management strategies. It can be shown, from the cross-sectional results (Chapter 4), that volatility is an essential variable for the creation of control-groups, and also significant for the assignation of trading strategies. Firstly this empirical research determines the control-groups (CGs) by using distinctive measures of volatility tolerance (from the cross-sectional data).

Secondly, this approach allocates the distinctive levels of trading strategies (computed in chapter 4) to each CG (on the tick by tick dataset). Each tick (i.e. one trading order by an agent), therefore, is related to a trading strategy. Afterwards, there is an aggregation process using the average in ten minutes of the trading strategy variables. Once the variables are computed, the trading management variables are analysed using predetermined estimation procedures as discussed in Chapter 4 (Panel 2SLS).

The approach considers the following explanatory variables:

a) The trading management strategies. Specifically, the strategies considered include command, planning, incremental, political, cultural, and enforced choice.

b) The order flows disaggregated at different volatilities are used for the estimation of control groups CGs.

The control groups include the following market agents:

i. Banks (commercial and investment banks)

ii. Market makers

iii. Individual speculators

iv. Speculative organisations

v. Public institutions (government and central banks)

vi. Funds (building society, leasing company, insurance company; and currency, money, mutual, pension, and hedge funds)

vii. Corporations (security houses, branch or subsidiary with sale desk, and financial subsidiaries)

This study, in accordance with previous literature, suggested in Chapter 4 that market organisations have a distinctive volatility tolerance. I calculated the volatility on tick frequency, and associated the percentiles to certain trading strategy using the cross-sectional data. Step by step, the variable generation process includes the following calculation procedure:

a) The calculation of a volatility measure (in tick frequency).

b) The calculation of volatility percentiles.

c) The generation of CGs, which implies the association of the volatility tolerance from each type of agent (survey data) to the volatility percentiles in the time series.

d) Finally, the trading strategies of each agent are assigned to the generated CGs. The sections 7.4., 7.5. and 7.6. explain in detail the procedure including a mathematical explanation.

This research shows that the choice of volatility measure is a key aspect to disaggregate the CGs. Volatility also permits testing to find out whether trading orders from specific CGs have different explanatory power. It also allows the study to create trading strategy variables. In the next two sections, I estimate and analyse (a) the combined results on volatility and volatility tolerance (cross-sectional data); (b) diverse volatility measures from the literature; (c) the allocation of order flows using specific CGs; (d) the assignation of trading strategies and generation of the trading management variables. Finally, I report the significant and non-significant trading management strategy variables, and discuss the findings.

7.2. Agents' tolerance to price volatility and volatility measurement.

Market agents evaluate portfolio investments and individual assets depending on the risk generated by the asset's volatility. The results suggest in chapter 3, that Market agents have specific tolerances to price volatility (heterogeneity in terms of volatility tolerance). In other words, market organisations have a distinct aversion to the volatilities of price returns. Particularly, the Kruskal-Wallis rank test reported the rejection of the null hypothesis of equal medians for 13 types of organizations. This finding is also significant when grouping the agents into 7 categories. Therefore, this study uses these results (i.e. the variance as a key proxy measure of the risk exposure and the volatility of price returns).

The use of volatility to disaggregate specific groups has gained support from previous literature. Particularly, the microstructure literature uses volatility (variance) patterns to explain the interactions of specific agents. Often, the empirical literature examines the influence of public and private information on exchange rate volatility (e.g. Pfleiderer 1988 among the first contributions). Other strands of literature use volatility patterns to examine the risk of inventories for banks and market makers.

7.3. Approaches to volatility measures

There are wide ranging approaches to estimate volatility. 'Sample variance' is habitually applied and is based on squared returns. However, the standard variance-ratio or comparable measures (from asymptotic distribution theory) do not provide a good approximation in a FX high frequency setting. Indeed, high frequency returns embody persistent conditional heteroskedastic components together with discrete informational arrival effects. As a result, serial correlation and outliers are generated in the intraday setting. This makes variance-ratio procedures unreliable. In effect, this type of variance measure is heavily influenced by extreme values. For this reason, the volatility measures in Forex usually apply absolute returns as they are less sensitive to outliers.

Specifically this study applies the most frequent definitions of volatility found within the FX Microstructure literature. These definitions include the following:

a) Many empirical studies rely on standard variance ratios (e.g. Amihud and Mendelson 1987, 1991; Stoll and Whaley 1990; Foster and George 1992; and Ito, Lyons and Melvin 1998). These papers have studied the high-frequency data for a variety of volatility patterns. The most common volatility ratio is based on the standard deviation. However, the absolute value of the returns is usually preferred because it better captures the autocorrelation and time series seasonality (Taylor 1987; Muller et al. 1992; and Grange and Ding 1993). The volatility $v(t_i)$ at time t_i is defined as:

$$\boldsymbol{v}(\boldsymbol{t_i}) \equiv \frac{\boldsymbol{1}}{\boldsymbol{n}}\sum_{\boldsymbol{k=1}}^{\boldsymbol{n}} |\boldsymbol{r}(\Delta\boldsymbol{t}; \boldsymbol{t_{i-k}})| \qquad (1$$

Where *r* represents the returns at a time frequency Δt for the t_{i-k} different moments within Δt.

The specification above is similar to the proxy for volatility applied by McGroarty et al. (2009) in the use of absolute returns. Their volatility specification is defined as:

$$\boldsymbol{v}(\boldsymbol{t_i}) \equiv |\,\mathbf{log}(\boldsymbol{p_{d,t}}) - \mathbf{log}(\boldsymbol{p_{d,t-1}})\,| \qquad (2$$

Where the return *r* is estimated from the price logarithms *p* during the day *d*, times *t* and *t-1*.

This study also applies a generalisation of the variance ratio introduced by Lo and MacKinlay (1988) and Poterba and Summers (1988). This ratio is widely used in empirical finance when the Efficient Markets Hypothesis (EMH) is tested. This variance ratio is defined as:

$$\boldsymbol{v}(\boldsymbol{t_i}) \equiv \frac{|\sum_{\boldsymbol{k=1}}^{\boldsymbol{n}} \boldsymbol{r}(\boldsymbol{t_{i+k}})|}{\sum_{\boldsymbol{k=1}}^{\boldsymbol{n}} |\boldsymbol{r}(\boldsymbol{t_{i+k}})|} \qquad (3$$

Where *r* represents the returns at a time frequency Δt for the t_{i+k} different moments within Δt. This ratio assumes values between *1* and *0*. Values close to *z*ero denote volatility randomness, and values close to *one* denote volatility trend.

b) Mougoue and Aggarwal (2011 p.2698) also used an alternate measure of volatility within their paper using the so-called ‘realized volatility’. The realized volatility is considered a better measure of asset price risk (e.g. Andersen and Bollerslev 1998a; Andersen et al. 2001; Kaul and Sapp 2006; and Kellard et al. 2010). Following Andersen and Bollerslev 1998, this study also uses a measure of five minute returns and daily returns. Explicitly, this measure of volatility is calculated as follows:

$$\boldsymbol{v_t} = (\boldsymbol{r_t^{close-to-open}})^2 + \sum_{i=1}^{P}(\boldsymbol{r_{t,i}^{open-to-close}})^2 \qquad (4$$

Where $r_t^{close-to-open}$ is the daily return from the close of the previous day *t-1* to the opening of the next day *t,* and $r_{t,i}^{open-to-close}$ are intraday returns on day *t* for an intraday interval *i* (Andersen and Bollerslev 1998b; and Andersen et al. 2001).

c) De-Gennaro and Shrieves (1997) modelled volatility with a generalized autoregressive conditional heteroskedasticity GARCH approach, including hourly dummies to capture intraday patterns. Bauwens et al. (2006) estimated the volatility using an exponential GARCH (EGARCH) approach at a 5 minute frequency. The volatility evidence in these papers indicates a strong seasonal component. Moreover, Mougoue and Aggarwal (2011) estimated the conditional volatility examining the GARCH, IGARCH, FIGARCH, and TARCH approaches. They found that EGARCH best specifies the approach in terms of goodness of fit in order to recover volatility measures. This study conducts a thorough search for the GARCH specification which best fits the data. EGARCH , and its specification is presented below:

$$\boldsymbol{RET_t} = \boldsymbol{\Psi_0} + \sum_{i=1}^{\lambda}\boldsymbol{\Psi_i RET_{t-i}} + \boldsymbol{\Gamma}\sqrt{\boldsymbol{h_t^2}} + \boldsymbol{\eta_t}$$

$$\boldsymbol{\eta_t} \sim \boldsymbol{GED}(\boldsymbol{0}, \boldsymbol{h_t^2}),$$

$$h_t^2 = \exp(\delta \ln(h_{t-1}^2) + K\left[\omega(\frac{|\eta_{t-1}|}{h_{t-1}} - E\left(\frac{|\eta_{t-1}|}{h_{t-1}}\right)) + \phi\left(\frac{|\eta_{t-1}|}{h_{t-1}}\right)\right]) \quad (5$$

Where RET_t are the logarithmic returns; h_t^2 is the conditional volatility of periodic future returns; $\eta_t$is the conventional zero-mean error term with constant variance-covariance matrix; $\Psi_{i,s}$, Γ, δ, K, ω, and ϕ are parameters to be estimated. GED is the general error distribution. The EGARCH estimates the conditional variance of the returns in the presence of volatility clustering. Moreover, the model has no positive constraint on estimated parameters, and accounts for the asymmetrical conditional variance patterns of the FX returns. The procedure avoids possible miss-specification in the volatility process.

It is recognised that there are other methods to calculate the variance, but they are not essential for this research as they are not commonly used in the literature. They may; however, be a source for future research.

Examples of other volatility estimates include:

a) The Anderson and Bollerslev (1998) approach which adds a day of the week effect (Cai et al. 2001). In the same strand of volatility measures McGroarty et al. (2006) used the approach of Andersen, Bollerslev, Diebold, and Labys (2001). Also, Andersen, Bollerslev, and Das (2001) estimate the intraday variance using an extension of the Fourier Flexible Form (FFF) proposed by Andersen and Bollerslev (1998).
b) Berger et al. (2009) proposed an empirical specification of volatility linked to information order flow in high frequency data.
c) The directional change frequency measures uses thresholds and measures trends. This is very familiar to chartists.

7.4. The allocation of order flows by percentiles of price volatility

This section chooses one volatility measure using the previous equations. This is a key issue for the determination of control groups, which is an intermediate step to the generation of trading management variables. There are several methods to calculate volatility, and the methods presented on the previous section are evaluated here.

As a result, this empirical investigation initially studies the impact of order flows at seven different price volatilities. Indeed, the best choice of volatility measure is the one which disentangles the trading orders with higher explanatory power among several specifications. To assess this, I use the PMG by FE estimation because all variables are time-variant. The steps of this calculation procedure include:

a) Generation of price returns r at tick frequency.

b) Calculation of the volatility using the measures defined in the equations (section 7.3.).

c) Computation of seven volatility percentiles.

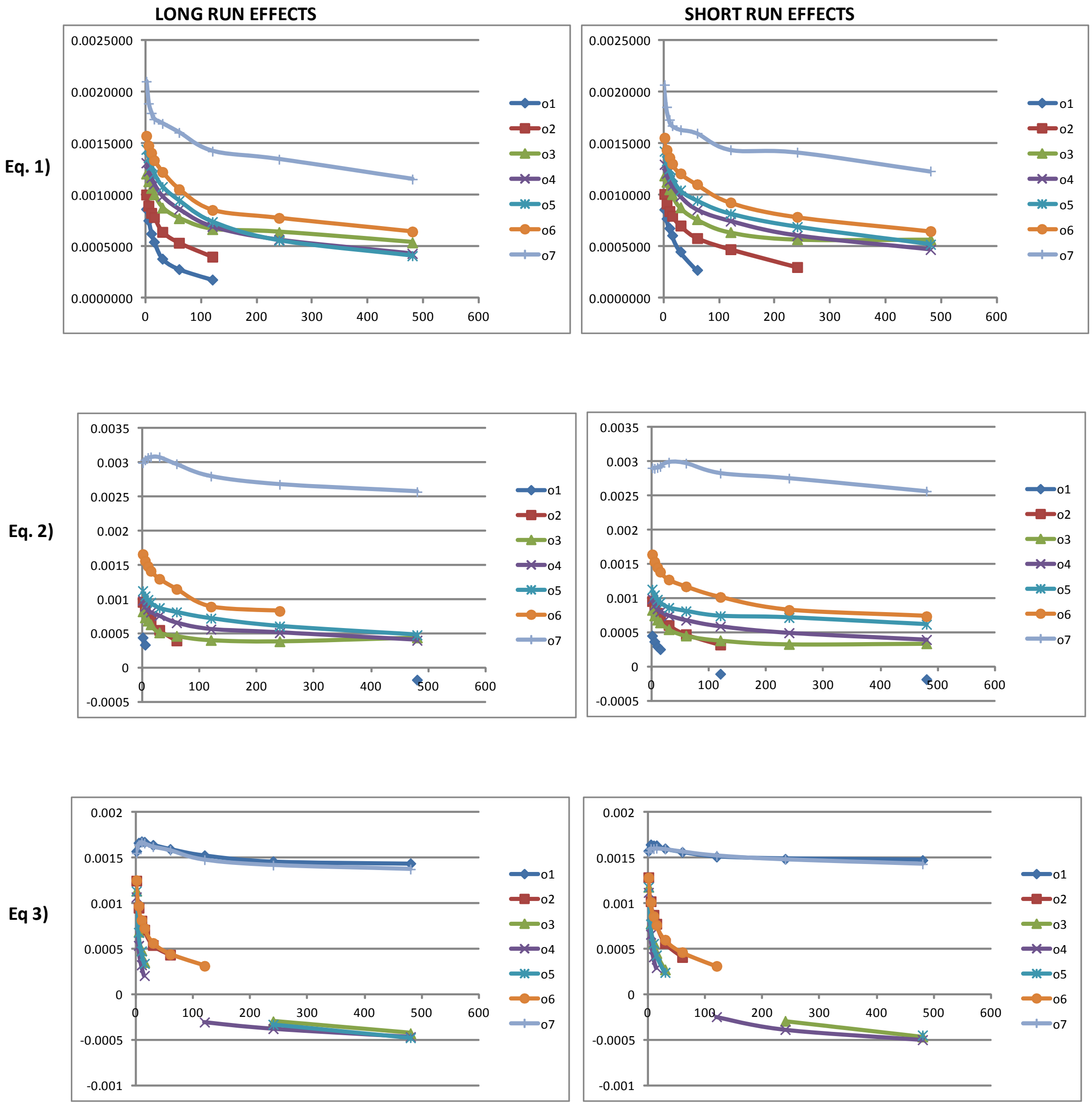
d) Separation of order flows given the seven volatility percentiles.

e) Transformation from unevenly recorded tick data to evenly-spaced intervals (10 minutes time frequency). The latter, following data managing suggestions in Frommel et al. (2008, p.1001), is caused by 'microstructure noise' that is generated by:

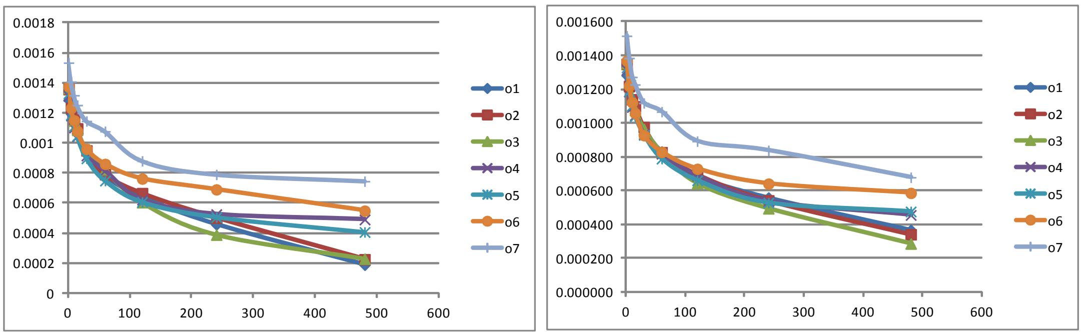
    - Differences between viewed and true prices
    - Spreads
    - Rounding errors

Figure 25. Order flow explanatory power at different volatilities and time frequencies.

The figure shows a Pooled Mean Group Estimation by Fixed Effects (PMG by FE). The outcome reports two panels, with long run and short run effects. The vertical axis reports a scale of estimated coefficient values. The horizontal axis shows the increasing time frequencies (in minutes). Variables from *o1* to *o7* denote order flows disaggregated into seven distinct measures of price volatility. Variable *o1* includes trading orders at the lowest volatility quartile, and *o7* trading orders at the highest volatility percentile. In the figure, the order flow *o7* possesses the highest explanatory power, whereas *o1* possesses the lowest. Based on the coefficients, equation 2 disaggregates order flows more efficiently than any other volatility measure. Indeed, the *o7* coefficient ranges from 0.003 to 0.0025 at time frequencies from 1 minute to 480 (8 hours).



Eq. 4)



Equation model: $LnP_t^k - LnP_{t-1}^k = \lambda_1 O_t^{1k} + \lambda_2 O_t^{2k} + \lambda_3 O_t^{3k} + \lambda_4 O_t^{4k} + \lambda_5 O_t^{5k} + \lambda_6 O_t^{6k} + \lambda_7 O_t^{7k} + \zeta_t^k$. $LnP_t^k - LnP_{t-1}^k$ is the logarithm of the spot price in time t for the currency k, in other words, $LnP_t^k - LnP_{t-1}^k$ is the exchange rate returns R. O_t^{1k} to O_t^{7k} is the order flow O at a time t for the currency k at 7 different volatilities of price returns.

The results presented in the figure suggest that order flows have higher explanatory power at higher volatilities. Based on the coefficients presented in figure 25, the equation 2 identifies more efficiently the order flows at the highest price volatilities. The results also show what is already known in the literature, that order flows at higher price volatilities have higher explanatory power.

Therefore, this empirical research applies the volatility calculation of equation 2. This measure of realised volatility is used to generate CG. The next section explains and estimates the trading management variables.

7.5. Trading Management Variables

The Table 100 summarizes the trading management variables and its characteristics:

Table 100. The characteristics of six trading management strategies (with material adapted from Bailey, Johnson and Daniels, 2000)

Strategy	Trait description	Scale Validity
Command	A trading floor manager (chief executive) is seen to have a high degree of control and authority over the trading strategy followed. The trading process can be described as a formal statement of trading rules. Trading strategies emerge from a vision associated with the powerful individual.	Bennis and Nanus (1985), Shrivastava and Nachman (1989), Westley and Mintzberg (1989). Kotter (1990).

Planning	Trading strategies are set of procedures. The procedures are analytic, deliberated, and sequential. Trading management strategies are generated, systematically analysed and trading alternatives evaluated. One strategic alternative is assumed to maximize the organisational objectives. The trading strategy has precise implementation plans, and systems for monitoring and controlling.	Ansoff (1965), Minztberg (1978), Steiner (1969), Argenti (1980), Rowe et al. (1989)
Incremental	Trading strategies attempt to be sensitive to the uncertainty of the environment through constant scanning and evaluation (learning). Trading strategies are the subject of review and constant change. A commitment to a trading strategy alternative may be just tentative.	Lindblom (1959), Mintzberg (1978), Quinn (1980), Quinn (1982), Johnson (1988)
Political	Decision-making and trading strategy development are resolved amongst stakeholders through bargaining, negotiation and compromise. Coalitions may form to pursue shared objectives, and to sponsor different trading strategy alternatives. Insider Information is a source of power for those traders controlling it.	Cyert and March (1963), Pettigrew (1973), Hinings et al. (1974), Pfeffer and Salancik (1978), Wilson (1982), Feldman (1986), Hickson et al. (1986)
Cultural	Strategy is developed by taken-for-granted codes of belief which are shared amongst organisational traders. These codes of behaviour simplify the complexity of the economic conditions, provide a quick interpretation of the market, enable decisions to be made with connection to the context and provide a guide to awarded behaviour. Their usefulness increases on uncertain and ambiguous situations. These guides of reference are underpinned by trading routines. Trading routines provide a repertoire for action.	Weick (1979), Deal and Kennedy (1982), Schon (1983), Gioia and Poole (1984), Trice and Beyer (1985), Johnson (1987), Spender (1989)
Enforced choice	Factors in the market persuade the adoption of flexible organisational structures and trading strategies which best fit to that environment. These trading external constraints include competition and economic pressures. These pressures limit the role organisational traders play in the choice of strategy. Trading strategies tend to be common to organisations within the sector.	Aldrich (1979), DiMaggio and Powell (1983), Hannan and Freeman (1989), Deephouse (1996)

The trading strategy averages (cross-sectional results) are allocated into seven control-groups (speculative organisations, banks, individual speculators, corporations, market makers, funds and public institutions). The following sections report the variables' calculation and analyse and evaluate these strategies.

7.6. Calculation of Trading strategy variables

This section mathematically explains the generation of the trading management variables. In brief, the trading management variables (*command, planning, incremental, cultural, political*, and *enforced choice*) are calculated with the average scores (cross-sectional data) of seven control-groups. These CGs aggregate speculative organisations, banks, individual speculators, corporations, market makers, funds and public institutions. These control-groups are habitually disaggregated within the literature using variables such as *returns volatility and trading regions* such as those used in this study.

The mathematical representation of trading strategies using the *return volatilities* comprise:

$$CM_t(Q_t) \qquad \textbf{(6}$$

$$PL_t(Q_t) \qquad \textbf{(7}$$

$$IN_t(Q_t) \qquad \textbf{(8}$$

$$PO_t(Q_t) \qquad \textbf{(9}$$

$$CL_t(Q_t) \qquad \textbf{(10}$$

$$EN_t(Q_t) \qquad \textbf{(11}$$

Where the variables CM_t; PL_t; IN_t; CL_t,; PO_t; and EN_t represent time-invariant estimations of the trading strategies related to command, planning, incremental, cultural, political, and enforced choice respectively for each sample observation in time t. The trading management strategies are related to cross-sectional data for p specific control-groups ($\boldsymbol{cm_p}$**;** pl_p; in_p ; po_p; cl_p; and en_p).These scores were calculated using the average survey results for trading strategies given seven control groups p. Control-groups are generated based on estimated volatility percentiles Q_t and estimated volatility tolerances.

Q_t is a time-variant variable whereas the trading strategies are time-invariant. The levels of calculated volatility *v* were ordered from low to high into percentiles from Q_1 to Q_{700} respectively. These volatility percentiles are comparable with the survey's volatility scale. As a result, the volatility is associated to the control-groups, and trading strategies are assigned to each control group (and orders on the market) in a real-time frequency.

Importantly, the calculation of trading management variables comprise data aggregation from real-time frequency (tick) to a ten minutes frequency (from unevenly to evenly spaced time). The data process (from tick to 10 minute frequency) causes the aggregation of the trading management scores. This fact begs the question whether the trading management scores can be summed or averaged. In brief, this empirical research adopted the calculation of the average scores instead of the sums for the following reasons:

a) Summing the trading management scores per minute generates collinearity. This was confirmed using a correlation analysis (where the calculated correlation was higher than 95%). This way of calculating the variables are; therefore, not considered in this research.

b) Averaging the trading management scores per minute is desirable because the correlations among variables are lower, and represent the level of trading management in the market without relying on the number of orders per every 10 minutes. The correlation coefficients are presented in the Table 101.

Table 101. Correlations between the trading management variables (averages per minute)

	command	*planning*	*incremental*	*political*	*cultural*	*enforced*
command	1					
planning	-0.4200 **	1				
incremental	-0.6640 **	0.6320 **	1			
political	0.4359 **	0.3431 **	-0.0530 **	1		
cultural	-0.3361 **	0.8128 **	0.5320 **	0.5737 **	1	
enforced	0.1318 **	-0.6605 **	-0.2751 **	-0.8179 **	-0.8833 **	1

The results presented in the table above show that all correlations are significant at the 5% level. The correlations also may suggest that regressions including two or more variables might bring about collinearity issues. The following sections report the scores and equations for each trading management variable.

Mathematically, the model to calculate the trading variables follows the following rationale:

Let Q_n represent *n* percentiles of the exchange rate volatility *v* calculated using equation 2; for $1 \leq n \leq 700$.

Let Q_t represent the percentile in time *t* for the observed exchange rate volatility *v* calculated using equation 2.

Let δ_p denote distinctive sensitivity (tolerance) to volatility from *p* control groups; for $1 \leq \delta_p \leq 700$; *and* $p = 1$ *to* 7.

From the cross-sectional results $\boldsymbol{\delta_1 = 80}$; $\boldsymbol{\delta_2 = 120}$; $\boldsymbol{\delta_3 = 148}$; $\boldsymbol{\delta_4 = 200}$; $\boldsymbol{\delta_5 = 214}$; $\boldsymbol{\delta_6 = 256}$; $\boldsymbol{\delta_7 = 480}$

Therefore, Q_{δ_p} denotes the volatility percentile (tolerance) for each *p* control-group (market agents).

I define $\delta_8 = 700$ as the upper boundary of the calculated volatility percentiles.

Let $\boldsymbol{cm_p}$; $\boldsymbol{pl_p}$; $\boldsymbol{in_p}$; $\boldsymbol{cu_p}$; $\boldsymbol{po_p}$; and $\boldsymbol{en_p}$ represent cross-sectional scores (estimates) for the trading strategies related to command, planning, incremental, cultural, political, and enforced choice respectively for each p control group.

Let CM_t; PL_t; IN_t; PO_t; and EN_t represent the trading strategies related to *command, planning, incremental, cultural, political*, and *enforced choice* respectively for each *t* moments expressed in ticks (real-time frequency). Therefore, the following equations denote the trading strategies calculation:

$$\boldsymbol{CM_t}(Q_t) = cm_p,\ Q_{\delta_p} \leq\ Q_t \leq\ Q_{\delta_{p+1}} \quad \text{for} \quad \text{p= 1 to 7} \qquad \textbf{(13}$$

$$\boldsymbol{PL_t}(Q_t) = pl_p,\ Q_{\delta_p} \leq\ Q_t \leq\ Q_{\delta_{p+1}} \quad \text{for} \quad \text{p= 1 to 7} \qquad \textbf{(14}$$

$$\boldsymbol{IN_t}(Q_t) = in_p,\ Q_{\delta_p} \leq\ Q_t \leq\ Q_{\delta_{p+1}} \quad \text{for} \quad \text{p= 1 to 7} \qquad \textbf{(15}$$

$$\boldsymbol{CU_t}(Q_t) = cu_p,\ Q_{\delta_p} \leq\ Q_t \leq\ Q_{\delta_{p+1}} \quad \text{for} \quad \text{p= 1 to 7} \qquad \textbf{(16}$$

$$\boldsymbol{PO_t}(Q_t) = po_p,\ Q_{\delta_p} \leq\ Q_t \leq\ Q_{\delta_{p+1}} \quad \text{for} \quad \text{p= 1 to 7} \qquad \textbf{(17}$$

$$\boldsymbol{EN_t}(Q_t) = en_p,\ Q_{\delta_p} \leq\ Q_t \leq\ Q_{\delta_{p+1}} \quad \text{for} \quad \text{p= 1 to 7} \qquad \textbf{(18}$$

The variables are then aggregated from real-time (tick by tick) to a 10 minute frequency as follows:

$$\overline{\boldsymbol{CM_t}}(Q_{t,k}) = \ln(\frac{\sum_k^1 cm_{p,k}}{k}),\ Q_{\delta_p} \leq\ Q_{t,k} \leq\ Q_{\delta_{p+1}} \quad \text{for p= 1 to 7} \qquad \textbf{(19}$$

$$\overline{\boldsymbol{PL_t}}(Q_{t,k}) = \ln(\frac{\sum_k^1 pl_{p,k}}{k}),\ Q_{\delta_p} \leq\ Q_{t,k} \leq\ Q_{\delta_{p+1}} \quad \text{for p= 1 to 7} \qquad \textbf{(20}$$

$$\overline{\boldsymbol{IN_t}}(Q_{t,k}) = \ln(\frac{\sum_k^1 in_{p,k}}{k}),\ Q_{\delta_p} \leq\ Q_{t,k} \leq\ Q_{\delta_{p+1}} \quad \text{for p= 1 to 7} \qquad \textbf{(21}$$

$$\overline{\boldsymbol{CU_t}}(Q_{t,k}) = \ln(\frac{\sum_k^1 cu_{p,k}}{k}),\ Q_{\delta_p} \leq\ Q_{t,k} \leq\ Q_{\delta_{p+1}} \quad \text{for p= 1 to 7} \qquad \textbf{(22}$$

$$\overline{\boldsymbol{PO_t}}(Q_{t,k}) = \ln(\frac{\sum_k^1 po_{p,k}}{k}),\ Q_{\delta_p} \leq\ Q_{t,k} \leq\ Q_{\delta_{p+1}} \quad \text{for p= 1 to 7} \qquad \textbf{(23}$$

$$\overline{\boldsymbol{EN_t}}(Q_{t,k}) = \ln(\frac{\sum_k^1 en_{p,k}}{k}),\ Q_{\delta_p} \leq\ Q_{t,k} \leq\ Q_{\delta_{p+1}} \quad \text{for p= 1 to 7} \qquad \textbf{(24}$$

Where $\overline{CM_t}$; $\overline{PL_t}$; $\overline{IN_t}$; $\overline{CU_t}$; $\overline{PO_t}$ and $\overline{EN_t}$ are the 10 minutes averages resulted from *k* market transactions in the real-time frequency.

7.7. Empirical Analysis on the influence of trading management on exchange rate determination

The next section will examine the following null hypothesis:

Ho: Trading strategies impact the exchange rate determination.

The results presented in this section are essential because they suggest a significant relationship between trading management strategies and foreign exchange determination. The results cover the period between September and November 2013. The cross-sectional data also covered the same time period (September to November 2013). The 10 minutes frequency dataset includes 61,510 observations for seven currencies. The sample is divided into two due to the great technical requirements of the method of estimation. Additional information on the dataset is found in the next chapter.

The following sections explain the relationship between volatility and each trading strategy, and report and explain the results of the Panel 2SLS estimation.

7.7.1. The relationship between trading strategies and volatility

This section explains the relationship between the trading strategies and volatility. This relationship is essential to test the significance of the trading variables using a Panel 2SLS estimation. First, the relationships between trading strategies and volatility of price returns *V* (provided in equations 6, 7, 8, 9, 10, and 11) are shown in the Figure 26.

The Table 102 brings about the following assumptions and analysis for each trading strategy:

Table 102. Trading strategies assumptions

Command	There is a strong negative relationship between the *command* strategy and low volatility of price returns, and there is a weak positive relationship between the *command* strategy and high volatilities of price returns. The relationship can be described as a convex function. This suggests that organisations particularly control the trading strategies at very low volatilities or at very high trading strategies. The pattern also suggests that transactions are handled with more human-participation (command) at very low price volatilities. There is low human-involvement at medium price volatilities and an increasing human-participation when volatilities are higher than the mean.
Political	There is a negative relationship between the political strategy and volatility, i.e. the market level of the political strategy decreases when volatility increases. This suggests that organisations are more likely to agree on trading strategies and form partnerships at very low volatilities. The political variable was expected to have a negligible impact at all volatility levels. This relationship; however, predicts that alliances among stakeholders are possible at low levels of volatility. The slope of the *political* strategy fluctuates given the level of volatility. The *political trend line* has concave and convex functions. The relationship also may indicate that insider information is a source of power at low levels of volatility only. If so, order flows at low volatilities may hide confidential information about the macroeconomics conditions. This latter point could be a topic for future research
Planning	There is a positive relationship between the *planning* strategy at low volatility of price returns, and there is a negative relationship between the *planning* strategy and high volatilities.

The *planning* trend line can be described as a concave function. This means that trading orders at medium levels of volatility convey information with higher levels of planning. This also may suggest that transactions are less planned at very high volatilities. This may be as result of trading orders triggering stop-loss orders during times of thin market liquidity, or during times of very important macroeconomic shocks.

Incremental

There is a negative relationship between *incremental* strategy and the volatility of price returns. Importantly, this relationship; however, predicts that learning from the economic conditions is very high only at a low volatility of the price returns. If so, order flows at low volatilities may hide the inferences about the macroeconomics conditions. This latter point could be a topic for future research.

This negative relation has a decreasing and negative slope. This suggests that learning from the market occurs predominantly at very low volatilities of price returns. The pattern also suggests that trading strategies can be subject of review especially at very low volatilities. Changes in the direction of price should occur at low volatilities.

Cultural

There is a negative relationship between *cultural* strategy and the volatility of price returns. This relationship also may indicate the decreasing importance of trading frames or routines as volatility increases.

This negative relation has a decreasing and negative slope. This suggests that common methods to trade (e.g. technical and fundamental analysis) decrease in performance when market volatility increase.

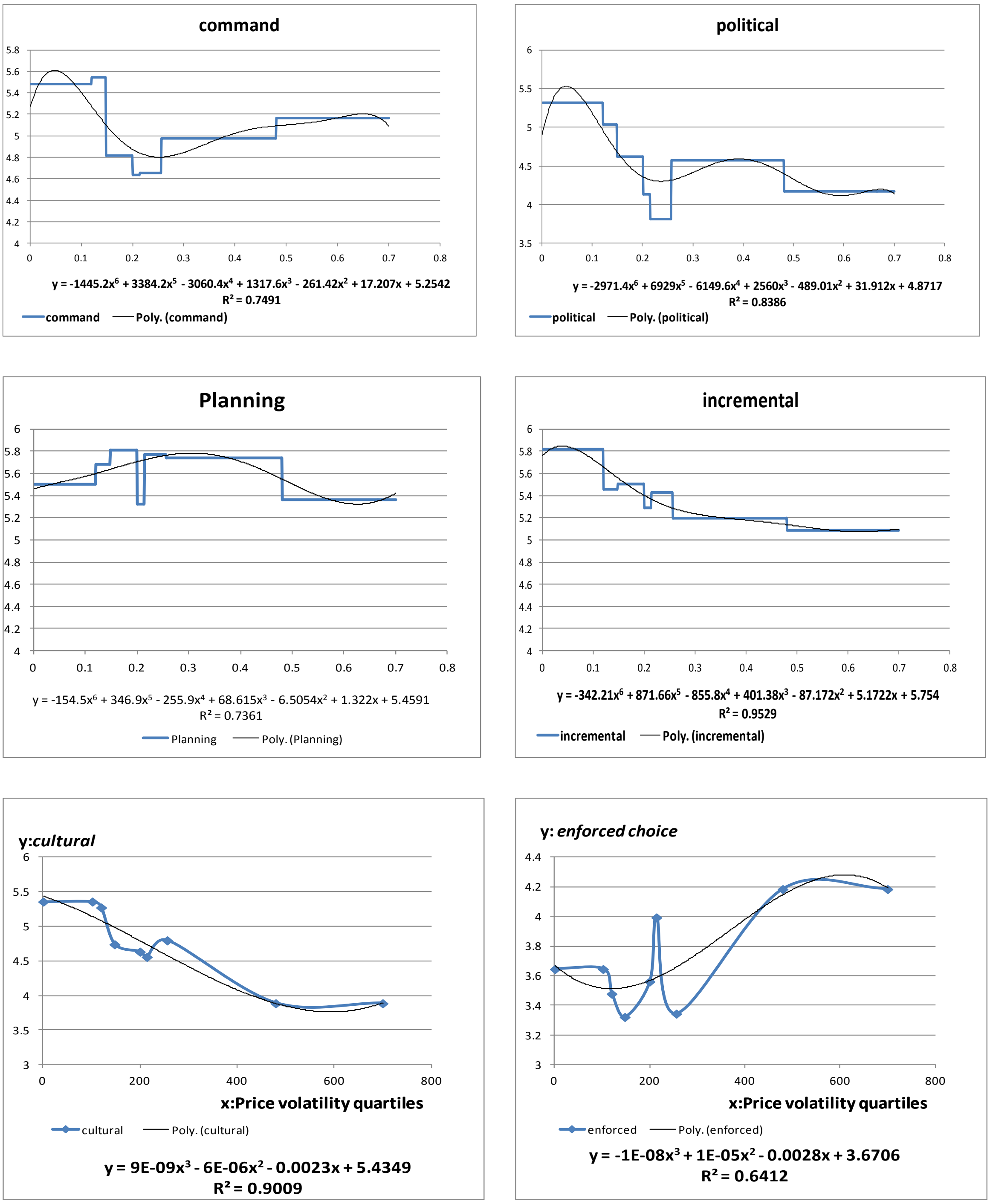
Enforced choice

Enforced choice strategy has concave and convex functions.

Overall, the relationship between the *enforced choice* strategy and volatility is positive at very high volatilities and negative at very low volatilities. This suggests that the environment imposes on the trading strategy especially at very high volatilities.

Figure 26. *Trading strategies vs.* volatility of price returns (percentiles)

The figure shows the relationship between six trading strategies and the volatility of price returns (percentiles). The blue line represents the survey scores for each trading strategy given the volatility tolerance (cross-sectional data). The black trend line applies a polynomial (order 6) curved line to display fluctuating data values. The equation of this trend line is presented underneath the figure, and it can be used to smooth the *command* scores. The *R-square* corresponds to the polynomial trend line.



7.7.1. Significance of the trading strategy variables

Notably, the estimation outcomes for the strategies *political, planning, incremental, cultural, and enforced choice* are significant (mainly at 1% alpha). Specifically, these results provide evidence of the importance of trading management strategy on exchange rate determination. These results also contribute to explain the cyclical component of the exchange rates. Contrary, the estimation results for *command* strategy are non-significant. This suggests that the central control of the trading strategies and the human-participation in the strategy is not a determinant of the exchange rates. The estimation outcomes for the political strategy are significant after standardising the variable to three levels of political strategy. The estimation results are presented in the Table 103.

Table 103. *Trading strategies* – Panel Second Step Least Square Estimation (P2SLS)

The Panel 2SLS estimation results for the trading strategies are presented below. On the left and right panels respectively are the regression results for two consecutive periods of time .

The dependable variable is the price returns *r*. Each panel includes:

(a) the estimated period of time*;* the *R square* or the portion of the variance explained by the explanatory variables; an *Adjusted R square;* and the *F* statistic. The latter is significant in both cases, signaling that the model correctly explains the dependent variable;

(b) the explanatory variables used in the regression are shown in the first column; i.e. order flows from *o1 to o7* for seven percentiles of volatility; being *o1* the order flows at the lowest percentile and *o7* the highest. The first column also reports the regression constant *_cons*;

(c) the estimated coeficients are shown in the second column. The coefficients of the *command* strategy are non-significant. The coefficients of the *political* strategy are significant (at an alpha of 1% and 5% respectively for the left and right panel). The coefficients of the strategies of *planning, incremental, cultural* and *enforced choice* are significant (at an alpha of 1%).

Importantly, the regressions appear to capture a significant cyclical component of the price returns. However, The coefficients differ in size (absolute value); the variables appeared to be more influential during September to mid-October. The coefficients possess opposite signs in both panels. The issue of the sign will be solved later on using the relative values of the trading strategies. Indeed, the variable measured here corresponds to the market's absolute level of planning. The coefficients of *o1* to *o7* are highly significant at an alpha level of 1% (*o4* at a 5% level on the left panel in some cases) and positive. The third column shows the standard deviations by the Wild method (following Atkinson and Crownwell 2012).

Period	01Sep - 18 Oct		
Number of obs	=		31393
F	=		6640.455
Prob > F	=		0.000
R-squared	=		0.629
Adj. R-squared	=		0.629

r	Coef.		Std.
o1	0.0002847	***	0.0000197
o2	0.0002839	***	0.0000401
o3	0.0004301	***	0.0000399
o4	0.0002030	**	0.0000989
o5	0.0002466	***	0.0000333
o6	0.0008877	***	0.0000148
o7	0.0031928	***	0.0000153
Command	-0.0019725		0.0016751
eta	1.0000000		.
_cons	0.0105535		0.0086101

Period	21Oct - 30Nov		
Number of obs	=		30117
F	=		8787.758
Prob > F	=		0.000
R-squared	=		0.700
Adj. R-squared	=		0.700

r	Coef.		Std.
o1	0.0002670	***	0.0000164
o2	0.0005088	***	0.0000459
o3	0.0002256	***	0.0000491
o4	0.0003686	***	0.0000602
o5	0.0004640	***	0.0000256
o6	0.0009579	***	0.0000142
o7	0.0031628	***	0.0000133
Command	-0.0006041		0.0017233
eta	1.0000000		.
_cons	0.0024556		0.0088517

Period	01Sep - 18 Oct		
Number of obs	=		31393
F	=		6643.605
Prob > F	=		0.000
R-squared	=		0.629
Adj. R-squared	=		0.629

r	Coef.		Std. Err
o1	0.0002851	***	0.00001970
o2	0.0002846	***	0.00004010
o3	0.0004293	***	0.00003980
o4	0.0002029	**	0.00009890
o5	0.0002467	***	0.00003330
o6	0.0008882	***	0.00001480
o7	0.0031920	***	0.00001530
political	-0.0006635	***	0.00022430
eta	1.0000000		.
_cons	0.0004187	*	0.00024940

Period	21Oct - 30Nov		
Number of obs	=		30117
F	=		8795.342
Prob > F	=		0.000
R-squared	=		0.701
Adj. R-squared	=		0.700

r	Coef.		Std. Err.
o1	0.0002683	***	0.00001630
o2	0.0005079	***	0.00004590
o3	0.0002246	***	0.00004910
o4	0.0003685	***	0.00006020
o5	0.0004650	***	0.00002560
o6	0.0009578	***	0.00001420
o7	0.0031620	***	0.00001330
political	0.0006355	**	0.00027230
eta	1.0000000		.
_cons	-0.0006467	**	0.00029290

Period	01Sep - 18 Oct		
Number of obs	=		31393
F	=		6657.447
Prob > F	=		0.000
R-squared	=		0.630
Adj. R-squared	=		0.629

r	Coef.		Std. Err
o1	0.0002846	***	0.00001970
o2	0.0002848	***	0.00004000
o3	0.0004317	***	0.00003980
o4	0.0002168	**	0.00009880
o5	0.0002480	***	0.00003330
o6	0.0008886	***	0.00001480
o7	0.0031918	***	0.00001530
planning	-0.0184074	***	0.00543210
eta	1.0000000		.
_cons	0.1033036	***	0.03036500

Period	21Oct - 30Nov		
Number of obs	=		
F	=		
Prob > F	=		
R-squared	=		
Adj. R-squared	=		

r	Coef.		S
o1	0.0002670	***	
o2	0.0005065	***	
o3	0.0002267	***	
o4	0.0003590	***	
o5	0.0004642	***	
o6	0.0009583	***	
o7	0.0031626	***	
planning	0.0103611	***	
eta	1.0000000		.
_cons	-0.0583850	***	

Period	01Sep - 18 Oct		Period	21Oct - 30Nov	
Number of obs	=	31393	Number of obs	=	30117
F	=	6648.634	F	=	8799.536
Prob > F	=	0.000	Prob > F	=	0.000
R-squared	=	0.629	R-squared	=	0.701
Adj. R-squared	=	0.629	Adj. R-squared	=	0.700

r	Coef.		Std. Err	r	Coef.		Std. Err.
o1	0.0002857	***	0.00001970	o1	0.0002675	***	0.00001630
o2	0.0002818	***	0.00004010	o2	0.0005122	***	0.00004590
o3	0.0004287	***	0.00003980	o3	0.0002255	***	0.00004910
o4	0.0002066	**	0.00009880	o4	0.0003638	***	0.00006020
o5	0.0002478	***	0.00003330	o5	0.0004639	***	0.00002560
o6	0.0008886	***	0.00001480	o6	0.0009580	***	0.00001420
o7	0.0031910	***	0.00001530	o7	0.0031626	***	0.00001330
Incremental	-0.0098815	***	0.00224150	*Incremental*	0.0006482	***	0.00021780
eta	1.0000000		.	eta	1.0000000		.
_cons	0.0533463	***	0.01200880	_cons	-0.0009344	***	0.00030130

Number of obs	=	31393	Number of obs	=	30117
F	=	6657.792	F	=	8802.998
Prob > F	=	0.000	Prob > F	=	0.000
R-squared	=	0.630	R-squared	=	0.701
Adj. R-squared	=	0.629	Adj. R-squared	=	0.701

r	Coef.		Std. Err	r	Coef.		Std. Err.
o1	0.0002857	***	0.00001970	o1	0.0002680	***	0.00001630
o2	0.0002866	***	0.00004000	o2	0.0005093	***	0.00004590
o3	0.0004277	***	0.00003980	o3	0.0002245	***	0.00004910
o4	0.0002067	**	0.00009880	o4	0.0003682	***	0.00006020
o5	0.0002480	***	0.00003330	o5	0.0004656	***	0.00002560
o6	0.0008895	***	0.00001480	o6	0.0009580	***	0.00001420
o7	0.0031901	***	0.00001530	o7	0.0031618	***	0.00001330
cultural	-0.0069142	***	0.00116550	*cultural*	0.0042246	***	0.00151320
eta	1.0000000		.	eta	1.0000000		.
_cons	0.0329191	***	0.00548640	_cons	-0.0204694	***	0.00710850

Number of obs	=	31393	Number of obs	=	30117
F	=	6659.101	F	=	8796.056
Prob > F	=	0.000	Prob > F	=	0.000
R-squared	=	0.630	R-squared	=	0.701
Adj. R-squared	=	0.630	Adj. R-squared	=	0.700

r	Coef.		Std. Err	r	Coef.		Std. Err.
o1	0.0002851	***	0.00001970	o1	0.0002675	***	0.00001630
o2	0.0002855	***	0.00004000	o2	0.0005090	***	0.00004590
o3	0.0004302	***	0.00003980	o3	0.0002273	***	0.00004910
o4	0.0002066	**	0.00009870	o4	0.0003727	***	0.00006020
o5	0.0002463	***	0.00003330	o5	0.0004666	***	0.00002560
o6	0.0008895	***	0.00001480	o6	0.0009580	***	0.00001420
o7	0.0031914	***	0.00001530	o7	0.0031618	***	0.00001330
enforced	0.0103524	***	0.00220440	*enforced*	-0.0054066	***	0.00193010
eta	1.0000000		.	eta	1.0000000		.
_cons	-0.0376712	***	0.00812000	_cons	0.0194567	***	0.00718240

1% significance *

5% significance **

10% significance ***

Equation model:

$$LnP_t^k - LnP_{t-1}^k = \lambda_1 O_t^{1k} + \lambda_2 O_t^{2k} + \lambda_3 O_t^{3k} + \lambda_4 O_t^{4k} + \lambda_5 O_t^{5k} + \lambda_6 O_t^{6k} + \lambda_7 O_t^{7k} + \lambda_8 \overline{TS}_t + \zeta_t^k.$$

Where $LnP_t^k - LnP_{t-1}^k$ is the logarithm of the spot price at the minute *t* for the currency *k*, in other words, $LnP_t^k - LnP_{t-1}^k$is the exchange rate returns *R*. O_t^{1k} to O_t^{7k} are the order flow *O* at the minute *t* for the currency *k* at 7 different price volatilities.

$\overline{TS}_t$ is the trading strategy to be evaluated or estimated. Therefore, $\overline{TS}_t$ generates six equation models, being replaced by the following variables:

$\overline{CM}_t$ (Equation 19) is the average of the command variable (10 minutes frequency).

$\overline{PL}_t$ (Equation 20) is the average of the *planning* (10 minutes frequency).

$\overline{IN}_t$ (Equation 21) is the average of the *incremental* variable (10 minutes frequency).

$\overline{CU}_t$ ((Equation 22) is the average of the *incremental* variable (10 minutes frequency).

$\overline{PO}_t$ (Equation 23) is the average of the *political* variable (10 minutes frequency).

$\overline{EN}_t$ (Equation 24) is the average of the *incremental* variable (10 minutes frequency).

Specifically, the estimation results in Table 103 bring about the following findings:

a) With the exception of the *command* strategy all trading strategies are significant at both periods of time (the significance level is 1% except for the political strategy which it was 5% during the second period of the time analysed). The null hypothesis, *Ho: Trading strategies impact the exchange rate determination;* is therefore accepted.

b) The coefficients of the significant trading variables capture a cyclical component of the exchange rates. Indeed, during the first period, there are positive relationships between the exchange rates returns *r* and the strategies *political, planning*, *incremental*, *and cultural* (*enforced choice* has a negative relationship with *r*).

c) The coefficient signs are contrary during the second period of time. This might be due to the change of the U.S. macroeconomic conditions after the 18th October 2013. On that day, the FED delayed its first reduction (from $85 billion to $70 Billion) in U.S. bonds purchases until March 2014. The result has produced an opposite sign because the macroeconomic shock generated a reverse cycle component against the USD, and in favour of the foreign exchange.

d) From all the trading strategies analysed, it was shown that the *planning* strategy has the highest impact on the determination of exchange rates (The coefficient equals -*0.0184074* from September 2013 to mid-October; and *0.103611* from mid-October to November 2013). Contrary to this it was shown that the *political* strategy has the lowest impact among the trading strategies. The *Enforced choice* strategy has the second highest impact in terms of trading strategy.

e) Importantly, the results contribute to the literature relating to informed traders. The results above suggest that trading strategies might be an important factor of informed trading.

f) The absolute size of the coefficients is higher in the first period of time than in the second (from September 2013 to mid-October 2013; and from mid-October to November 2013, respectively). As all currencies studied were based on the U.S. dollar (USD), the different size in the coefficients could indicate that trading strategies have a higher impact when the macroeconomic conditions of the US improve. This point can be subject of further research.

g) The significant coefficient of the *cultural* strategy suggests that commonly used trading strategies are more important at low volatilities of price returns. These commonly used trading strategies are technical and fundamental trading strategies. Their usefulness decreases as high volatility conditions rise.

Using the Akaike information criterion, the Table 104 selected a model. This is conducted by comparing different combinations of the trading strategy variables.

Table 104. *Trading strategies* – Panel Second Step Least Square Estimation (P2SLS)

The Panel 2SLS estimation results for the trading strategies are presented below. The dependable variable is the price returns *r*. The results includes:

(a) the estimated period of time*;* the *R square* or the portion of the variance explained by the explanatory variables; *Adjusted R square;* and the *F* estatistic. The latter is significant, signaling that the model correctly explains the dependent variable;

(b) the explanatory variables used in the regression as shown in the first column; i.e. order flows from *o1 to o7* for seven percentiles of volatility; being *o1* the order flows at the lowest percentile and *o7* the highest. The first column also reports the regression constant *_cons*;

(c) the estimated coeficients as shown in the second column. The coefficients of the *command* strategy are non-significant. The coefficients of the *political* strategy are significant (at an alpha of 1% and 5% respectively for the left and right panel). The coefficients of the strategies of *planning, cultural* and *enforced choice* are significant (at an alpha of 1%).

Importantly, the regressions appear to capture a significant cyclical component of the price returns. However, The coefficients differ in size (absolute value); the variables appeared to be more influential during September to mid-October. The coefficients possess opposite signs in both panels. Indeed, the variable measured here corresponds to the market's absolute level of planning. The coefficients of *o1* to *o7* are highly significant at an alpha level of 1% (*o4* at a 5% level on the left panel in some cases) and positive. The third column shows the standard deviations by the Wild method (following Atkinson and Crownwell 2014).

Number of obs	=	31393
F	=	6657.447
Prob > F	=	0.000
R-squared	=	0.630
Adj. R-squared	=	0.629

r	Coef.		Std. Err.
o1	0.0002869	***	0.0000192
o2	0.0002837	***	0.0000392
o3	0.0004300	***	0.0000391
o4	0.0002164	**	0.0000959
o5	0.0002529	***	0.0000326
o6	0.0008928	***	0.0000145
o7	0.0031887	***	0.0000149
plast	-0.0225394	***	0.0042122
incst	-0.0124457	***	0.0025358
_cons	0.1930504	***	0.0247159

Number of obs	=	30101
F	=	7826.986
Prob > F	=	0.000
R-squared	=	0.701
Adj. R-squared	=	0.701

r	Coef.		Std. Err.
o1	0.0002675	***	0.0000163
o2	0.0005102	***	0.0000459
o3	0.0002263	***	0.0000491
o4	0.0003570	***	0.0000602
o5	0.0004641	***	0.0000256
o6	0.0009583	***	0.0000142
o7	0.0031625	***	0.0000133
plast	0.0123521	***	0.0033746
incst	0.0079663	***	0.0022429
_cons	-0.1122523	***	0.0205256

The results presented above suggest the following conclusions:

a) Importantly, the variance of the trading variables *political*, *cultural* and *incremental* is better explained by the *planning* and *incremental* trading strategies.

b) The results suggest that the *planning* strategy is the most important explanatory variable for the determination of the exchange rates.

c) The results suggest that the *incremental* strategy explain a portion of the variance of the dependable variable that the *planning* strategy is not able to capture.

CHAPTER 8. CONCLUSIONS

The concept of economic heterogeneity is crucial for this research. Theoretical models assuming agents' heterogeneous behaviour are perhaps one of the most successful strands of research to deal with the exchange rates 'puzzle'. This study is based on the microstructure market approach in particular, and develops further the Portfolio Shift Model (Evans 2002, 2010). The Portfolio Shift Model assumes heterogeneous behaviour and market structures. This approach has provided one of the most successful frameworks to explain the exchange rates determination.

This study aims to examine how far the strategies influence the exchange rates determination. Thus, this empirical research (a) explores 'trading strategies' as another element of the economic heterogeneity; (b) it analyses the dynamics of 'strategic objectives' in th e market, and their influence on the exchange rate determination; and finally (c) it examines the strategic information as an important determinant of the exchange rates determination.

This empirical research contributes to the 'exchange rate puzzle' in finding another source of heterogeneity: the trading strategies in the context of the Microstructure Markets literature. The exchange rate puzzle is not resolved in this thesis; but I contribute in suggesting that trading strategies appear to improve the explanatory power of the Portfolio Shift Model.

The importance of this topic of research (strategy and exchange rate determination) is considerable, given that the market daily transactions are equal to 5 trillion dollars. Any improvement or research progress in the exchange rate determination will bring about large economic benefits, crucial changes in macroeconomic policies, and also bring about an in-depth understanding of other macroeconomic linkages such as imported inflation, competitiveness, resources allocation, and debacles in exports, etc.

The literature review covers 413 papers, working papers, articles and PhD theses on Microstructure Market Models (MMM). The literature review was divided into three main topics or guiding concepts relevant for the research focus: strategic objectives, trading strategies, and strategic information. The following paragraphs include the most important features of the literature review and the essential literature, which provide supporting assumptions and structure to this thesis.

This study finds the work of King et al. (2009, 2012) to be highly important, as many up-to-date stylised facts and microstructure features are presented in their research. The concept of heterogeneity in this study is based on the research of Frechette and Weaver (2001) and Moosa and Shamsuddin (2003, p49), because they include trading strategies as an important element of economic heterogeneity. Their concept is very important, as there is a research gap here that examines the relevance of trading strategies.

This study is supported by one of the most cited works in the field (i.e. Lyons 2001b); particularly, through his contributions regarding order flow and his theoretical framework. Order flow is the net value of one or a set of initiated transactions. The work of Fan and Lyons (2003) has strong linkages as they have focused on trading strategies. This study has added to the current research by confirming their findings on heterogeneous behaviour when order flow is disaggregated.

Essential for this thesis, especially for the topic of strategic objective, the papers of Evans (2002, 2010, 2011), and Evans and Lyons (2002a, 2002b, 2005, 2009) have provided the theoretical model in which order flow is combined with data releases, which can be further specialised to include the variables of this empirical investigation. The paper of Gradojevic (2011) is also an influential one. He has studied the diverse types of market agents. This empirical research also confirms his findings related to the importance of customer types for the exchange rates.

The Portfolio Shift Model is the primary framework in this study. The features of this model allow for the study of the trading strategies. This is because the model represents how the trading activity occurs in the interbank market. The PS model's explanatory power is very high compared to other models. Another reason to select the PS model is that the approach supplies validity and reliability as the model has been tested in many recent papers.

This study has covered the essential literature related to the trading strategies. The work of Carrera (1999) provides support to this study as he has studied the agents' strategic behaviours (during currency attacks). This study has focused on the agents' reactions to information, which bring about the trading strategies (as described in Melvin and Yin 1990). This finding is explained further in the paper of Evans and Lyons (2002) and Evan (2006). In the same fashion, this study examines the effect of transactions and trading strategies from the point of view of the distinctive types of agents.

The literature related to price clustering is also linked with this study (e.g. Liu 2011). Liu's findings show that trading behaviours and strategies are related to market conditions, times, price clustering, and price cascades. It can also be shown that price cascades triggers the trading strategies (Osler 2005).

Basically, the literature related to 'trading strategies' is important as:

a) They show how agents generate trading strategies.

b) Their evidence provides support that agents have reaction and interpretation functions to trade in the market.

c) These papers suggest that agents' types and trading strategies are heterogeneous and important in the exchange rate determination.

d) They allow this research to examine how far the trading management strategies are relevant.

The choice of variables to forecast and explain the exchange rates are other sources of very important literature. This study is linked with previous research addressing the use of order flow, technical analysis, fundamental analysis, and correlated assets (e.g. Evans 2010; Osler, 2006; Cao, Evans, and Lyons 2006; Fan and Lyons 2003; Evans 2011; Taylor 1990; Taylor and Allen 1992; Menkhoff, Osler and Schmeling 2010; Andersen, Bollerslev, Diebold and Vega 2007; Burnside, Eicenbaum, and Rebelo 2009).

The literature above also addresses the issues relevant to model the exchange rates. These issues include unit roots, timely patterns in the volatility, heteroskedasticity, and time-varying leptokurtosis. These issues are often addressed using GMM.

The survey methodology is supported by the works of Ito (1990), Allen and Taylor (1990), Taylor and Allen (1992), Cavaglia et al. (1998), and Menkhoff (1998). The use of panel data in the empirical results is supported by a vast amount of academic papers. Importantly, the work of Beber, Breedon, and Buraschi (2010) (also Wang 2003) created a variable for 'heterogeneity'; similarly, this study creates a variable for trading strategies in chapter 7.

The survey methodology (Chapter 3) included the sample size and the pilot test. This chapter also included an explanation on the applied quantitative methods such as the estimation of reliability, validity, hypotheses tests, discriminant factor analysis, and logistic regression.

The most important results of chapter 4 comprise of the following:

a) By showing that by far the ‘profiting from investments’ is the most important market objective. These results confirm the theoretical assumptions of MMM (e.g. Fan and Lyons 2003; Osler, 2006; Cao, Evans, and Lyons 2006; Evans 2010; Evans 2011).
b) The second most important strategic objective is to ‘protect against currency consistent volatility’. This finding is similar to the empirical results of Beber, Breedon, and Buraschi (2010); they have found that differences in beliefs influence the shape of the implied volatility, risk-premiums volatility, and future currency returns. This finding also reinforces the use of volatility later on in the combined results chapter.
c) The results suggest that other strategic objectives could be included in the empirical research as they are very important for the market. The evidence suggests that strategic objectives are multi-dimensional. These strategic objectives include the following:

   - Profit from intermediation
   - Protection against low or high historical prices
   - Protection against inflation
   - Imports, exports or the simple need to exchange currencies
   - Hedging purposes

d) The importance of ‘planning’ among other trading strategies is noteworthy, as is the importance of the trading strategies ‘learning’ and ‘command’ (although not more than planning). The trading strategies ‘cultural’ and ‘political’ indicate a good level of importance, and ‘environmental’ has a medium level of importance.

e) The trading strategy ‘planning’ has significant relationships with all strategic objectives. ‘Command’ is important, but the results may imply that this strategy is mediated by the ‘planning’ strategy.

f) The strategic objective ‘profit from intermediation’ is explained by the trading strategies ‘learning’ and ‘cultural’. In other words, learning from complex economic situations is carried on through the use of models to simplify complexities.

g) The trading strategy enforced choice appears to be unrelated to the strategic objectives except for a weak relationship with ‘hedging’.

h) Order flows explain the strategic objectives at all-time frequencies. The literature has shown that order flow will decrease its explanatory power at low frequencies. This decrease of explanatory power might be attributed to less strategic objectives related to order flow at low time frequencies.

i) All trading strategies have a relationship of mutual dependency.

j) Order flow appears to be more important at very high frequencies (In accordance with Gradojevic 2007b and Chaboud et al. 2008)

In Chapter 5 Methodology, it was discussed how the trading management variables fit in the theoretical model and in the estimation model, and explains how econometric issues are tackled with the estimation procedure.

This empirical investigation has applied the Portfolio Shift (PS) model (Lyons 1997, Evans 2002, Evans 2011). Importantly, this theoretical model allows the inclusion of omitted variables within the common knowledge factor ξ_t. This thesis has used this feature to include the trading strategies variables.

This thesis used a fixed effects model as it is expected that explanatory variables are serially correlated with the omitted variables (the effects on the cross-section unit are constant across time). Another important feature is that the standard errors of the Fixed Effects approach are not large. The drawback is the model's inability to estimate the effects of time-invariant variables. As this study uses time-invariant variables (trading strategies), the estimation approach includes a particular fixed effects estimation followed by a procedure to recover the time-invariant estimates (panel 2SLS) (Atkinson and Cornwell 2012).

This study made use of recent and advanced estimation techniques: the panel two-step least squares regression with weak instruments and time-invariant regressors (panel 2SLS). As one critical issue in the dataset is the possible co-integration in panels, this study conducted a Pooled Mean Group by Fixed Effects (PMG by FE) in the first stage of the panel 2SLS. PMG by FE will tackle the co-integration issue. Chapter 5 also covered the data analysis for key variables such as order flow.

Chapter 6 discussed the estimation of the panel fixed effects. This chapter showed that several fixed effects approaches (e.g. heterogeneous parameter models) do not tackle the heteroskedasticity, the cross-sectional dependence or the co-integration issue. Therefore, this study has estimated and compared the Dynamic Equation Models. Particularly, this chapter explained the Pooled Mean Group (PMG) estimator (Pesaran, Shin and Smith 1997, 1999).

The coefficients estimated by the PMG by FE estimator are found signed as was expected. The results reported indicate that the simultaneous equation bias is minimal for this data, confirming that PMG by FE is preferred over the PMG by mean groups (MG). The results presented in this chapter have brought about the following findings:

a) They confirm the robustness of the PS Model (Evans and Lyons, 2002a and 2002b). This makes available a solution to the ER disconnection puzzle or the apparent disconnection between exchange rates and fundamentals.

b) Order flow is confirmed as a key variable for the exchange rate determination. Contrary to Reitz, Schmidt, and Taylor (2011), the results indicate that order flow may convey information for short run speculative strategies.

c) The PMG approach estimates the common long-run coefficient without imposing identical dynamics for each currency in the short run. The results indicated that slope homogeneity and error variances are the same for all currency pairs.

d) This chapter also confirmed the importance of the real-time macroeconomic conditions; a proxy developed by Evans (2010).

e) The explanatory power is higher than traditional models, including the most recent monetary models with central banks reaction functions.

f) Contrary to some literature, these results did not find a significant relationship with the interest rate differentials.

Chapter 7 examined whether trading strategies influence the exchange rates. The results implied the following findings:

a) Except for the Command trading strategy, all trading strategies are significant. The results above suggest that trading strategies might be an important factor for the informed trading.

b) From all trading strategies, the planning strategy has the highest influence on exchange rate returns.

c) The absolute value of the coefficients varies in both samples. This might imply that U.S. macroeconomic conditions have a higher influence on trading strategies. The coefficients have different sign presumably due to the change of the U.S. macroeconomic conditions after the 18th October 2013. On that day, the FED delayed its first reduction (from $85 billion to $70 Billion) in U.S. bonds purchases until March 2014.

d) In line with the survey results, the incremental (or learning) strategy explains a portion of the variance of the exchange rates that the planning strategy does not explain. Planning and Learning strategies are together the combination of trading strategies that have higher influence on the exchange rates determination.

8.1. Recommendations

This section put forward some recommendations for the organisations interested in the exchange rates determination.

Organisations can use trading strategies to explain the exchange rates. The results showed that at some specific moments the market should increase the planning and the learning strategies. These trading moments are important to help understand the cyclical component of the exchange rates, and suggest that agents are clustering to decide the direction of the market price. As these trading strategies are related through a reaction function to the volatility, the recommendation in terms of trading would be to step away from very high market volatilities, as the planned transactions occur mainly at normal volatility conditions, and the learning strategies occur at very low volatility conditions.

Secondly, the empirical investigation contributed to resolving the exchange rates puzzle by suggesting that trading management strategies are made to influence the exchange rate determination. The trading strategies have been studied using strategic information or reaction functions limited to fundamental and technical analysis. This research contributes to the debate by suggesting reaction functions on trading management strategies. Academics and researchers can further confirm or reject this point in future research.

Thirdly, the thesis suggests that the use of very sophisticated and up-to-date methods such as Panel 2SLS, as it is more appropriate to solve problems such as co-integration, heteroskedasticity, large time observations and time invariant variables. This study suggests that this methodology, as the fixed effect estimator in the first stage, has better asymptotic properties than random effects or GMM given the dataset characteristics.

Fourthly, to what extent do the contributions of this study make generalisations? This study has a different approach to the calculation of trading strategies. The contributions generalise as the sample requirements were met and the methods and post-estimation tests validate the generalisation. Moreover, the survey method and an estimation method were conducted with the same conclusions for the planning and learning trading strategies.

8.2. Research Limitations

This section identifies limitations to the research. These are: (a) the quality of the findings; and (b) the ability to answer the research questions and/or to conduct the hypotheses tests. Specifically, this section addresses the following issues:

a) Limitations related to the reviewed literature.
b) Limitations related to the research design.
c) Other technical limitations.

There are a number of limitations related to the scope of literature covered in this research. Particularly, this research has narrowed down the literature. It has chosen the Microstructure Markets Approach for the exchange rates as its characteristics permit the research to model the trading strategies. A competing approach highlights the heterogeneity among agents (probably initiated by the work of Frankel and Froot(1987)) and is based on the financial asset pricing framework. If this other approach had been taken the empirical evaluation would then have been modelled through simulation (e.g. Brock and Hommes 1997, 1998; Lux, 1998; Lux and Marchesi, 2000; Chiarella and He, 2002; De Grauwe and Grimaldi 2005 and 2006), or it would have been based on a small number of studies that examine and estimate the heterogeneous agents' models with switching mechanisms (i.e. Boswijk et al. 2007; De Jong et al. 2009a, b; and Frijns et al. 2010). Further research might use these methodologies to test the trading strategies.

The limitations related to the research design comprise the traditional limitations brought about by a survey methodology, as well as the limitations generated by the dataset processes such as co-integration and cross-sectional dependence. These have been tackled using PMG by FE in the first stage of the Panel 2SLS method (Atkinson and Cornwell 2014).

Among the limitations of the single cross-sectional survey method are the following:

a) The responses are not time-varying
b) The cause-effect relationships are very difficult to prove
c) Time-related limitations to carry out the survey
d) Limitation of funds to conduct the survey method

Finally, other research limitations or technical limitations are those related to the dataset characteristics, software and hardware. The limitations include:

a) The data management is difficult as the dataset comprised of more than 2 million observations in a tick by tick frequency.
b) The software used was Stata MP, a version that includes multiple usages of processor cores.
c) The required hardware to manage a large dataset is expensive, and particularly, some estimations and procedures have required large amounts of computer memory.

8.3. Further Research

This section reviews suggested topics of research brought about by the empirical findings as follows:

a) The topic of strategic objectives in the foreign exchange rates market needs further research in terms of its hierarchy and structure. Indeed, the hierarchical cluster analysis (see Appendix in chapter 4) indicates that Strategic objectives might follow a hierarchical structure.
b) Another source of future research could be to explain how far strategic objectives and risk tolerance are related. Moreover, this study has applied two measures of risk

tolerance. However, contrary to the findings of Hanna and Lindamood (2004), the two measures of risk did not show any strong or weak relationship.

c) From the logistic regressions between strategic objectives and trading strategies, the results may suggest that different types of news will affect, in different ways and strength, certain types of market agents. This can be a topic for further research in the discussion on ‘informed transactions’.

d) Following on from the survey results, the most important strategic objective (i.e. profit from investments) is not influenced by the strategic information. Further research might confirm and explain the cause of this finding.

e) More insight is needed regarding the impact of other type of assets (prices and order flows) on the exchange rate determination.

f) The pilot survey results have showed how low the participation of women is in the foreign exchange market. It can be important to research the causes of this phenomenon.

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