Exchange Rate Changes and Net Positions of Speculators in the EuroFX futures market - Does Market Size Matter?

Economics

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Abstract

This thesis analyses whether the size of the EuroFX futures market (measured through the growth rate of the total open interest in the EuroFX futures market at the Chicago Mercantile Exchange) has an effect in the determination of the Euro per dollar exchange rate in short horizons, and if the relationship between changes in the net positions of speculators in the EuroFX futures market and changes in the Euro per dollar exchange rate is affected by the size of the market. For the period from January 5, 1999 to December 28, 2010, it could be concluded that when the growth rate of the EuroFX futures market is relatively stable, this variable is a determinant to explain exchange rate movements in the short-term, and also that the relationship between changes in the net positions of speculators in the EuroFX futures market and changes in the Euro per dollar exchange rate is affected by the fast growth in the EuroFX futures market. This implies that speculators should consider the growth of the EuroFX futures market to forecast changes in the spot exchange rate when the size of the market is relatively stable.

To my family, four hearts united forever in love.

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I.   *Introduction*

In the last decade, economists have presented new approaches in order to explain short-term exchange rate movements.[1] This is mainly because they agree that traditional models of exchange rate determination have done a poor job in explaining changes in short horizons and that their capacity to forecast ex-post changes is almost nil.[2]

One of these new approaches is the one proposed by Evans and Lyons (1999), the so called microstructure approach, which states that order flow is a determinant to explain exchange rate movements in the short run because it conveys information.

Additionally, Klitgaard and Weir (2004) uses information about other market participants at the Chicago Mercantile Exchange (CME) to find a relationship between changes in the net positions of speculators in the futures markets and changes in the exchange rate of different currencies on short-term horizons, finding a strong and stable contemporaneous connection.

However, Torre and Provorova (2007) analyzed this same relationship for the Mexican peso, finding that this relationship is not constant over the years and they suggest that as the futures market of the Mexican peso has deepened (i.e. has increased over time), a variation in the net positions of speculators of a given magnitude has been associated with a diminishing response of the exchange rate.

Therefore, in this thesis it was decided to analyze if the relationship between the Euro per dollar exchange rate (EUR/USD exchange rate) and the net positions of speculators in the EuroFX futures market at the CME within the micro approach to exchange rate determination is also

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[1] For example: Evans (2002); Evans and Lyons (2002, 2004a); Payne (2003); Bjones, Rime and Solheim (2005); and Carlson and Osler (2005).
[2] Please see Meese and Rogoff (1983); Frankel and Rose (1995); Flood and Taylor (1996); Cheung et al. (2002); Evans and Lyons (2004a); and Engel and West (2005).

unstable when controlled by the size of the EuroFX futures market, and thus, to review if the size of EuroFX futures market (measured through the growth rate of the total open interest in the EuroFX futures market) plays an important role in the determination of the EUR/USD exchange rate.

The results included in this thesis suggest that the relationship between weekly changes in the net positions of speculators in the EuroFX futures market at the CME and weekly percentage changes in the EUR/USD exchange rate is unstable when the EuroFX futures market presents fast growth, and that the size of the EuroFX futures market is a determinant to explain exchange rate movements in the short-term when the EuroFX futures market is relatively stable (i.e. that the growth rate of the total open interest is relatively low). The analysis included in this report is for the period from January 5, 1999 to December 28, 2010.

This report is organized as follows: In Section II and III, the conceptual and theoretical frameworks are presented. Section IV describes the empirical model specifications as well as the data on which this thesis is based. Section V presents a description of the results, and Section VI includes the conclusions and recommendations for further research.

II. *EuroFX futures market*

This section includes some basic definitions to understand the EuroFX futures market, describes the structure of the EuroFX futures market at the CME, as well as its development over the analyzed period and its relationship with the EUR/USD exchange rate.

A. Definitions

To understand the EuroFX futures market, first it is important to know all of the basic terms and definitions that apply to this unique market. Therefore, in this section, the history as well as the mechanics of the EuroFX futures market will be reviewed.

1. *Mechanics of EuroFX futures*

Currency futures contracts were developed in 1972 by the CME and then Chairman Leo Melamed in cooperation with Nobel Prize winning economist, Milton Friedman.

Since 1972, the currency futures contracts that began trading at the CME were on the British pound, Canadian dollar, German Deutsche mark, Japanese yen, and Swiss franc. These contracts were a great advantage to anyone involved in importing and exporting goods across international markets. Over the years, many currency futures contracts have been added and now contracts such as the EuroFX, Canadian dollar, Australian dollar, Mexican peso, New Zealand dollar, Russian ruble, South African rand, Brazilian real, Polish zloty, Norwegian krone, Swedish krona, Hungarian forint, Czech koruna, Israeli shekel, Chinese renminbi and Korean won are also traded at the CME.

A currency futures contract is a standardized contract between two parties to exchange a specified currency of standardized quantity for a price agreed today (the future price) but with delivery occurring at a specified future date, which is called the delivery date.

Therefore, the EuroFX futures contract is based upon the EUR/USD exchange rate, and even though it is traded at different markets worldwide, in this thesis it was decided to use information from the CME in the United States, which is still considered the primary market.

In the EuroFX futures market at the CME, participants buy and sell EuroFX futures contracts. These contracts require one firm to supply and another one to demand Euros at a future date at an agreed price against the U.S. dollar. The firm or participant supplying Euros gains if the Euro depreciates against the U.S. dollar relative to future prices. However, the participant buying Euros gains if the Euro appreciates.

The CME includes information for the EuroFX futures contracts since January 5, 1999. Each EuroFX futures has a nominal value of 125 000 Euros and is traded the first six months in the March quarterly cycle (i.e. March, June, September and December). Information about the EuroFX futures contracts and all the other currencies at the CME is released on a weekly basis at the Commitments of Traders Report published by the U.S. Commodity Futures Trading Commission (CFTC) every Friday. These reports provide a breakdown of each Tuesday's open interest for the EuroFX futures market.[3]

The market participants or traders at the CME are divided in three different groups: Commercial, Non-Commercial and Non-Reportable traders:

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[3] These reports can be found in the U.S. Commodity Futures Trading Commission at the following link: http://www.cftc.gov/MarketReports/CommitmentsofTraders/HistoricalCompressed/index.htm

All the reported futures positions of a trader in a commodity are classified as Commercial if the trader uses futures contracts in that particular commodity for hedging purposes (i.e. firms or individuals using futures contracts as an insurance against adverse situations). Non-Commercial traders are defined as firms or individuals using futures contracts for speculations purposes (i.e. trading futures contracts only to make profits with exchange rate movements). Finally, Non-Reportable traders refer to a relatively small number of traders whose positions cannot be classified and thus it includes Commercial and Non-Commercial traders.

Therefore, participants in the EuroFX futures market can use these EuroFX futures contracts either for hedging or speculation purposes. However, the group of interest in this thesis is the Non-Commercial traders or speculators, who trade EuroFX futures contracts to make profits and not for fundamental purposes such as to hedge foreign exchange risk.

The contracts for buying EuroFX futures are known as long positions while the contracts to sell EuroFX futures are called short positions. For example, traders who "go long" or buy EuroFX futures are committed to take or accept delivery of 125 000 Euros; while traders who "go short" or sell EuroFX futures are committed to make delivery of 125 000 Euros. The short making delivery is compensated by the buyer accepting delivery by an amount equal to the futures settlement quoted in U.S. dollars on the last day of trading.

Another important term is the total open interest in the EuroFX futures market. Total open interest is the total number of all EuroFX futures contracts entered into and not yet offset by a transaction, by delivery, by exercise, etc. (i.e. the aggregate of all long positions or the aggregate of all short positions, but not the aggregate of both). Finally, net positions refer to the difference between the total long positions and the total short positions.

Therefore, in this thesis the net positions of speculators are defined as the difference between the total long positions and the total short positions of Non-Commercial and Non-Reportable traders at the CME.[4]

2.   *EuroFX Futures - Pricing theory*

A EuroFX futures contracts may be considered as a EuroFX forward contracts (i.e. agreements between a buyer and a seller on a price, quantity, and a future delivery date for EuroFX; however, nothing about the contract is standardized; thus, each contract has terms and conditions that are negotiated between the buyer and the seller) and typically these EuroFX futures contracts are priced in accordance with the same cost of carry considerations discussed in forward pricing theory.

A forward contract is almost identical in operational terms to a spot transaction with the significant difference that the value or settlement date is deferred. Rather than settle two days hence, outright forwards are typically traded for settlement in 1 week, 2 weeks, 1 month, 2 months, 3 months, 6 months, or 12 months, among others. Forward is also referred to as "straight dates." Therefore, while the forward contract may be settled some days, weeks or months later, no consideration is necessarily passed between buyer and seller when the transaction is consummated.

Nevertheless, many dealers will demand that customers post some acceptable collateral to cover market risks in the interim, particularly if a trade goes "underwater."

The value of an outright forward relative to the spot value of the currency may be modelled by taking into consideration the costs and benefits associated with purchasing and carrying the currency over the life of the forward transaction. Consider, for example, the prospect of buying

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[4] It was decided to include the Non-Reportable traders because this group also includes speculators that cannot be classified and also because Klitgaard and Weir (2004) included this group in their analysis.

Euros with U.S. dollars on a forward basis. The forward value may be calculated as follows, where "r_t" represents the short-term rate that may be earned by investing the "term" currency; "r_b" represents the short-term rate associated with the "base" currency; and, δ represents the number of days until full term.

Forward Rate = Spot Rate*(1 + [r_t*(δ/360)]/1+ [r_b*(δ/360)])

Assume that the U.S. short-term rate is 1.99% and the applicable Euro short-term rate is 3.98% while the spot rate is 0.6372 Euros per dollar. A 60-day forward rate may be calculated as 1.3008 as follows. The convention in most markets is to calculate short-term rates based on a 360-day count assumption.

Forward Rate = 0.6372* {(1 + [0.0199*(60/360)]) / (1+ [0.0398*(60/360)])}

= 0.6351

However, there are still some differences in the determination of a futures rate. For example, some unique terminology is often applied to the futures markets. In particular, futures market participants often speak of "the basis" or the relationship between futures and spot prices in a very specific way. The basis is the difference between the cash price and the futures price. Hedging is not a perfect science, i.e. that there are several influences such as seasonal factors, commissions, opportunity costs (interest rates), and slightly different fill prices that hinder the ability to create a perfect dollar-for-dollar hedge.

The basis may be either positive or negative contingent upon relationship between short-term interest rates prevailing with respect to the base and terms currencies. EuroFX futures contracts at the CME are generally quoted in terms of U.S. dollars (USD) per Euros (EUR) i.e. that USD becomes the "terms" currency and EUR is base currency in this context. The appropriate level

for the EuroFX futures contract, or the "fair market value," may be calculated using the following formula.

Futures rate = Spot Price*{(1 + [r_t*(δ/360)]) / (1+ [r_b*(δ/365)])}

Where the terms rate exceeds the base rate, futures should trade at premium to the spot price of the currency. This is a condition known as "negative carry" in futures markets because costs are incurred to buy and carry EUR. But when the terms rate is less than the base rate, futures should trade at discount to spot. This is a circumstance known as "positive carry" because earnings accrue from buying and carrying EUR.

As an example, consider the fair market value for a March 2010 EuroFX futures contract as of January 19, 2010. At the time, note that the spot value of the EUR/USD exchange rate was 0.6999. There were 63 days until March 23, 2010 futures delivery date. The term rate (or USD rate) stood at 0.13% per a 360 rate convention while the base rate (EUR rate) was at 0.59%, likewise with 360 rate convention. As such, the March 2010 EuroFX futures rate could have been calculated as 0.6993 EUR per USD.

Futures rate = Spot Rate x (1 + [Rterm x (d/360)]/1+ [Rbase x (d/360)])

Futures rate = 0.6999*{(1 + [0.13%*(63/360)]) / (1+ [0.59%*(63/360)])}

= 0.6993

The basis may be quoted at 6 points (i.e. Basis = Futures price – spot price or equal to 0.6999-0.6993 = 0.0006 or 6 points). Note that the EuroFX futures rate is below the spot price and that the basis will tend to decrease in further deferred futures contract months, i.e., futures in successively deferred months run to smaller levels. This is a condition of positive carry because

costs are incurred when borrowing USD to buy EUR because Euro rates ("base rate") exceed U.S. rates ("terms rate").

However, as the expiration of the EuroFX futures contract is approaching the basis will tend to converge towards zero. This is attributed to the fact that the impact of the differential short-term rates becomes less relevant as expiration approaches. Finally, by the time the EuroFX futures contract becomes deliverable, the EuroFX futures contract becomes a direct proxy for the spot delivery of the currency in question and the basis is said to converge to zero. Therefore, according to futures pricing theory spot and futures prices will tend to converge such that the basis will gravitate towards zero by the time the contract is about to expire.

The following figure shows the above mentioned.

Figure 1: Basis
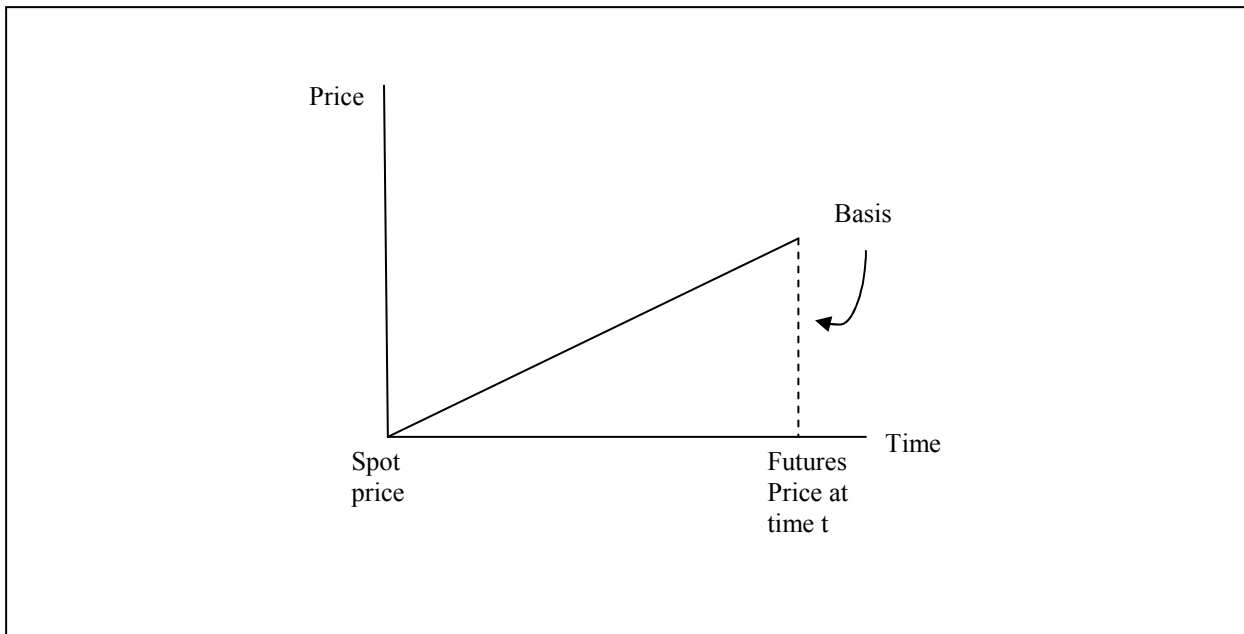
Source: Please see Kline, D. (2001)

B. Development of the EuroFX futures market

1. *Growth rate of the EuroFX futures market*

Once some basic concepts were introduced and the different participants in the EuroFX futures market were identified, it was time to review the development of the EuroFX futures market since its beginning in 1999 at the CME. Table 1 shows the average total open interest for the EuroFX futures market, as well as its growth rate for the period from 1999 to 2010.

Table 1: Open Interest for the EuroFX futures market at the CME and its growth rate from 1999 to 2010

Year	Total Open Interest in the EuroFX futures market (Number of contracts)	Growth Rate
1999	44 307	
2000	68 107	54 %
2001	94 696	39 %
2002	108 278	14 %
2003	104 538	-3 %
2004	139 249	33 %
2005	147 561	6 %
2006	165 807	12 %
2007	207 177	25 %
2008	178 212	-14 %
2009	140 719	-21 %
2010	214 295	52 %
Average 1999-2001	**69 037**	
Average 2002-2004	**117 355**	**70 %**
Average 2005-2007	**173 515**	**48 %**
Average 2008-2010	**177 742**	**2 %**

Source: Own estimates using information published by the U.S. CFCT.

The first column indicates that the total number of EuroFX futures contracts has increased almost five times since 1999 (i.e. the size of the EuroFX futures market has increased). However, the growth of the EuroFX futures market has not been constant over the period and it has decreased in recent years.

Please take a look at the average number of EuroFX futures contracts for the period 2002-2004, which registered an average of 117 355 contracts and a 70% growth rate in comparison with the average number of EuroFX futures contracts registered during 1999-2001. However, for the period 2005-2007, the average number of EuroFX futures contracts only increased 48% in comparison with the average number of EuroFX futures contracts during 2002-2004, and for the last three years (i.e. 2008-2010) the average number of EuroFX futures contracts had only a growth rate of 2%, a significantly low rate in comparison with the high rate registered during the first 3 years of the EuroFX futures market.

2. *Total open interest in the EuroFX futures market and the EUR/USD exchange rate*

The previous section showed that the growth rate of the total open interest in the EuroFX futures market has decreased over time and has reached stable growth. During 2010, the growth rate was approximately 3% in comparison with 2007, i.e. without considering the period of the late-2000s financial crisis, the EuroFX futures market has been in similar levels than the ones observed during 2007.

Nevertheless, the relevant issue in this thesis is if there is a relationship between the size of the EuroFX futures market (measured through the total number of EuroFX futures contracts i.e. total open interest) and the EUR/USD exchange rate. Figure 2 shows the total open interest in the EuroFX futures market (as a variable measuring the size of the EuroFX futures market) and the EUR/USD exchange rate for the period from January 5, 1999 to December 28, 2010.

Figure 2: Evolution of the total open interest in the EuroFX futures market and the EUR/USD exchange rate from January 5, 1999 to December 28, 2010.
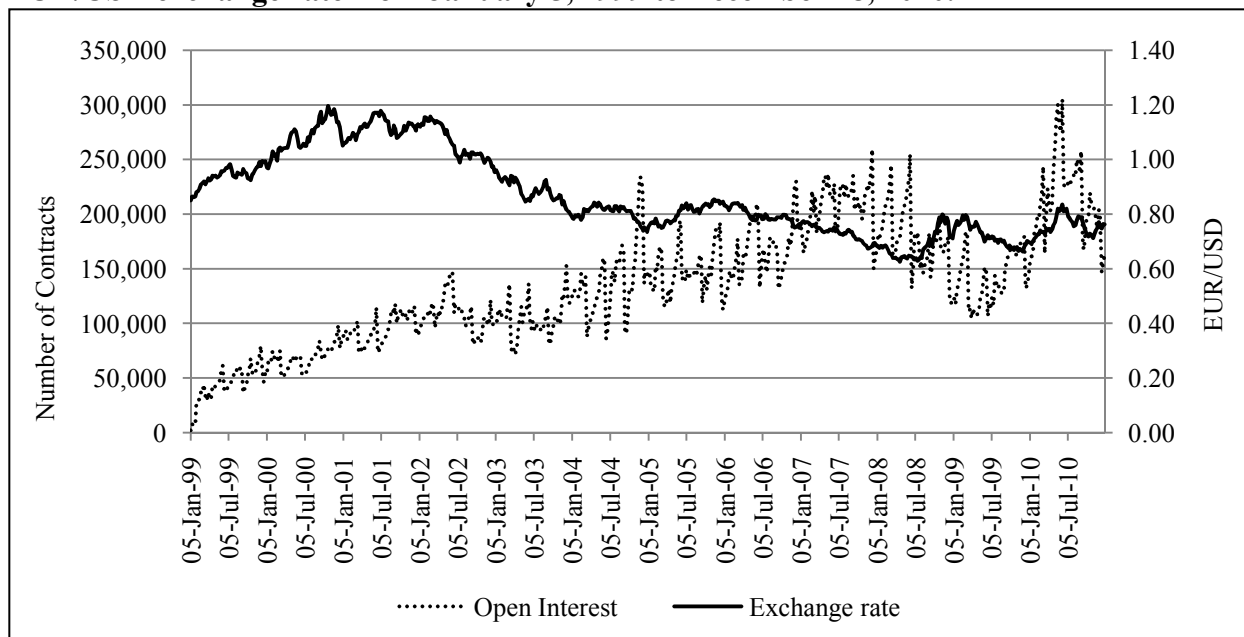
The above figure shows visual evidence that there is a strong negative relationship between the total open interest in the EuroFX futures market and the EUR/USD exchange rate. Additionally, the correlation between these two variables is -0.67, which suggests that there is a strong negative correlation between these time series.

Therefore, it could be assumed that the size of the EuroFX futures market (measured through the growth rate of the total open interest of the EuroFX futures market) explains changes in the EUR/USD exchange rate. However, this subject will be described in more detail in future sections.

III. *Net positions of Speculators and the Micro approach*

Section II showed that the EuroFX futures market has grown since 1999 but also that the growth rate has been declining in recent years. This section performs an exploratory analysis of the relationship between the net positions of speculators and the EUR/USD exchange rate as well as a brief description of the micro approach in order to establish an empirical relation between net positions of speculators in the determination of the EUR/USD exchange rate in short horizons.

A. Net positions and exchange rates

As defined in section II in this thesis, net positions of speculators is defined as the difference between the total long positions and the total short positions of Non-Commercial and Non-Reportable traders at the CME. Figure 3 shows the net positions of speculators and the EUR/USD exchange rate for the period from January 5, 1999 to December 28, 2010.

Figure 3: Evolution of the net positions of speculators and the EUR/USD exchange rate from January 5, 1999 to December 28, 2010.

Sources: Bloomberg and CFTC

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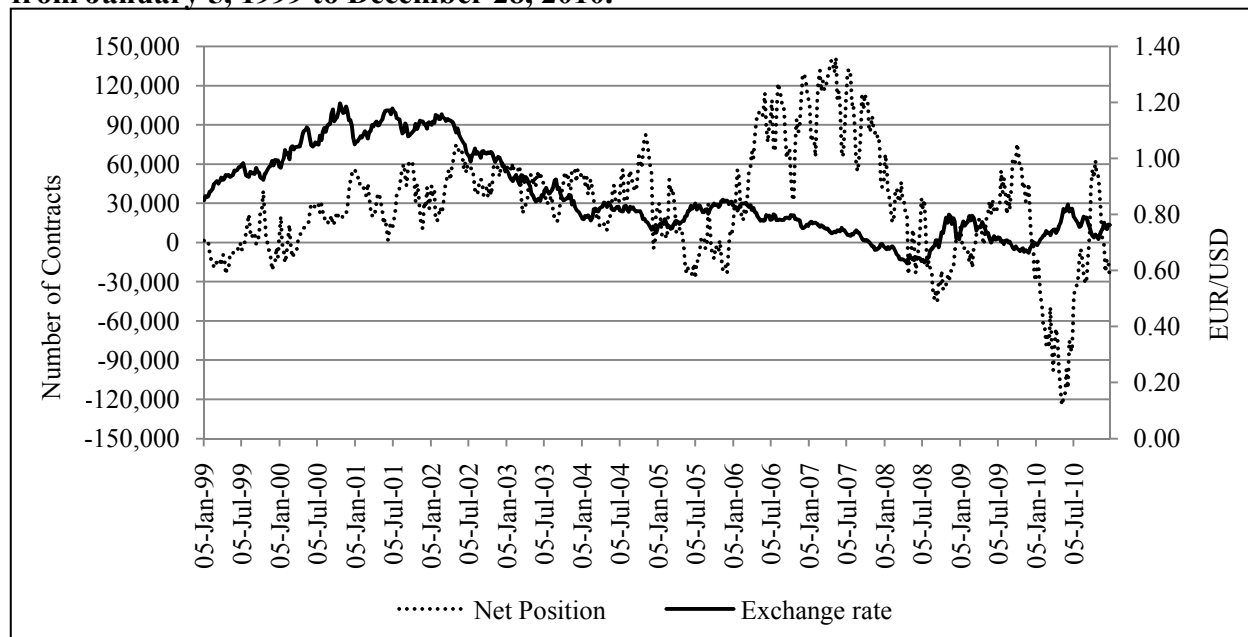
Figure 3 shows a negative relationship between net positions of speculators in the EuroFX futures market and the EUR/USD exchange rate. This relationship is also negative when using weekly changes in the net positions of speculators and percentage changes on the EUR/USD exchange rate (Figure 4). The correlation between these two variables is -0.46, a correlation significantly high in comparison with the correlation of these two variables in their levels (-0.12) as included in Figure 3.

Figure 4: Weekly changes of the net positions of speculators in the EuroFX futures market and weekly percentage changes in the EUR/USD exchange rate from January 12, 1999 to December 28, 2010.
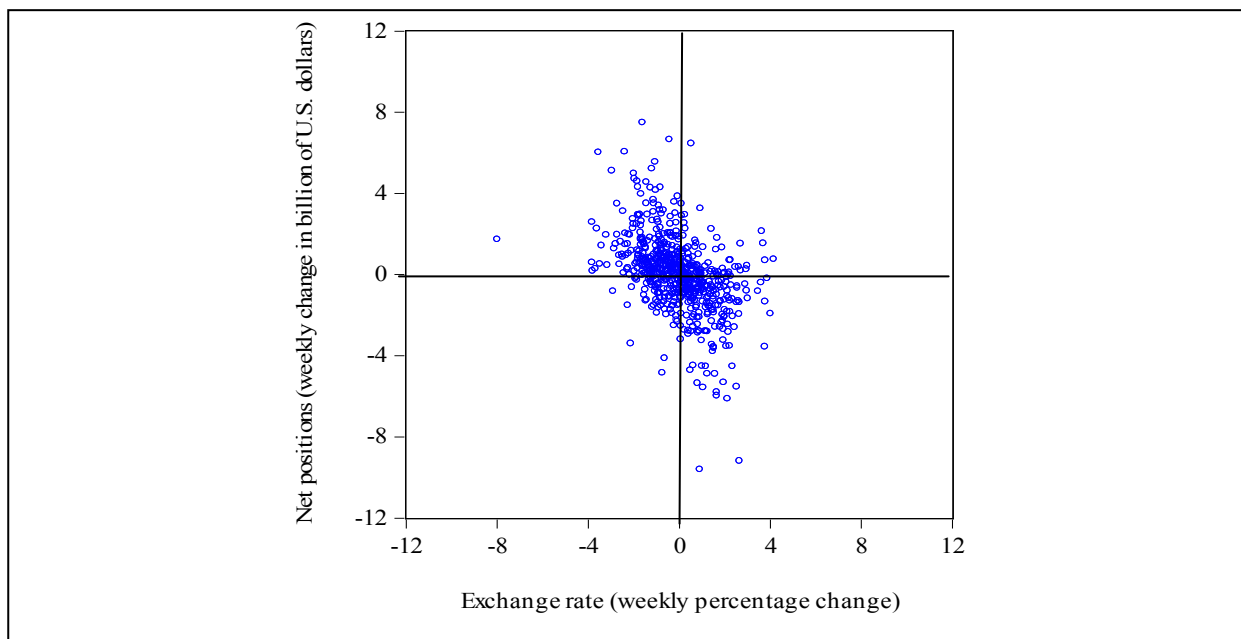
Sources: Bloomberg and CFTC

The above figure shows the weekly percentage changes in the EUR/USD exchange rate plotted against changes in the net positions of speculators in the EuroFX futures market. To interpret this figure, please note that an observation in the upper-left quadrant represents a week when speculators increased their holdings of short contracts in Euros relative to long contracts, and the Euro depreciated relative to the U.S. dollar in the same week. Similarly, the lower-right quadrant

shows speculators increasing their long positions contracts in Euros relative to short positions during a week when the Euro appreciated, also suggesting a move in a consistent direction. Observations in the other two quadrants suggest speculators moved in a direction inconsistent with the contemporaneous change in the Euro over the same week.

Therefore, it can be concluded that there is a strong negative relationship between weekly changes in the net positions of speculators in the EuroFX futures market and weekly percentage changes in the EUR/USD exchange rate. However, the following section provides a more detailed explanation of this relationship.

B. The Micro approach

As mentioned, traditional models using macroeconomic variables (such as interest rates, prices, GDP, among others) have completely failed in the determination of exchange rate movements in short horizons. In this regard, Evans and Lyons (1999) proposed a new approach to explain this dynamic in short-term periods, the so called "micro approach", which focuses mainly on "dispersed information" used by traders.[5] Dispersed information refers to information related to some relevant indicators for exchange rate dynamics, such as the demand for money, risk preferences, inflation expectations and interest rates as well as macro news included in the actions of other participants in the market. [6]

The dispersed information that is included in the cumulative flow of signed transactions between traders is known as Order flow. These transactions are signed positively or negatively and vary according to whether the trader is buying or selling, respectively. In other words, a positive sum over the period indicates pressure to buy, while a negative sum indicates pressure to sell.

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[5] For evidence that foreign exchange order flow conveys information, please see Lyons (1995); Covrig and Melvin (1998); Ito, Lyons, and Melvin (1998); Yao (1998); Payne (1999); Cheung and Wong (2000); Naranjo and Nimalendran (2000); and Evans (2002).
[6] Please see Evans and Lyons (2004a).

Therefore, order flow is interpreted as a variable that conveys information about macroeconomic fundamentals that is dispersed among market participants. This aggregate of information provides a link between macroeconomic variables such as inflation, prices and other economic indicators and the determination of exchange rates.

Lyons (2001) proposes a diagram showing that information processing has two stages for determining exchange rates. The first stage is the analysis or observation of macro fundamentals by non-dealer market participants, such as mutual funds, hedge funds, individuals with special information, among others. The second stage is the interpretation of the dealers of the first stage analysis, and such interpretation comes from reading order flows. Thus, dealers set prices on the basis of this interpretation.[7]

The following figure shows the diagram proposed by Lyons (2001).

Figure 5: Two stages of information processing
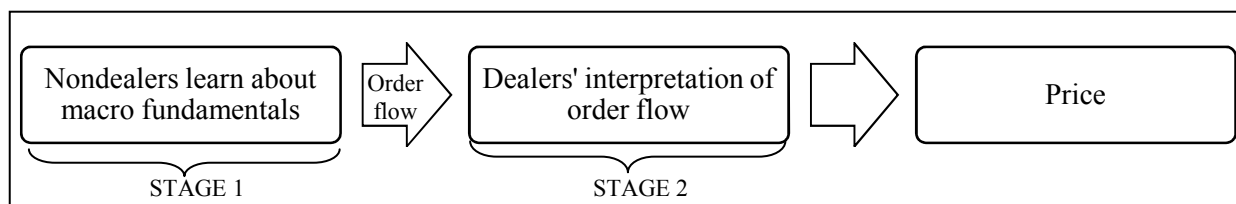
Source: Lyons (2001)

Using this approach, Evans and Lyons (1999) found that daily order flow can explain 40 and 60 percent of daily exchange rate movements for the Japanese yen/USD exchange rate and the Deutschmark/USD exchange rate, respectively, with similar levels reported for other currencies.

Following the micro approach proposed by Evans and Lyons (1999), Klitgaard and Weir (2004) used net positions of speculators in the futures markets as a variable that includes the

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[7] Please see Lyons (2001).

interpretation of public and private information. Their explanation was based on the idea that speculators in the futures markets seem to have enough dispersed information to allow them to change their positions in a way that anticipates the direction of exchange rate. These authors found that weekly changes in the net positions of speculators can tract between 30 to 45 percent of exchange rate movements of the major currencies over the same week. However, they did not find that net positions can predict changes over the following week, and they simply suggested that this strong relationship is due to the fact that changes in the net positions reflect the actions of speculators, who bet that the underlying demand will move exchange rates from their prevailing values.

By using the same logic used for the micro approach model for exchange rate determination suggested by Klitgaard and Weir (2004). Speculators in the EuroFX futures contracts consider public and private information to take actions in the EuroFX futures market (i.e. to take long or short positions). Therefore, the net positions of speculators in the EuroFX futures market could be interpreted as a variable that conveys information and that could be used to determine trends in the EUR/USD exchange rate.

Although some people might think that the only thing that net positions of speculators states is that the Euro appreciates (depreciates) when the number of contracts that speculators want to buy (sell) is greater than what they want to sell (buy), the role of this variable should not be underestimated, because it incorporates basic ideas of financial economics.

The first of these basic ideas is that the net positions play two distinct roles that are quite useful to understand this exchange rate dynamics. First, net positions of speculators clear the EuroFX futures market (i.e. Equilibrium in the EuroFX futures market) and second, net positions of speculators in the EuroFX futures market transmit information.

The first of these two roles is reflective for example when the EUR/USD exchange rate appreciates as a result of the number of long positions exceeding the number of short positions. Additionally, the second role is more important and it is often not taken into account. In a world of dispersed information, the transaction flow affects agents' expectations on prices and macroeconomic fundamentals. Empirical evidence of this second role of the net positions can be illustrated with the following two facts: 1) Transactions affect exchange rates in different ways, depending on the type of institution that is behind these transactions, and 2) Transactions occurring in the market of one currency have an impact on market prices in other currencies.

Changes in the net positions of speculators in the EuroFX futures market are primarily for the purpose of taking advantage of the market movements in the short run. These participants (speculators) are constantly interpreting the public and private information about the constant changes on the demand and supply of Euros. Thus, once they have developed some perspective about the direction they believe the price of Euros will take, speculators reveal their interpretation by taking long or short positions in the EuroFX futures market and, as a result, they determine the level of net positions.

Therefore, the net positions of speculators could be used as a variable that represents an approximation of their expectations on the economic variables, based on both public and private information, and, thus, by adding this variable in a model to determine exchange rates could improve the coefficients of other explanatory variables.

Of course, an OLS regression model including the net positions of speculators as an explanatory variable could be criticized because of the possible existence of simultaneous relationships between net positions and the spot exchange rate.[8] However, as mentioned in this thesis the important issue is to review if the size of the EuroFX futures market (measured through the

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[8] Critics argue that not only the movements in the net positions cause movements in the exchange rate, but also that there is an opposite relationship in the direction that speculators before making a long or short position in the futures market, observe the level and trend of the exchange rate and utilize this information to make their decision and thus any coefficients resulting of a OLS regression between them would be biased.

growth rate of the total open interest in the EuroFX futures market) plays a role in the determination of the EUR/USD exchange rate and not if the net positions of speculators determine changes in the EUR/USD exchange rate in the following week.[9]

By the contrary, in this thesis the size of the EuroFX futures market (measured through the growth rate of the total open interest in the EuroFX futures market) will be used as an additional explanatory variable in the model proposed by Klitgaard and Weir (2004) in order to review if by adding this variable it has an effect on the relationship between changes in the net positions of speculators in the EuroFX futures market and percentage changes in the EUR/USD exchange rate under the micro approach, and, thus, to find that when controlling for the size of the EuroFX futures market there is an opportunity to forecast changes in the EUR/USD exchange rate in the short-term.

Therefore, the reasons for including this additional variable (i.e. the size of the EuroFX future market) as an explanatory variable in the model proposed by Klitgaard and Weir (2004) could be summarized as follow:

- There is a strong negative relationship between the number of contacts in the total open interest in the EuroFX futures market and the EUR/USD exchange as shown in Figure 2;

- Torre and Provorova (2007) found that the coefficient of net positions is unstable, suggesting that the size of the Mexican peso futures market peso is a possible reason for the coefficient instability; and

- Even though it could be a possible existence of simultaneous relationships between the net positions of speculators in the EuroFX futures market and the EUR/USD exchange rate, the use of the net positions of speculators as an explanatory variable in a model to determine

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[9] It is important to mention that in this thesis no exogeneity tests were performed. Therefore, this presents an opportunity for further research.

exchange rate fluctuations could help to improve the coefficients of other explanatory variables, such as the size of the EuroFX futures market.

Due to the above, in this thesis it was decided to add the growth rate of the total open interest in the EuroFX futures market (as a variable measuring the size of the EuroFX futures market) to the models proposed by Klitgaard and Weird (2004) and Torre and Provorova (2007) in order to prove that the size of the EuroFX futures market also conveys information and, thus, that it could be used as an explanatory variable to determine changes in the EUR/USD exchange rate.

The theory behind this hypothesis is that total open interest in the EuroFX futures market also conveys information. As mentioned, total open interest in the EuroFX futures market refers to the total number of EuroFX futures contracts entered into and not yet offset by a transaction, by delivery, by exercise, etc. i.e. that are not closed or delivered and thus it is considered as "open".

The total open interest could increase, decrease or remain the same and it is affected by daily price action. The total open interest increases when the number of open positions in the EuroFX futures market increases e.g. if a large number of new buyers (long positions) or sellers (short positions) come into the market. Similarly, open interest decreases if positions are being liquidated during the day. Nevertheless, if one trader is initiating a position but the other is liquidating, the total open interest remains unchanged.

Consequently, the total open interest provides traders with an idea of whether market movement is due to new money coming into the market or old money leaving the market. From January 5, 1999 to December 28, 2010, 65 percent of the changes in open interest were mainly due to new money coming into the EuroFX futures market and only 35 percent of the changes in open interest were either to old money leaving the EuroFX futures market or by liquidated Euro futures positions. This suggests that most of the changes in the total open interest in the EuroFX futures market refer to positive money flow into the EuroFX futures market. Positive money

flow could be interpreted as a signal of present economic activity either in Europe or the United States, and, thus, it conveys information of macro fundamentals. Accordingly, Hong and Yogo (2011) suggest that open interest is a better signal of future economic activity and, thus, has a remarkable power to forecast currency prices.[10]

As a result, these new money flow movements could reflect the strength or weakness behind the Euro currency, and, thus, there is an opportunity for traders (including speculators) in the EuroFX futures market to use this variable to predict exchange rate movements in the following week.

Therefore, it could be assumed that it is not enough to use the net positions of speculators as an only explanatory variable for exchange rate determination, and, thus, the growth rate of the EuroFX futures market should also be included in models for exchange rate determination under the micro approach.

The following section presents the empirical model specifications as well as the data on which this thesis is based.

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[10] Please see Hong and Yogo (2011).

IV. *The Size of the EuroFX futures market - An Empirical Model*

A. Preceding models

The relationship between net positions of speculators and the EUR/USD exchange rate can be formalized following the model suggested by Evans and Lyons (1999). This model integrates public macroeconomic information and private heterogeneous agents' information in a microstructure trading setup, where, in equilibrium, order flow aggregates private information. In their setup, order flow serves as a mapping device from dispersed information in the market to prices. The price change at the end of each period can be specified as follow:

$$\Delta P_t = \beta_{1t} \, \Delta X_t + \beta_{2t} \, \Delta(i_t - i_t^*) + \eta_t \qquad\qquad\qquad Model\ (1)$$

Where, ΔP_t is the daily change in the log exchange rate (domestic price of the foreign currency); ΔX_t is daily order flow (i.e. private agents' information)[11]; $\Delta(i_t - i_t^*)$ is the interest rate differential between the nominal dollar interest rate (i) and the nominal non-dollar interest rate (i_t^*), which capture the public macroeconomic information; and η_t is the residual term.

Klitgaard and Weir (2004) used a more simplified model than the one used by Evans and Lyons (1999). The model used by Klitgaard and Weir (2004) is as follows:

$$\Delta fx_t = \alpha_{1t} \, \Delta sp_t + \varepsilon_t \qquad\qquad\qquad Model\ (2)$$

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[11] Please note that the model of Evans and Lyons (2002) refers to the concept of "order flow" and not to the concept of net positions of speculators as an explanatory variable in exchange rate dynamics. However, researchers that have had access to order flows data (which is not publicly available) have found that this variable as well as net positions of speculators shows a strong positive contemporaneous correlation with short-term exchange rates. In this thesis, as Klitgaard and Weir (2004) and Torre and Provorova (2007), net positions of speculators will be used as it is information that is publicly available.

Where, the left-hand-side variable, Δfx_t is the percentage change in the foreign currency per dollar exchange rate. The variable Δsp_t is the change in the net foreign currency position of speculators (long contracts in the foreign currency minus short contracts) in billions of dollars.

Additionally, Torre and Provorova (2007) used this simplified model, but including the weekly change in the interest rate differential as proposed by Evans and Lyons (1999) in *Model (1)*. The model used by Torre and Provorova (2007) looks as follows:

$$\Delta fx_t = \alpha_{1t} \Delta sp_t + \alpha_{2t} \Delta(i_t - i_t^*) + \varepsilon_t \hspace{3cm} \textit{Model (3)}$$

Where, Δfx_t, is the weekly percentage change in the Mexican peso per dollar exchange rate. The variable Δsp_t is the weekly change in the net position of speculators in millions of dollars, and the $\Delta(i_t - i_t^*)$ is the weekly change in the interest rate differential, where i is the fund rate in Mexico and i^* is the Federal fund interest rate in the United States.

The results of the above models could be summarized as follow:

Evans and Lyons (1999) found that daily order flow can explain 40 and 60 percent of daily exchange rate movements for the Japanese yen/USD exchange rate and the Deutschmark/USD exchange rate, respectively, with similar levels reported for other currencies.

Klitgaard and Weir (2004) found that weekly changes in the net positions of speculators can tract between 30 to 45 percent of exchange rate movements of the major currencies over the same week finding a strong and stable contemporaneous connection between net positions of speculators and exchange rate movements in short horizons. However, they did not find that net positions can predict changes over the following week.

Torre and Provorova (2007) found that the relationship between the Mexican peso/USD exchange rate and the net positions of speculators in the Mexican peso futures market has not been constant over their analyzed period, suggesting that an increase of the Mexican peso futures market could be an explanation, and, thus, speculators should consider this variable to predict exchange rate movements.

As a result, in this thesis it was interesting to consider the growth of the EuroFX futures market as an explanatory variable to explain exchange rate fluctuations. The model proposed in this thesis is included in the following section.

B. A new model: Does market size matter?

As mentioned, the model included in this thesis is similar to the model proposed by Evans and Lyons (1999), Klitgaard and Weir (2004) and Torre and Provorova (2007). However, the main difference is that here the size of the EuroFX futures market (measured through the growth rate of the total open interest in the EuroFX futures market) will be included as an explanatory variable in the determination of the EUR/USD exchange rate. Thus, the new model takes the following form:

$$\Delta fx_t = \alpha_{1t}\,\Delta sp_t + \alpha_{2t}\,\Delta(i_t - i_t^*) + \alpha_{3t}\,g_t + \varepsilon_t \qquad\qquad \textit{Model (4)}$$

Where, the left hand side variable, Δfx_t, is the weekly percentage change in the Euro per dollar exchange rate multiplied by 100. The variable Δsp_t is the weekly change in the net position of speculators in billions of dollars, the $\Delta(i_t - i_t^*)$ is the weekly change in the interest rate differential, where i is the Euro OverNight Index Average (EONIA) rate and i^* is the Federal fund interest rate (FED rate) in the United States. Finally, g_t is the weekly growth rate of the total

open interest total in the EuroFX futures market in terms of the total number of EuroFX futures contracts.

The data set of the EUR/USD exchange rate (i.e. $\Delta fx_{t,}$) was taken from Bloomberg. This data is published daily from January 4, 1999. Therefore, it was decided to use the exchange rate at the end of each Tuesday in order to be consistent with the other time series data. However, this data set is non-stationary (See Appendix I) and, as a result, it was decided to calculate the weekly percentage change (Tuesday to Tuesday) multiplied by 100.[12]

The data set of the net position of speculators in the EuroFX futures market was taken from the CME.[13] This data is published weekly from January 5, 1999 to December 28, 2010. Net positions data are long contracts minus short contracts for Non-Commercial and Non-Reportable firms in billions of dollars.[14]

To construct the weekly change in the interest rate differential, the EONIA rate data was taken from the European Central Bank (ECB). The EONIA rate is the daily average of overnight rates for unsecured interbank lending in the euro-zone. The FED rate data was taken from the Federal Reserve System[15]. The FED rate is the interest rate at which private depository institutions (mostly banks) lend balances (federal funds) at the Federal Reserve to other depository institutions, usually overnight (i.e. the interest rate banks charge each other for loans). The interest rate differential time series are also weekly from January 5, 1999 to December 28, 2010.

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[12] The weekly percentage change in the EUR/USD exchange rate was calculated using log-differences.
[13] Source: http://www.cftc.gov/MarketReports/CommitmentsofTraders/HistoricalCompressed/index.htm
[14] The exchange rate used to calculate this data set was the daily exchange rate published by the ECB.
[15] Source: http://www.federalreserve.gov

Finally, the weekly growth rate of the total open interest in the EuroFX futures market in terms of the total number of EuroFX futures contracts was calculated, as well, using the information published by the CME. [16]

Model (4) will be estimated from January 5, 1999 to December 28, 2010 (i.e. the total period) and it would be reviewed that all the variables included in the model are stationary in their levels. If the variables are non stationary in their levels then the cointegration of the different data sets will be reviewed in order to review if it is necessary to include an error correction term into *Model (4)*.

In addition, autocorrelation and heteroskedasticy tests will be used in order to confirm that the model does not present serial autocorrelation or heteroskedasticity in the residuals. If so, *Model (4)* will be modified in order to correct these problems.

Finally, a rolling regression analysis will be performed in order to analyze the coefficients estimated in *Model (4)* and to determine whether there is a behavioural pattern of the coefficient of the net positions that could suggest a connection with the size of the EuroFX futures market as proposed by Torre and Provorova (2007). Finally, *Model (4)* will be estimated for different subsamples in order to review if the coefficient of the size of the EuroFX futures market (measured through the growth rate of the total open interest in the EuroFX futures market) obtained in the total period is significant and different from zero in each subsample.

The aforementioned will be described in more detail in the following section.

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[16] The weekly growth rate of the total open interest in the EuroFX futures market was calculated using log-differences.

V. *Empirical Results*

A. Total period (January 5, 1999 – December 28, 2010)

In order to estimate *Model (4)*, first it was necessary to review if the variables included in *Model (4)* were stationary in their levels and, if not, to review that the variables are not cointegrated. The statonarity and cointegration tests can be found in Appendix 1. These tests confirmed that all the variables included in *Model (4)* are non stationary in their levels (without using log-differences). However, according to the cointegration tests, the variables used in *Model (4)* are not cointegrated and, as a result, it was not necessary to include an error correction term in the model.

Therefore, *Model (4)* was estimated using OLS regression analysis for the total period from January 5, 1999 to December 28, 2010, which gave us a total of 625 observations.

1. *OLS regression results*

The following table shows the OLS regression results of *Model (4)* for the total period from January 5, 1999 to December 28, 2010. [17]

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[17] The OLS regression does not include a constant term because it was never statistically significant, similar to the results reported by Klitgaard and Weir (2004). In the presence of a constant term, the coefficient of net positions of speculators proved to be almost the same, and the values for the R^2 and t-Student statistics were almost identical.

Table 2: Regression results of *Model (4)*: January 5, 1999 to December 28, 2010.

Variable	Coefficient	Standard. Error	t-Statistic	Probability.
Δsp_t	-0.36	0.03	-13.25	0.00
$\Delta(i_t - i_t^*)$	-0.06	0.18	-0.33	0.74
g_t	0.74	0.35	2.11	0.04
R^2	0.22			
Durbin-Watson	2.04			

Source: Own estimations using E-views 7

Table 2 shows that the coefficient of the net positions of speculators in the EuroFX futures market and the growth rate in the EuroFX futures market are significant and different from zero. The negative coefficient for the weekly change in the net positions indicates that an increase (decrease) of 1 billion dollars in the net positions of speculators in the EuroFX futures market is correlated with 0.36 percent appreciation (depreciation) of the Euro against the dollar.

However, the Granger causality test suggests that the causality between net positions of speculators in the EuroFX futures market and the EUR/USD exchange rate runs one way, from exchange rates to net positions, but not the other way (See Appendix 2) and, thus, the coefficient of the net positions of speculators is biased.

Nevertheless, it is important to remember that this thesis is not focusing in the effectiveness of the net positions of speculators to predict changes in the EUR/USD exchange rate in short-terms, but in the roll that plays the size of the EuroFX futures market (through the growth rate of the total open interest in the EuroFX futures market) to forecast changes in the EUR/USD exchange rate in short horizons when adding this variable into a model to determine exchange rate fluctuations under the micro approach. (See section III.D of this report).

The coefficient of the size of the EuroFX futures market (measured through the growth rate of the total open interest) is also statistically significant and different. The positive coefficient of 0.74 for the growth rate of the total open interest means that an increase (decrease) in the total open interest is correlated with a 0.74 percent appreciation (or depreciation) of the Euro against the dollar in the following week.

The R^2 indicates that the variables included in *Model (4)* explains 22 percent of the weekly percentage change of the EUR/USD exchange rates and the Durbin-Watson suggests that there is not serial autocorrelation (additionally, the Breusch-Godfrey test was performed in order to confirm this result, please see Appendix 3). However, the ARCH test suggests that *Model (4)* presents Heteroskedasticity in the residuals (See Appendix 4).

2.   *EGARCH model*

In order to correct the Heteroskedasticity in the residuals, it was necessary to add an Exponential GARCH term (EGARCH) in *Model (4)*.

The EGARCH model was proposed by Nelson (1991). Nelson and Cao (1992) argue that the non-negativity constraints in the linear GARCH model are too restrictive. The basic GARCH model assumes that positive and negative shocks of the same absolute magnitude will have the identical influence on the future conditional variances. In contrast, the asymmetry effect is a feature of many financial time series. The asymmetry effect, also known as "leverage" effect, refers to the characteristic of time series on asset prices that an unexpected drop tends to increase volatility more than an unexpected increase of the same magnitude. Therefore, in the EGARCH model, the conditional variance, σ^2_t, is an asymmetric function of lagged disturbances, ε_{t-i}

The results of the EGARCH model are included in the following table.

Table 3: Regression results of *Model (4)* including an EGARCH term: January 5, 1999 to December 28, 2010.

Variable	Coefficient	Standard Error	Z-Statistic	Probability
@SQRT(GARCH)	-0.01	0.04	-0.30	0.77
Δsp_t	-0.32	0.02	-16.62	0.00
$\Delta(i_t - i_t^*)$	-0.07	0.15	-0.48	0.63
g_t	0.76	0.18	4.19	0.00
Variance Equation				
C(5)	-0.17	0.04	-4.10	0.00
C(6)	0.24	0.05	4.41	0.00
C(7)	0.04	0.02	1.64	0.10
C(8)	0.95	0.02	52.75	0.00
R-squared	0.22			
Durbin-Watson stat	2.03			

Source: Own estimations using E-views 7

By including the EGARCH term to *Model (4)*, the results of the coefficients do not change significantly and the R^2 remains in similar levels; however, by adding the EGARCH term to *Model (4)*, the conditional heteroskedasticity in the data has been modelled successfully (See Appendix 4).

Therefore, it could be concluded that the coefficient of the growth rate of the total open interest in the EuroFX futures market is statistically significant and different from zero, and, as a result, the hypothesis presented in this thesis that the size of the EuroFX futures market explains short-term movements on the EUR/USD exchange rate could not be rejected.

Nevertheless, is this relationship constant over time? In order to analyse the relationship between the size of the EuroFX futures market and weekly percentage changes in the EUR/USD exchange rates there are different methods to determine if the relationship between a dependent variable and an independent has been stable over time.

In particular, first, the recursive residuals estimation of the coefficients of the net positions of speculators and the CUSUM of square test will be reviewed and subsequently, a rolling regression analysis will be conducted. The latter will help to determine whether there is a behavioural pattern of the coefficient of the net positions of speculators that could suggest a connection with the size of the EuroFX futures market.

The following graphs show the CUSUM of square test as well as the recursive residuals estimation of the coefficients of the net positions of speculators in the EuroFX futures market.

Figure 6: Estimations of the recursive residuals (left) and the CUSUM of square test (right) of the coefficient of the net positions of speculators, 1999-2010.
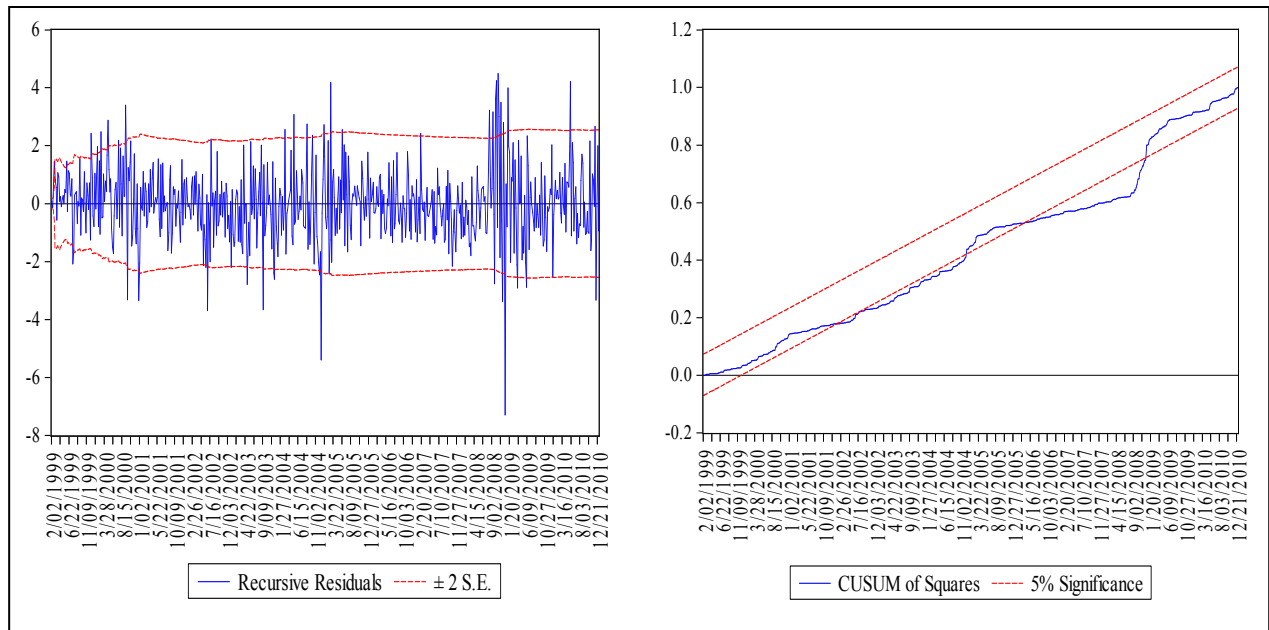
Source: Own estimations using E-views 7

Figure 6 presents the graphs of the estimations of the recursive residuals test (left) as well as the results of the CUSUM of squares test (right) for the coefficient of the net positions of speculators in the EuroFX futures market. As it can be observed from the figure, both tests suggest that in all cases there is visual evidence of instability in the estimated coefficients which means there is

evidence of structural breaks and the coefficient of the net positions of speculators in the EuroFX futures market has not been stable over time.

These results are similar to those reported by Torre and Provorova (2007) for the Mexican peso in the sense that the relationship between weekly percentage changes of the Mexican peso/USD exchange rate and weekly changes on the net positions of speculators in the Mexican peso futures market is also not constant over the period analyzed by these authors.

Torre and Provorova (2007) suggested that the relationship between net positions of speculators and exchange rate has not been constant over time due to an increase in the Mexican peso futures market over the analyzed period. However, these authors did not include a variable representing the size of the futures market in their model. Furthermore, in this thesis it is still needed to review if the structural breaks in the data are due to the size of the EuroFX futures market (measured through the growth rate of the total open interest in the EuroFX futures market) as suggested in previous literature.

B.   Rolling Regressions Analysis

The hypothesis that the instability of the coefficients is associated with the size of the EuroFX futures market (measured through the growth rate of the total open interest in the EuroFX futures market) suggested by Torre and Provorova (2007) was tested by contrasting the dynamics of the total open interest in the EuroFX futures market with the behaviour of the coefficients of a "rolling regression" between weekly percentage changes in the EUR/USD exchange rate and weekly changes in net positions of speculators in the EuroFX futures market. [18]

The logic behind this analysis is that as the EuroFX futures market at the CME increases its size (measured through the total open interest in the EuroFX futures market) it requires a higher variation in the net positions of speculators to induce the same weekly percentage change in the EUR/USD exchange rate, implying that the absolute value of the coefficient of the net positions of speculators must decrease.

For the rolling regression analysis, rolling windows of x observations (where, x = 50, 100, 150, 200, 250 and 300) were used for the period from 1999 to 2010. The results are presented in the following figure.

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[18] A rolling regressions analysis of a time series model is often used to assess the model's stability over time. When analyzing financial time series data using a statistical model, a key assumption is that the parameters of the model are constant over time. However, the economic environment often changes considerably, and it may not be reasonable to assume that a model's parameters are constant. A common technique to assess the constancy of a model's parameters is to compute parameter estimates over a rolling window of a fixed size through the sample. If the parameters are truly constant over the entire sample, then the estimates over the rolling windows should not be too different. If the parameters change at some point during the sample, then the rolling estimates should capture this instability.

Figure 7: Estimations of the coefficients of the net positions of speculators using rolling regressions analysis for each of the different rolling windows, 1999-2010.
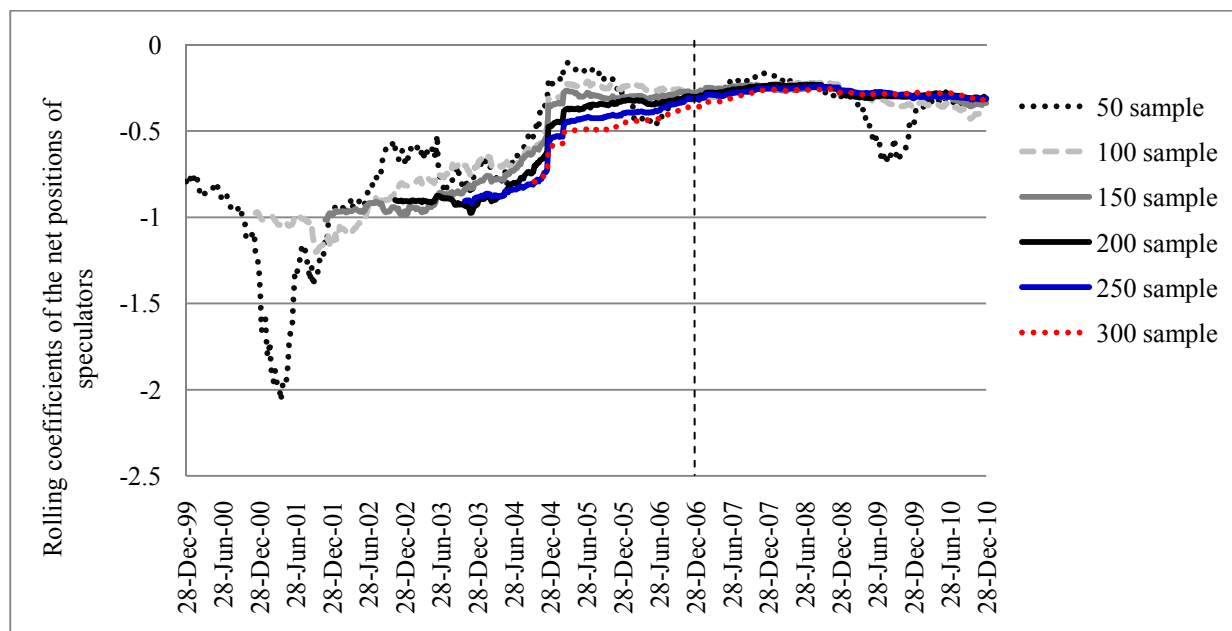
Source: Own estimations using E-views 7

The figure above shows visual evidence that the coefficients of the net positions of speculators in the EuroFX futures market have only been relatively stable since 2007 (without considering the late-2000s financial crisis) where the growth of the EuroFX futures market was relatively stable as well (please see Table 1). Therefore, the hypothesis that the coefficients of the net positions of speculators have not been constant due to an increase in the EuroFX futures market cannot be rejected as suggested by Torre and Provorova (2007).

However, for purposes of comparison, the moving average of the total open interest in the EuroFX futures market (number of contracts) was calculated for each of the rolling windows of x observations[19], and the results are included in the following figure.

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[19] It was necessary to calculate the moving average of the total open interest in the EuroFX futures market in order to smooth out short-term fluctuations and highlight longer-term trends or cycles in the data.

Figure 8: Moving average of the total open interest of the EuroFX futures market (number of contracts) vs. the estimated coefficients of the net positions of speculators using rolling regressions analysis for each of the rolling windows, 1999-2010.*

(a)　50 sample

(b)　100 sample

(c)　150 sample

(d)　200 sample

(e)　250 sample

(f)　300 sample

*Please note that in the graphs above, the solid lines represent the moving average of the total open interest of the EuroFX futures market in number of contracts and the dotted lines represent the estimated coefficients of the net positions of speculators using rolling regressions analysis for each of the rolling windows of x observations.
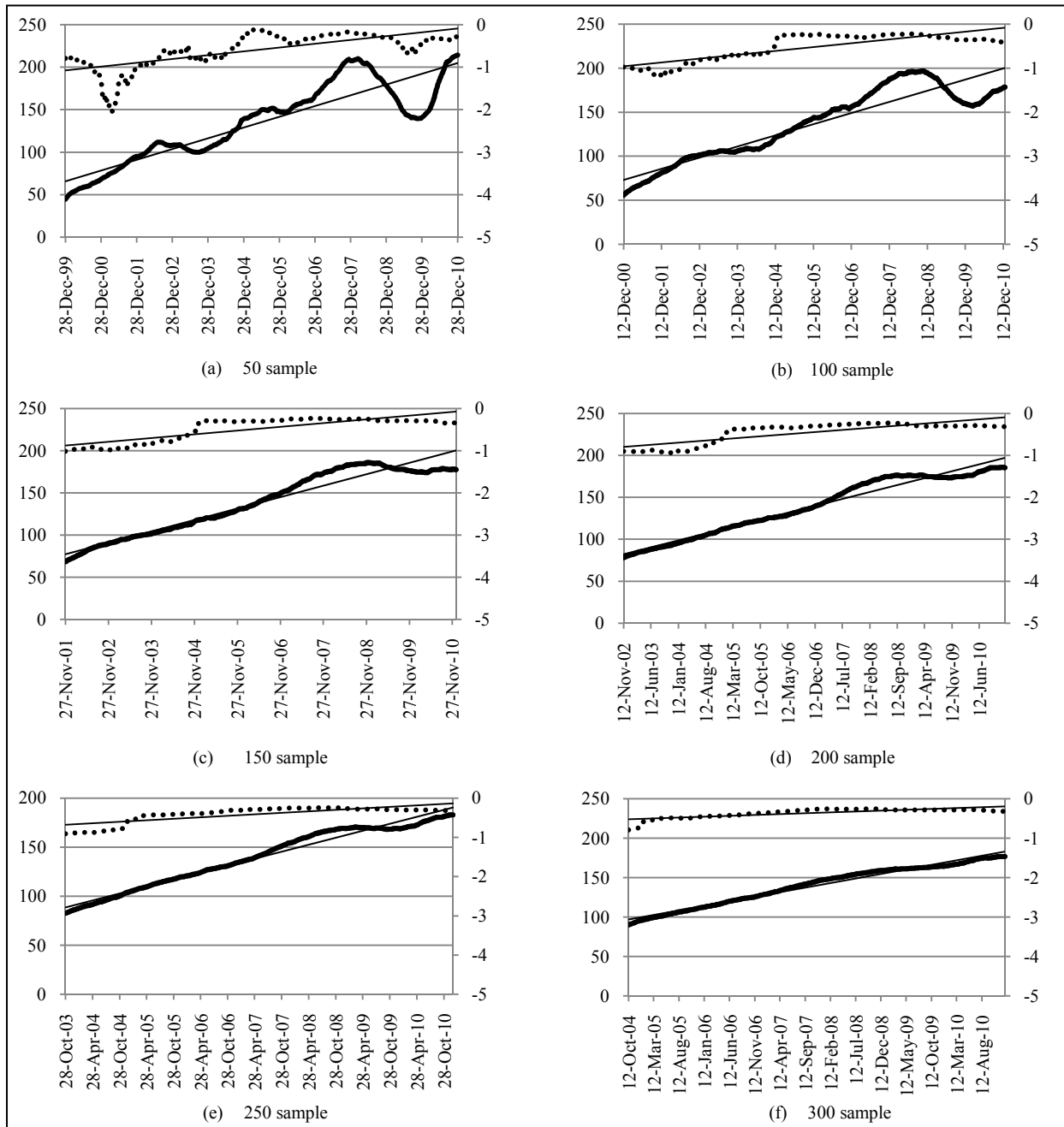*Source: Own estimations*

Figure 8 shows visual evidence that when the size of the EuroFX futures market was considerably high the sensibility of the coefficient of the net positions of speculators reduced in absolute values, particularly in the 50, 100 and 150 rolling windows (graphs a, b and c), as calculated by Torre and Provorova (2007). However, as the number of observations is increased in the rolling window, this evidence decreases (graphs d, e and f).

Additionally, Figure 8 shows that the size of the EuroFX futures market started to decrease considerably due to the late-2000s financial crisis, increasing again the sensitivity of the coefficient of the net positions of speculators in the EuroFX futures market.

Therefore, it is not possible to reject the hypothesis that an increase in the size of the EuroFX futures market has an impact on the sensitivity of the coefficient of the net positions.

The following exercise was to conduct Granger causality tests between the coefficients for a rolling window of x observations and the moving average of total open interest for the same window of x observations. The idea here is that if the "market size" effectively influences over the sensibility of the EUR/USD exchange rate to changes in the net positions of speculators - captured by the estimated coefficient, then the moving average value of total open interest should "cause", in the sense of Granger, the "rolling coefficients".

The results of these tests are presented in Table 4, which shows that only in the rolling window of 50 observations the moving average of total open interest "Granger-cause" the rolling coefficients, but the rolling coefficient does not cause the total open interest. This evidence therefore reinforces graph (a), suggesting again that the hypothesis that a fast growth in the size of the EuroFX futures market affects the sensitivity of the EUR/USD exchange rate to changes in net positions of speculators cannot be rejected.

Additionally, the results included in Table 4 also confirm the hypothesis that as the EuroFX future market is solid and stable (i.e. the growth rate is relatively low) the influence it has in the coefficient of the net positions is lower. Therefore, in the rolling windows of 100, 150, 200, 250 and 300 observations, the moving average of total open interest does not "Granger-cause" the rolling coefficients, and the rolling coefficient does not cause the total open interest. [20]

Table 4: Granger Causality tests, 1999-2010 (Open Interest* vs. Rolling Coefficient)**

Null Hypothesis	Obs.	F-Statistic	Prob.
x = 50	**573**		
"Open Interest" does not Granger cause "Rolling Coefficient"		3.63	0.03
"Rolling coefficient" does not Granger cause "Open Interest"		0.23	0.79
x = 100	**523**		
"Open Interest" does not Granger cause "Rolling Coefficient"		2.09	0.13
"Rolling coefficient" does not Granger cause "Open Interest"		0.89	0.41
x = 150	**473**		
"Open Interest" does not Granger cause "Rolling Coefficient"		1.39	0.25
"Rolling coefficient" does not Granger cause "Open Interest"		3.94	0.02
x = 200	**423**		
"Open Interest" does not Granger cause "Rolling Coefficient"		2.12	0.12
"Rolling coefficient" does not Granger cause "Open Interest"		1.78	0.17
x = 250	**373**		
"Open Interest" does not Granger cause "Rolling Coefficient"		0.88	0.42
"Rolling coefficient" does not Granger cause "Open Interest"		0.67	0.51
x = 300	**323**		
"Open Interest" does not Granger cause "Rolling Coefficient"		0.99	0.37
"Rolling coefficient" does not Granger cause "Open Interest"		0.48	0.62

*Open interest is the moving average of total open interest for each for the rolling windows of x observations.
**Rolling Coefficient is the series of estimated coefficients obtained in the rolling regression analysis for the same window of x observations. *Source: Own estimations using E-views 7.*

The results support evidence that the fast growth in the EuroFX futures market had an impact in the stability of the coefficient of the net positions of the speculators, but when the EuroFX futures market becomes solid and stable (i.e. the growth rate of the total open interest in the

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[20] The only rolling window that presents a "Granger-casual" relation between the rolling coefficients and the total open interest is the one for 150 observations; however, this will not be analyzed further in this report.

EuroFX futures market is relatively stable) then this variable could be used by speculators to forecast changes in the EUR/USD exchange rate on short-terms. The estimates presented here indicate that the higher (lower) the growth rates of the EuroFX futures market (measured through the total open interest) the lowest its effectiveness to predict changes in the EUR/USD exchange rate in short horizons.

C. Is the coefficient of the size of the EuroFX futures market constant over time?

In order to confirm the results obtained in the previous sections, it was decided to re-run *Model (4)* but for different subsamples in order to review if the coefficient of the size of the EuroFX futures market (measured trough the growth rate of the total open interest in the EuroFX futures market) obtained in the total period is significant and different from zero in each subsample.

The following table includes the different subsamples to be estimated:

Table 5: Subsamples to be estimated

Subsample	Period to be estimated
Klitgaard and Weir	January 5, 1999 - May 20, 2003.
Torre and Provorova	January 5, 1999 - November 1, 2005
Fast Growth	January 5, 1999 - December 26, 2006
Stable Growth	January 3, 2007 - December 28, 2010

The first two subsamples were used in order to perform a direct comparison between the results obtained by Klitgaard and Weird (2004) and Torre and Provorova (2007) but including an additional variable (i.e. the growth rate of the total open interest in the EuroFX futures market). For the latter subsamples, it was decided to split the total period estimated in section V.A. using visual evidence provided by Figure 7, where it was found that the coefficients of the net

positions have been stable since 2007 where the growth of the EuroFX futures market was relatively stable (without considering the impact of the late-2000s financial crisis).

Finally, for this analysis it was initially considered to estimate a similar model specification to the one included in *Model (4)*. However, since changes in the interest rate differentials were not statistically significant, it was decided to work with the following specification:

$$\Delta fx_t = \alpha_{1t}\, \Delta sp_t + \alpha_{2t}\, g_t + \varepsilon_t \qquad\qquad\qquad\qquad\qquad \textit{Model (5)}$$

The following table shows the regression results of *Model (5)* for each of the subsamples mentioned above.

Table 6: Regression results of *Model (5)* for each subsample.

Subsample	Variable	Coefficient	Standard. Error	t-Statistic	Probability.
Klitgaard and Weir	Δsp_t	-0.91	0.08	-11.11	0.00
228 obs. $R^2 = 0.39$	g_t	0.55	0.42	1.33	0.19
Torre and Provorova	Δsp_t	-0.52	0.05	-10.08	0.00
356 obs. $R^2 = 0.22$	g_t	0.45	0.40	1.12	0.27
Fast Growth	Δsp_t	-0.45	0.04	-11.36	0.00
417 obs. $R^2 = 0.24$	g_t	0.38	0.37	1.02	0.31
Stable Growth	Δsp_t	-0.30	0.04	-7.60	0.00
208 obs. $R^2 = 0.24$	g_t	2.48	0.83	2.97	0.00

Source: Own estimations using E-views 7

The Breusch-Godfrey tests for all of the above estimations were performed in order to confirm that there is not serial autocorrelation (See Appendix 3). These tests confirmed that neither of the

estimation of *Model (5)* for the different subsamples presents serial autocorrelation problems. In addition, the ARCH tests were performed in order to review the Heteroskedasticity in the residuals (See Appendix 4) and only the estimation of subsample: Stable Growth presents Heteroskedasticity in the residuals. However, this would be corrected further.

Klitgaard and Weir (2004) found a coefficient for changes of the net positions of speculators of -.88 with an R^2 of .36 for a period from January 5, 1999 to May 20, 2003. The estimation of *Model (5)*, including the growth rate of the total open interest in the EuroFX futures market, found a coefficient of -.91 with a R^2 of .39 for the same period analyzed by these authors. Therefore, it could be concluded that adding the growth rate of the total open interest in the EuroFX futures market improves the model estimated by Klitgaard and Weird (2004). However, the coefficient of the growth rate of the total open interest in the EuroFX futures market is not significant during this subsample and the hypothesis that the size of the EuroFX futures market cannot predict changes in the EUR/USD exchange rate during periods of fast growth cannot be rejected.

Torre and Provorova (2007) used a period from January 5, 1999 to November 1, 2005 to analyze the relationship between the Mexican peso/USD exchange rate and the net positions of speculators in the Mexican peso futures market. The estimation of *Model (5),* using the same period estimated by Torre and Provorova (2007), reported a coefficient of -.52 for the net positions of speculators with a R^2 of .22, a similar level as the one obtained during the total period. However, the coefficient of the growth rate of the total open interest in the EuroFX futures market is still not significant. Torre and Provorova (2007) suggested that the relationship between the Mexican peso/USD exchange rate and net positions of speculators has not been constant due to an increase over time in the Mexican peso futures market. However, these authors do not include a variable of "size" in their model and thus it is not possible to directly compare their results with the results included in this thesis due to comparability factors, such as differences in the currency futures market.

The subsample: Fast Growth includes observations from January 5, 1999 to December 26, 2006. The coefficient obtained for changes of the net positions of speculators was -.45 with an R^2 of .24; however, the coefficient of the growth rate of the total open interest in the EuroFX futures market is still not significant confirming that the hypothesis that the size of the EuroFX futures market cannot predict changes in the EUR/USD exchange rate during periods of fast growth cannot be rejected.

Finally, the estimation of *Model (5)* for subsample: Stable Growth (i.e. from January 3, 2007 to December 28, 2010) calculated a coefficient of the net positions of speculators of -.30 with an R^2 of .24 and this time the coefficient of the growth rate of the total open interest in the EuroFX futures market is equal to 2.48, which is significant and different from zero, as expected. However, and as mentioned, the estimation of this subsample presented Heteroskedasticity in the residuals and thus, it was necessary to correct this problem using the White and Newey-West methods. Both methods correct the standard errors in the OLS regressions, eliminating the heteroskedasticity problems in the residuals.

The following table includes the estimations of *Model (5)* for subsample: Stable Growth using the White and Newey-West Methods.

Table 7: Regression results of *Model (5)* for subsample: Stable Growth using the White and Newey-West methods.

White heteroskedasticity-consistent standard errors & covariance				
Variable	Coefficient	Standard. Error	t-Statistic	Probability.
Δsp_t	-0.30	0.03	-9.54	0.00
g_t	2.48	1.19	2.08	0.04
R^2	0.24			
Durbin-Watson	2.02			
HAC Newey-West standard errors & covariance				
Variable	Coefficient	Standard. Error	t-Statistic	Probability.
Δsp_t	-0.30	0.03	-9.40	0.00
g_t	2.48	1.23	2.01	0.04
R^2	0.24			
Durbin-Watson	2.02			

Source: Own estimations using E-views 7

The table shows that the estimated coefficients remain in similar levels to the ones obtained in Table 6, and the coefficient of the growth rate of the total open interest in the EuroFX futures market is significant and different from zero by correcting the heteroskedasticity problems in the residuals.

Therefore, it could be concluded that when the growth rate of the EuroFX futures market is relatively stable it has an impact in predicting changes in the EUR/USD exchange rate in short-term.

VI. *Conclusions and Recommendations*

In recent years the microstructure approach to exchange rate determination has been consolidating as a complement to existing theoretical background to explain the short-term dynamics of this variable. In particular, this approach has helped to rationalize, for example, why changes in net positions of speculators in currency futures contracts are related to a significant fraction of the fluctuations. Although there are some about the effectiveness of the net positions of speculators to determine exchange rate fluctuations due to a possible existence of simultaneous relationship between exchange rates and net positions, the use of this variable as an approximation of speculators' expectations on the economic variable based on both public and private information.

Considering the history of this approach, this thesis analyzes the relationship between changes in net positions of speculators in the EuroFX futures market at the CME and the EUR/USD exchange rate, but includes an additional explanatory variable to the model in order to investigate if the size of the EuroFX futures market (measured through the growth rate of the total open interest in the EuroFX futures market) has an effect in the determination of the EUR/USD exchange rate in short-terms and if this variable is connected to the instability of the coefficient of the net positions of speculators in the EuroFX futures market.

The analysis does not reject the hypothesis of a positive and statistically significant relationship between weekly percentage changes in the EUR/USD exchange rate and the growth rate in the EuroFX futures market when the growth rate is relatively stable, and also suggests that the size of the EuroFX futures market influences the sensitivity of weekly percentage changes in the EUR/USD exchange rate and weekly changes in the net positions of speculators in the EuroFX futures market. Indeed, the evidence shows that the higher the growth rate of the EuroFX futures market, the lower the sensitivity of weekly changes in the EUR/USD exchange rate to changes in

net positions of speculators in the EuroFX futures markets, as suggested by Torre and Provorova (2007).

Therefore, the connection between the size of the EuroFX futures market and the EUR/USD exchange rate could be used by those who use or want to use the framework of microstructure for purposes of forecasting exchange rates, to consider this trait in their efforts.

On the other hand, it is also important to mention that the work presented in this thesis is simply an initial effort to understand the effect of the size of the currency futures market on exchange rate dynamics and, therefore, it is subject to extensions and improvements. For example, to estimate the model proposed in this thesis for other currencies futures market and, thus, to analyse if this relationship applies for the determination of other currencies.

Also, the fact that the size of the EuroFX futures market only influences the EUR/USD exchange rate in periods where the growth rate of the EuroFX future market is relatively stable invites future research to examine what forces are behind the dynamics of this variable, i.e. to document the factors leading to increases or decreases in the size of the EuroFX futures markets. For example, it might be interesting to investigate whether the size of the EuroFX futures market or other currency futures markets depends on economic stability of the respective countries, or internationally traded volumes, or the rate of economic growth, and so on.

Finally, it would be interesting to investigate theoretically and empirically, if the ability of the growth rate of the EuroFX futures market to explain EUR/USD exchange rate fluctuations remains also during periods of financial crisis and, if not, to analyze the reasons behind these results.

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APPENDIX 1: Unit Roots and Cointegration Tests

If an OLS regression is estimated with non-stationary data and its residuals are stationary, then the time series are cointegrated. To test for cointegration first unit root tests should be performed for each of the different data sets. If all data sets are non-stationary and if a linear regression between these data sets produces a stationary error term then the data sets are said to be cointegrated.

Unit root tests

A time series Y_t is stationary if its mean and variance are constant over time and if the value of the covariance between two time periods depends only on the distance or lag between these two periods, and not of the time in which the covariance is calculated. Therefore, a stationary time series Y_t is the one whose statistical properties can be expressed as follows:

Mean: $E(Y_t) = \mu$

Variance: $\text{var}(Y_t) = E(Y_t - \mu)^2 = \sigma^2$

Covariance: $\text{cov}(Y_t, Y_{t+k}) = E[(Y_t - \mu)(Y_{t+k} - \mu)]$

To find out if the time series of the EUR/USD exchange rate (fx_t), the net positions of speculators (sp_t), the differential of interest rates ($i_t - i_t^*$) and the total open interest in the EuroFX futures market (*open interest$_t$*) are stationary, it was necessary to perform unit root tests of Augmented Dickey Fuller (ADF).

For each of the data sets mentioned above, three possible specifications were considered:

None: $\Delta Y_t = \delta Y_{t-1} + u_t$

Constant: $\Delta Y_t = \beta_1 + \delta Y_{t-1} + u_t$

Constant and tendency: $\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + u_t,$

Where, "δ" is the first difference operator. The null hypothesis of the ADF test is that the data set under analysis has a unit root, i.e. "δ" is not significantly different from zero. The ADF tests results are presented in the following table.[21]

Table A1.1: The results of the Augmented Dickey Fuller tests for each data set.

Augmented Dickey Fuller Tests: Null Hypothesis = "Data set" has a unit root				
t-statistic	Specification	Prob*	R^2	D-W
fx_t				
-0.4348	None	0.5259	0.0002	1.9077
-0.9358	Constant	0.7767	0.0014	1.9045
-2.5845	Constant and trend	0.2876	0.0113	1.9007
sp_t				
-2.8504	None	0.0043	0.0128	1.8412
-3.2866	Constant	0.0159	0.0170	1.8324
-3.2763	Constant and trend	0.0711	0.0173	1.8330
$(i_t - i_t^*)$				
-1.3787	None	0.1562	0.2034	2.0534
-1.3362	Constant	0.6141	0.2036	2.0536
-1.2532	Constant and trend	0.8977	0.2036	2.0537
open interest$_t$ (number of contracts)				
0.0658	None	0.7034	0.4621	2.0078
-2.0817	Constant	0.2523	0.4666	2.0098
-3.1928	Constant and trend	0.0868	0.4722	2.0237

Source: Own estimations using E-views 7

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[21] For basic presentations on unit root tests, please see Gujarati (1999) and Kennedy (2004).

The table above shows that the t-statistics of the EUR/USD exchange rate and the differential of interest rates do not exceed the critical values at 1%, 5% and 10%, indicating that the coefficient "δ" is not significantly different from zero for the three forms specified. This means that the EUR/USD exchange rate and the differential of interest rates are non-stationary.

For the net positions of speculators only in the first two specifications, the t-statistics exceed all the critical values at 1%, 5% and 10%, while for the latter specification, the null hypothesis that sp_t has a unit root cannot be rejected. In addition, the t-statistics of the total open interest in the EuroFX futures market do not exceed all the critical values in the first two specifications indicating that the data set of total open interest in the EuroFX futures market is non-stationary.

Therefore, it could be concluded that the four data sets have a unit root and thus, they are non stationary in their levels, indicating that it is necessary to review if the data sets are cointegrated.

Engle-Granger test for Cointegration

To test for cointegration between two or more non-stationary time series, it simply requires running an OLS regression, saving the residuals and then running the ADF test on the residual to determine if the error term has a unit root.

If the error term has a unit root (.e. $\hat{\varepsilon}_t \sim I(1)$) then the regression is spurious and there is no long-run equilibrium between the data sets. However, if the error term is stationary (i.e. $\hat{\varepsilon}_t \sim I(0)$) then the data sets are cointegrated. To get $\hat{\varepsilon}_t$, first it was necessary to estimate the following equation:

$fx_t = c + \alpha_{1t}\, sp_t + \alpha_{2t}\, (i_t - i_t{}^*) + \alpha_{3t}\, open\ interest_t + \varepsilon_t$ *Equation A.1*

The OLS regression results of *Equation A.1* are included in the following table:

Table A1.2: Regression results of *Equation A.1*: January 5, 1999 to December 28, 2010.

Variable	Coefficient	Standard. Error	t-Statistic	Probability.
C	1.11	0.01	93.49	0.00
sp_t	-0.00	0.00	-0.28	0.78
$(i_t - i_t^*)$	0.00	0.00	0.47	0.64
open interest$_t$	-0.00	0.00	-22.00	0.00
R^2	0.46			
Durbin-Watson	0.09			

Source: Own estimations using E-views 7

And the residuals of the regression of *Equation A.1* are included in the following figure.

Figure A1: Residuals obtained from the OLS regression of *Equation A.1:* January 5, 1999 to December 28, 2010.
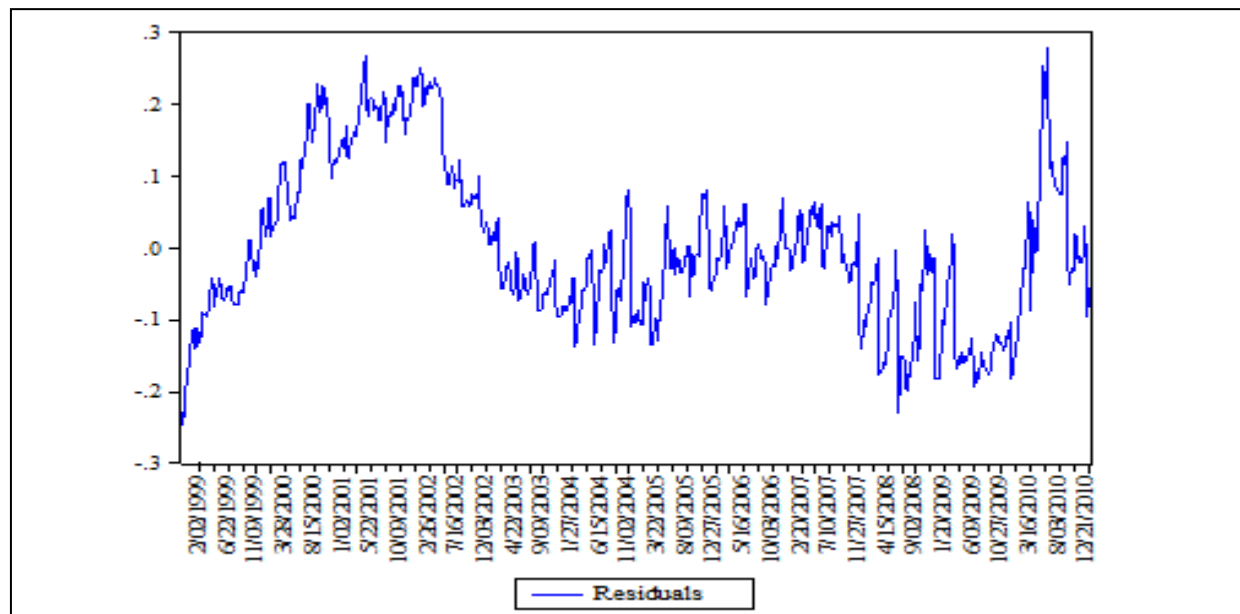
Source: Own estimations using E-views 7

Then, the residuals obtained from *Equation A.1* were tested using the ADF test in order to determine if the error term has a unit root. The following table includes the results of the ADF test.

Table A1.3: The results of the Augmented Dickey Fuller tests for the residuals, "$\hat{\varepsilon}_t$".

Augmented Dickey Fuller Tests: Null Hypothesis = $\hat{\varepsilon}_t$ has a unit root			
t-statistic	Specification	R^2	D-W
$\hat{\varepsilon}_t$			
-4.2244	None	0.02772	2.1453
-4.2214	Constant	0.02781	2.1455
-4.7850	Constant and trend	0.03610	2.1408

Source: Own estimations using E-views 7

However, it is not correct to use the critical values provided by the ADF test. Instead, it was necessary to calculate the Engle-Granger critical values. To calculate the Engle-Granger critical values the following formula was used:

$$C(p,T,N) = \beta_\infty + \beta_1 T^{-1} + \beta_2 T^{-2}$$

Where, "p" denotes the percent quantile or "size" of one-tail test, "T" refers to the number of observations in the unit test regression, "N" means the number of non-stationary series for which null of non-cointegration is being tested, "β_∞" is the estimated asymptotic critical values presented by Mackinnon (1990)[22], "β_1" is the coefficient on T^{-1} and "β_2" is the coeficient on T^{-2} in the response surface regression obtained by Mackinnon (1990).[23]

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[22] Please see Mackinnon (1990).
[23] Ibidem

Table A1.4: Engle-Granger critical values.

	Size	β_∞	β_1	β_2	Critical Value $(\beta_\infty + \beta_1 T^{-1} + \beta_2 T^{-2})$
Engle-Granger Critical Values N = 4 and T= 626					
	1% level	-4.6493	-17.188	-59.20	**-4.622**
No trend	5% level	-4.1000	-10.745	-21.57	**-4.083**
	10% level	-3.8110	-8.317	-5.19	**-3.798**
	1% level	-4.9695	-22.504	-50.22	**-4.933**
With Trend	5% level	-4.4294	-14.501	-19.54	**-4.406**
	10% level	-4.1474	-11.165	-9.88	**-4.130**

Source: Own estimations using E-views 7

Using the t-statistics included in table A1.3 and the Engle-Granger critical values included in table A1.4, it could be concluded that the t-statistics do not exceed the Engle-Granger critical values at the levels of 5% and 10%, indicating that the error term is non-stationary and thus the data sets are not cointegrated.

However, in order to confirm these results, the Cointegration Test – Engle-Granger was performed. The results of the Cointegration Test are included in the following table.

Table A1.5: Cointegration Test - Engle-Granger of the OLS regression of *Equation A.1*.

Cointegration Test - Engle-Granger
Null hypothesis: Series are not cointegrated

	Value	Prob.*
Engle-Granger tau-statistic	-2.502778	0.6737
Engle-Granger z-statistic	-13.84322	0.5947

Source: Own estimations using E-views 7

The table above shows that the data sets included in *Equation A.1* are not cointegrated. Therefore, it could be concluded that there is no long-run equilibrium and, as a result, there is no need to include an error correction term in *Model (4)*.

APPENDIX 2: Granger Causality test

The Granger Causality test is used to estimate whether changes in a variable will have an impact on changes in other variables. For example, to estimate if changes in the weekly percentage changes in the EUR/USD exchange rate (Δfx_t) will have an impact in the net positions of speculators in the EuroFX futures market (Δsp_t) it is necessary to use the Granger Causality test.

The Granger Causality test consists of estimating, simultaneously, a system of two equations for two variables, in this case Δfx_t and Δsp_t. In the first equation Δfx_t is expressed in terms of previous variations, both of the EUR/USD exchange rate as of previous variations of the net positions of speculators. The second equation is an identical specification of the first equation, but using as dependent variable changes in net positions of speculators, i.e. Δsp_t. As a result, the following system of two equations is obtained:

$$\Delta fx_t = \alpha_0 + \alpha_1 \Delta fx_{t-1} + \alpha_2 \Delta fx_{t-2} + \ldots + \alpha_L \Delta fx_{t-L} + \beta_1 \Delta sp_{t-1} + \beta_2 \Delta sp_{t-2} + \ldots + \beta_L \Delta sp_{t-L} + \upsilon_t$$

$$\Delta sp_t = \alpha_0 + \alpha_1 \Delta sp_{t-1} + \alpha_2 \Delta sp_{t-2} + \ldots + \alpha_L \Delta sp_{t-L} + \beta_1 \Delta fx_{t-1} + \beta_2 \Delta fx_{t-2} + \ldots + \beta_L \Delta fx_{t-L} + \varepsilon_t$$

Where, Δfx_t represents the weekly percentage change in the EUR/USD exchange rate and Δsp_t is the weekly change in the net positions of speculators in the EuroFX futures market. The subscript "t" specifies the week of those observations, while the subscript "L" indicates the number of lags.

The regressions are performed with all possible pairs of Δfx_t and Δsp_t. Afterward, the test calculates the F-statistic for the following null hypothesis:

H_0: $\beta_1 = \beta_2 = \beta_3 = \ldots = \beta_L = 0$,

The null hypothesis states that variations in the net positions of speculators (Δsp_t) do not Granger cause variations in the EUR/USD exchange rate (Δfx_t) in the first equation, and that variations in the EUR/USD exchange rate (Δfx_t) do not Granger cause changes in net positions of speculators (Δsp_t) in the second equation. [24]

Traditionally, it is recommended to use a significant amount of lags to analyze the relevance of all the previous information, but furthermore, the number of lags has to correspond to the longest period during which it is believed that a variable can help in predicting another one. Since this report is analyzing the short-term relationship between these two variables, only one lag was considered. [25]

Table A2 presents the results of Granger causality tests with one lag for each of the variables included in *Model (4)*.

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[24] In saying that changes in the net positions of speculators "Granger cause" variations in the EUR/USD exchange rate does not imply that the second variable is, in effect, a result of the first one, but a variation in the first variable occurred before the second one. Therefore, some authors suggest that evidence of Granger causality tests do not actually deal with causality but with precedence, which is neither a necessary, nor a sufficient condition for causality. Please see Learner (1985) and Hoover (1988).

[25] The results did not change including more lags.

Table A2: Granger Causality tests, January 5, 1999 to December 28, 2010

Granger Causality Test – 1 Lag Null Hypothesis	Obs.	F-Statistic	Prob.
"Δfx_t" does not Granger cause "Δsp_t"	624	10.74	0.00
"Δsp_t " does not Granger cause "Δfx_t"		0.01	0.90
"Δfx_t" does not Granger cause "$\Delta(i_t - i_t^*)$"	624	0.12	0.73
"$\Delta(i_t - i_t^*)$" does not Granger cause "Δfx_t"		0.11	0.74
"Δfx_t" does not Granger cause "g_t"	624	0.00	0.97
"g_t" does not Granger cause "Δfx_t"		0.06	0.80

Source: Own estimations using E-views 7

The table above shows that for the total period (from January 5, 1999 to December 28, 2010) there is evidence that the causality between net positions of speculators and the EUR/USD exchange rate runs one way, from weekly percentage changes in the EUR/USD exchange rate (Δfx_t) to weekly changes in the net positions of speculators (Δsp_t), but not the other way, and, as a result, the coefficient of the net positions of speculators obtained in *Model (4)* could be questionable.

Nevertheless, it is important to remember that this thesis is focussing mainly on the relationship between the size of the EuroFX futures market, "g_t", and the EUR/USD exchange rate in order to analyse if the growth rate of the EuroFX futures market could be used to forecast changes in the EUR/USD exchange rate in short horizons. According to table A2 there is no evidence of a Granger casual relationship in any sense between the size of the EuroFX futures market and the EUR/USD exchange rate and thus, the use of g_t as an exogenous variable in *Model (4)* as well as its coefficient should not be questionable.

APPENDIX 3: Breusch-Godfrey Serial Correlation LM Test

The Breusch-Godfrey Serial Correlation LM Test is specified in order to analyze whether higher order autocorrelation exists or not, thus in the alternative hypothesis it is necessary to include more general specifications than in the first-order autoregressive model, and that can be generalized to any specification ARMA (p, q).

The null hypothesis is considered now that there is no autocorrelation, while the alternative hypothesis specifies a particular pattern of autocorrelation.

For example, an autoregressive model of order p, i.e. $u_t = \varphi_1 u_{t-1} + \varphi_2 u_{t-2} + ... + \varphi_p u_{t-p} + \varepsilon_t$

Where the null hypothesis would be formulated with the assumption of no autocorrelation, i.e. that all the autoregressive coefficients are equal to zero

$H_0 = \varphi_1 = \varphi_2 = ... = \varphi_p = 0$

The test for error autocorrelation is based on an auxiliary regression involving the residuals from the original regression, regressed on a set of lagged residuals (up to order p) and all the variables which were used in the initial regression.

Essentially the test analyzes if the coefficients of the lagged residuals in the auxiliary regression are all zero.

The results of the Breusch-Godfrey Serial Correlation LM Test are reported in two forms. In the first form, the test statistic is calculated as TR^2, where T is the number of observations in the

original regression and R^2 is the R-squared in the auxiliary regression. This has a Chi-square ($\chi^2_{(p)}$) distribution for p restrictions (lags). If TR_2 is smaller (higher) than $\chi^2_{(p)0.05}$ then the null hypothesis of no autocorrelation (at the 5% significance level) can be accepted (rejected). In the second form, the test statistic is calculated as $F_{cal} = (T-k-1-p)R^2/p(1-R^2)$, where k is the number of regressors in the original equation. This has an $F(p,T-k-1-p)$ distribution. If the F_{cal} is smaller (higher) than the $F_{tables,0.05}$ then the null hypothesis of no autocorrelation (at the 5% significance level) can be accepted (rejected).

The following table shows the results of the Breusch-Godfrey Serial Correlation LM Test of Model (4) for the total period.

Table A3.1: Breusch-Godfrey test of *Model (4)*: January 5, 1999 to December 28, 2010.

Breusch-Godfrey Serial Correlation LM Test: H_0 = No Serial Autocorrelation 2 lags			
F-statistic	0.797451	Prob. F(2,620)	0.4509
Obs*R-squared	1.353647	Prob. Chi-Square(2)	0.5082

Source: Own estimations using E-views 7

The table above shows the serial correlation LM test results for *Model (4)* with 2 lags. The results of the Breusch-Godfrey Serial Correlation LM Test strongly accept the null hypothesis of no serial correlation.

In addition, the Breusch-Godfrey Serial Correlation LM Tests were performed for the different subsamples used in this thesis. The following table shows the results of the Breusch-Godfrey Serial Correlation LM Tests for these subsamples.

Table A3.2: Breusch-Godfrey test of *Model (5)* for each of the different subsamples.

Breusch-Godfrey Serial Correlation LM Test:
H_0 = No Serial Autocorrelation
2 lags

Klitgaard and Weir

F-statistic	0.071260	Prob. F(2,224)	0.9312
Obs*R-squared	0.061032	Prob. Chi-Square(2)	0.9699

Torre and Provorova

F-statistic	0.133980	Prob. F(2,352)	0.8747
Obs*R-squared	0.239457	Prob. Chi-Square(2)	0.8872

Fast Growth

F-statistic	0.216376	Prob. F(2,413)	0.8055
Obs*R-squared	0.390444	Prob. Chi-Square(2)	0.8227

Stable Growth

F-statistic	0.512711	Prob. F(2,204)	0.5996
Obs*R-squared	0.947094	Prob. Chi-Square(2)	0.6228

Table A.3.2 shows the serial correlation LM test results for *Model (5)* for the different subsamples with 2 lags. The results of the Breusch-Godfrey Serial Correlation LM Tests strongly accept the null hypothesis of no serial correlation for all of the different subsamples.

APPENDIX 4: Heteroskedasticity

The assumption of homoscedasticity in the variances of the error terms is a key assumption for OLS model as a best linear unbiased estimator. This assumption states that the error term, u_i has a constant variance. This assumption could be expressed as follow:

$$\text{Var}\,(u_i|\Delta sp_i,\, \Delta(i_t - i_t^*),\, g_t) = E\,[u_i - E(u_i) \mid \Delta sp_i,\, \Delta(i_t - i_t^*),\, g_t]^2$$

$$= E(u_i^{\,2} \mid \Delta sp_i,\, \Delta(i_t - i_t^*),\, g_t)$$

$$= \sigma^2$$

This is that the variance of u_i for different values of the exogenous variables (conditional variance of u_i) is a positive constant number equal to σ^2. Additionally, this assumption means that populations of changes in the EUR/USD exchange rate, Δfx, for various values of changes in net positions of speculators, Δsp, the interest rate differential, $\Delta(i_t - i_t^*)$ and the growth rate of the EuroFX futures market, g_t, have the same variance. If the conditional variance of Δfx is not constant, then the OLS regression model will present heteroskedasticity in the residuals, i.e.

$$\text{Var}\,(u_i|\Delta sp_i,\, \Delta(i_t - i_t^*),\, g_t) = \sigma i_i^{\,2}\,,$$

Where, the subscript "i" indicates that the population variance of Δfx is not constant. In general, the problems of heteroskedasticity are observed more in cross-sectional data, rarely on time series.

Therefore, it was decided to perform the ARCH test (Engle, 1982) for the period from January 5, 1999 to December 28, 2010 (see Table A4.1). The F-statistic indicates that the null hypothesis should be rejected, at a 99% confidence level.

Table A4.1: Heteroskedasticity Tests of *Model (4)*: January 5, 1999 to December 28, 2010.

Heteroskedasticity Test - ARCH			
H_0 = No Heteroskedasticity			
1 lag			
F-statistic	7.970591	Prob. F(1,622)	0.0049
Obs*R-squared	7.895049	Prob. Chi-Square(1)	0.0050

Source: Own estimations using E-views 7

This result indicates that the variance of the errors is not constant and therefore does not meet the assumption of homoscedasticity. This implies that the estimated coefficients are not the ones of minimum variance. To correct the problem of heteroskedasticity in the model it was necessary to include and EGARCH term in *Model (4)*.

The EGARCH model was proposed by Nelson (1991). Nelson and Cao (1992) argue that the nonnegativity constraints in the linear GARCH model are too restrictive. The basic GARCH model assumes that positive and negative shocks of the same absolute magnitude will have the identical influence on the future conditional variances. In contrast, the asymmetry effect is a feature of many financial time series. The asymmetry effect, also known as "leverage" effect, refers to the characteristic of time series on asset prices that an unexpected drop tends to increase volatility more than an unexpected increase of the same magnitude. Therefore, in the EGARCH model, the conditional variance, σ^2_t, is an asymmetric function of lagged disturbances, ε_{t-i}, as follows:

$$\ln(h_t) = w + \sum_{i=1}^{q} \propto_i g(z_{t-i}) + \sum_{j=1}^{p} \gamma_j \ln(h_{t-j})$$

Where,

$$g(z_t) = \theta z_t + \gamma[|z_t| - E|z_t|]; \text{ and}$$

$$z_t = \varepsilon_t / \sqrt{h_t}$$

The coefficient of the second term in $g(z_t)$ is set to be 1 ($\gamma=1$) in our formulation. Note that $E|zt| = (2/\pi)^{1/2}$ if $z_t \sim N(0,1)$. The properties of the EGARCH model are summarized as follows:

- The function $g(z_t)$ is linear in z_t with slope coefficient $\theta+1$ if z_t is positive while $g(z_t)$ is linear in z_t with slope coefficient $\theta-1$ if z_t is negative

- Suppose that $\theta = 0$. Large innovations increase the conditional variance if $|z_t|$ - $E|z_t| > 0$ and decrease the conditional variance if $|z_t|$ - $E|z_t| < 0$

- Suppose that $\theta < 0$. The innovation in variance, $g(z_t)$, is positive if the innovations z_t are less than $(2/\pi)^{1/2}$ / $\theta-1$. Therefore, the negative innovations in returns, ε_t, cause the innovation to the conditional variance to be positive if θ is less than 1.

The results of the corrected model are presented in Table 3 of this report while Table A4.2 includes the ARCH test of the corrected model (including the EGARCH term).

Table A4.2: Heteroskedasticity Tests of *Model (4)* including an EGARCH term: January 5, 1999 to December 28, 2010.

Heteroskedasticity Test - ARCH H_0 = No Heteroskedasticity 1 lag			
F-statistic	0.014203	Prob. F(1,622)	0.9052
Obs*R-squared	0.014248	Prob. Chi-Square(1)	0.9050

Source: Own estimations using E-views 7

The table above shows that the heteroskedasticity in the residuals has been modelled successfully.

In addition, the ARCH tests were performed for the different subsamples used in this thesis. The following table shows the results of the ARCH test for these subsamples.

Table A4.3: Heteroskedasticity Tests of *Model (5)* for each of the different subsamples.

Heteroskedasticity Test - ARCH
H_0 = No Heteroskedasticity
1 lag

Klitgaard and Weir			
F-statistic	0.371970	Prob. F(1,225)	0.5425
Obs*R-squared	0.374657	Prob. Chi-Square(1)	0.5405
Torre and Provorova			
F-statistic	0.988482	Prob. F(1,353)	0.3208
Obs*R-squared	0.991307	Prob. Chi-Square(1)	0.3194
Fast Growth			
F-statistic	1.585154	Prob. F(1,414)	0.2087
Obs*R-squared	1.586737	Prob. Chi-Square(1)	0.2078
Stable Growth			
F-statistic	4.063056	Prob. F(1,205)	0.0451
Obs*R-squared	4.022961	Prob. Chi-Square(1)	0.0449

Source: Own estimations using E-views 7

These results indicate that for the subsample: Stable Growth, the variance of the errors is not constant and therefore does not meet the assumption of homoscedasticity. This implies that the estimated coefficient of the growth rate in the total open interest is not the minimum variance. To correct the problem of heteroskedasticity in the model it was necessary to use the White and Newey-West methods. These results are included in Table 7.