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High frequency arbitrage in foreign exchange markets

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Abstract

In this thesis we investigate the efficiency of the FX market by searching for triangular and multi-currency arbitrage opportunities from 1997 to 2007. We show that both triangular and multi-currency arbitrage opportunities exist in the FX market. Further, we find evidence of a decreasing trend in relation to the total number of arbitrage opportunities per year. In most cases we see a decrease of over 50 % and all the way up to 80 – 90 %. Finally, we use actual unmasked volume data to investigate the profit potential of these arbitrage opportunities. Our results show the same negative tendency, i.e. the profit potential has been reduced sharply in recent years with a decrease of over 50 % for all triangular roundtrips, and as high as 99 % for multi-currency roundtrips.

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1.0 Introduction

Over the last decade the term known as high frequency trading (HFT) has emerged. Recently it has drawn significantly public attention due to an equity market crash in the United States. This crash, called the Flash Crash, happened on Thursday May 6, 2010 (Gomber et al 2011). Research of HFT have mainly been conducted in relation to the equity market, we however will investigate this topic in the perspective of the foreign exchange (FX) market. Similar to the equity market, the FX market has numerous features that make it attractive to HFT. After being prominent in the equity market, HFT has now increased its presence in the FX market. In our opinion this is an important aspect to investigate, due to the fact that one can expect to see continuing interest and extensive future growth in this type of FX trading. A wider use of electronic trading in FX, both regarding the broker – dealer market and at the retail level, facilitates the development of this trend. Contrary to other markets HFT in FX operates on low margins, small order sizes with high volume and low latency. Further, this type of FX trading usually has a short holding period, i.e. less than five seconds (Bank for International Settlements 2011).

Today the FX market is the largest financial market in terms of the number of market participants and volume of transactions in the world. It is open 24 hours a day, five days a week (Bank for International Settlements 2010). For just about any hour of any business day this market is acknowledged to be both deep and liquid, especially for major currency pairs. Even though HFT has been most prevalent among the major currency pairs, it has the potential to spread to other traded currencies, including some emerging market currencies (Bank for International Settlements 2011).

In both theoretical and empirical literature, the FX market is assumed to be efficient, due to the size and liquidity. This implies that risk free arbitrage opportunities, when we account for transaction costs, should not exist. This reasoning can be explained by the law of one price. The law of one price states that all identical assets will have the same price no matter where the asset is traded, or how the asset is created. Further, Grossman and Stiglitz (1976, 1980) introduced the well-known theory “arbitrage paradox”. The arbitrage paradox states that if arbitrage opportunities do not exist, market participants will not have

any incentives to observe the market, which would lead to short-term arbitrage opportunities. Once these opportunities are acknowledged, short-term arbitrage traders will take advantage of them, and end the circuit by eliminating them.

In this thesis we will investigate risk free arbitrage opportunities in the FX market. With high frequency data ranging from 1997 to 2007 our main objective will be to determine if risk free arbitrage opportunities do exist, and count the occurrence. The form of arbitrage we will search for is triangular and multi-currency arbitrage. We define multi-currency arbitrage as a roundtrip of four or more currency pairs. Using a high frequency database we examining the following currency pairs; DEM/CHF, DEM/JPY, EUR/CHF, EUR/GBP, EUR/JPY, EUR/USD, GBP/DEM, GBP/USD, USD/CHF, USD/DEM and USD/JPY. These currency pairs make us able to search for the following eight triangular and multi-currency roundtrips;

- 1) USD/DEM – DEM/CHF – USD/CHF
- 2) USD/DEM – DEM/JPY – USD/JPY
- 3) GBP/USD – USD/DEM – GBP/DEM
- 4) EUR/GBP – GBP/USD – EUR/USD
- 5) EUR/USD – USD/JPY – EUR/JPY
- 6) EUR/USD – USD/CHF – EUR/CHF
- 7) EUR/GBP – GBP/USD – USD/JPY – EUR/JPY
- 8) EUR/GBP – GBP/USD – USD/CHF – EUR/CHF

For each transaction, the corresponding reverse roundtrip will be included, resulting in 16 roundtrips in total. Further, we will find out if the total number of arbitrage opportunities per year has decreased or increased from 1997 to 2007. Furthermore, we will calculate the profit potential in relation to arbitrage opportunities. Our profit calculations will be from 2003 to 2007, due to lack of unmasked volume in the previous years.

In the FX literature only a handful of researchers have investigated arbitrage opportunities in relation to HFT. In 2002 Aiba et al. investigated triangular arbitrage for two months in 1999 of the following currency pairs USD/JPY, EUR/USD and EUR/JPY. They find that arbitrage opportunities existed for up to 90 minutes in each trading day, i.e. 6.4 % of the time. Further, in 2008 Marshall et

al. examined triangular arbitrage in 2005 for three roundtrips. The first roundtrip is EUR/USD, USD/CHF and EUR/CHF, the second is EUR/GBP, GBP/USD and EUR/USD, and the last is EUR/USD, USD/JPY and EUR/JPY. They show that triangular arbitrage opportunities do exist for these particular roundtrips, and that arbitrage profit increases as trading activity decreases. In the same year, Fenn et al. investigated triangular arbitrage opportunities for EUR/USD, USD/CHF and EUR/CHF along with EUR/USD, USD/JPY and EUR/JPY. They found evidence that arbitrage opportunities do exist. However, the majority of opportunities persisted less than one second and with a profit potential of one basis point. The most recent paper investigating triangular arbitrage is a working paper by Ito et al (2012). They examine EUR/USD, USD/JPY and EUR/JPY in a 12 year time period ranging from 1999 to 2010. They find that risk free arbitrage opportunities do exist. Contrary, to Marshall et al, the majority of opportunities tend to occur when markets are active and liquid. Further, they show that the total number and duration of opportunities decreases throughout their time period.

Moreover, in this thesis we are contributing to the literature by investigating triangular arbitrage with different currency pairs, adding multi-currency arbitrage, and providing weekly details, both with respect to opportunities and profits potential. As an arbitrage strategy, triangular arbitrage takes the advantage of three exchange rates among three currencies. Suppose that we exchange one euro to some amount of Japanese yen, exchange that amount of Japanese yen to some amount of US dollar, and then convert that amount of US dollar back to euro. Then how much euro do we have? The same principle applies for multi-currency arbitrage by adding one or more currency pairs. We find that there are arbitrage opportunities, i.e. we have more than one euro. For all 16 roundtrips we find that there exist arbitrage opportunities, regardless of which year we detected the possibility. Further, we show that the total number of arbitrage opportunities, i.e. the frequency of occurrence, decreases from 1997 to 2007. Regarding profit potential, our results show that it declines sharply from 2003 to 2007 for each of the 16 roundtrips. Each roundtrip is characterized by having their lowest respective profit in 2007, in some cases close to zero.

The rest of the thesis is organized as follows. In section two we will address applicable background information of the FX market, define the term HFT and

discuss market size and liquidity in conjunction to both the FX market in general and HFT. Further, we will provide a brief overview of the most traded currencies and active market participants in the FX market. Moreover, we will review the history of changes in the FX market in order to gain a better understanding of HFT. Lastly, we will explain the EBS platform.

Third section reviews previous research done on subjects which are of relevance to our thesis. Since most research is focused in the equity market, we will first review papers that include HFT effects in the equity market. Further, we will address papers that investigate HFT effects in the FX market. The third and most important part will be papers that investigate arbitrage in the FX market. In this part research articles by Aiba et al. (2002), Marshall et al. (2008), Fenn et al. (2008) and Ito et al. (2012) will be especially important.

In section four we describe the data material used in our research. In detail, we explain part one, two and three of our dataset. Further, we provide an example of how quotes are recorded for each set.

Following, in section five, will we discuss the methodology. As a starting point we use the four articles discussed above. Further, we address how we calculate triangular arbitrage and multi-currency arbitrage, as well as our assumptions.

Furthermore, in section six, we will present our results and analysis for each roundtrip and their respective time period. We will provide an analysis based on both with and without volume. From 2003 to 2007 potential profit calculations will be discussed in relation to both triangular and multi-currency roundtrips.

We summarize and conclude our results in seven eight by arguing that triangular and multi-currency arbitrage opportunities do occur in HFT, that they do decrease throughout the years and that it is possible to earn profit when taking transaction cost into account.

Further research will be discussed in section eight, while a bibliography will be provided in section nine.

2.0 Background information

2.1 The foreign exchange market

The FX market is a market for trading currencies which is globally dispersed, i.e. it determines the values of different currencies. In order to keep this market globally decentralized financial centres, that purposes as anchors, connect a wide range of different buyers and sellers. As we will show below the main participants in this market are the larger international banks (The Economist 2005).

2.1.1 Market size and liquidity

The FX market is the world's largest and most liquid financial market. This uniqueness derives from the huge trading volumes in this asset class. Today, London, New York and Tokyo are commonly referred to as the top financial centres, which make it possible for this market to have continuous operations, i.e. to be open 24 hours a day, five days a week. Further, during the two last decades the global market turnover has been continuously growing, with the exception of the period from 1998 until 2001. This decline can be explained by the introduction of the euro.

According to the Bank for International Settlements (BIS) the global market turnover has grown with approximately 20 % from April 2007 until April 2010. The average daily turnover is estimated at 4.0 trillion USD as of April 2010 compared to 3.3 trillion USD as of April 2007. This enormous increase in turnover is more or less due to the increased activity of HFT and the emergence of retail investors (Bank for International Settlements 2010).

2.1.2 What is high frequency trading in foreign exchange?

Due to advances in information technology and the spread of electronic trading HFT is now a growing trend in the FX market. HFT is the use of a computer driven investment strategy whereby futures, options, equities, currencies and all other financial instruments that is capable in electronic trading are held for a very short period, usually seconds or milliseconds (Brogaard 2011b). In order to capture a fraction of a currency unit on every trade, high frequency traders (HFTs) are in and out of positions thousands or tens of thousands of times each trading day (Huffington post 2010).

2.1.3 Market size and activity of high frequency trading

Direct measurements of HFT activity through survey data in foreign exchange turnover is impossible to obtain. The main reason for this is that firms who engage in HFT tend to gain access to dealers by the use of prime brokers. Since the dealers only report trades with prime brokers it is impossible to measure trades that generates HFT flows and to identify HFT versus non – HFT activity within automated trades (Bank for International Settlements 2011).

However, given the known characteristics of HFT participants, it is possible to obtain indirect measurements of HFT activity through major electronic platforms, i.e. through EBS and/or Reuters. First of all, we know that the trades are electronically executed. Second, HFTs tend to emphasize the most liquid pairs. Lastly, since most servers are situated in the United States and the United Kingdom, we know that their activity is geographically concentrated (Bank for International Settlements 2011).

As mentioned earlier the market turnover in the FX market has risen enormously in recent years. The BIS triennial survey of 2010 indicates that HFT is one of the main drivers behind this growth. With a growth of almost 700 billion USD from April 2007 until April 2010, the survey suggests that about three quarters of the overall growth came from the rise in spot turnover. This growth was registered mostly in the United Kingdom, and to a smaller degree in the United States (King and Rime 2010).

Further, if we break down these estimates by execution method, we find evidence suggesting that trading on multi-bank platforms drove almost half of the spot turnover increase in the United States. This, however, is not remarkable as most HFT firms in the United States use multi-bank electronic communications networks (ECNs). Contrary, in the United Kingdom this growth in turnover can be explained by electronic brokers. It accounted for almost one third of the turnover growth. Neither this is a surprise since both Reuters and EBS are based in London, and are widely used by HFT firms (Bank for International Settlements 2011). As a result of this massive growth the FX market is now entering into a new era with HFTs as the most active market participant. Furthermore, this growth will most likely be even larger in the future with new technology to come.

2.1.4 Overview of the most traded currencies

Rank	Currency	Symbol	% daily share (April 2010)
<i>1</i>	United States dollar	USD (\$)	84.90%
<i>2</i>	Euro	EUR (€)	39.10%
<i>3</i>	Japanese yen	JPY (¥)	19.00%
<i>4</i>	Pound sterling	GBP (£)	12.90%
<i>5</i>	Australian dollar	AUD (\$)	7.60%
<i>6</i>	Swiss franc	CHF (Fr)	6.40%
<i>7</i>	Canadian dollar	CAD (\$)	5.30%
<i>8</i>	Hong Kong dollar	HKD (\$)	2.40%
<i>9</i>	Swedish krona	SEK (kr)	2.20%
<i>10</i>	New Zealand dollar	NZD (\$)	1.60%
<i>11</i>	South Korean won	KRW (₩)	1.50%
<i>12</i>	Singapore dollar	SGD (\$)	1.40%
<i>13</i>	Norwegian krone	NOK (kr)	1.30%
<i>14</i>	Mexican peso	MXN (\$)	1.30%
<i>15</i>	Indian rupee	INR (₹)	0.90%
<i>16</i>	Other	Other	12.20%
		Total	200.00%

Table 1: This table shows the most traded currencies sorted by value in 2010.

Table 1 indicates that USD, EUR and JPY are the most traded currencies in the world with 84.90 %, 39.10 % and 19.00 % of the daily market share as of April 2010, respectively (Bank for International Settlements 2010). Further, the total amount of currencies traded is 200 %, the reason for this is that there are two currencies of each transaction.

Furthermore, according to the Triennial Survey of BIS in 2010 the most traded currency pairs in the spot market were EUR/USD, USD/JPY and USD/GBP with 28.00 %, 14.00 % and 9.00 %, respectively. These three currency pairs along with USD/CHF, USD/AUD and USD/CAD are all considered major currency pairs. Other currency pairs fall into the category of minor currency pairs.

As of today the FX markets are in several ways dollar-centered. However, trading in the euro has grown noticeably since the introduction in 1999. In fact, through our dataset we observe that the euro are trading more versus non-European currencies, i.e. not necessary to go through USD. This being said, there are an open debate of how long the FX market will remain dollar-centered.

2.1.5 Overview of the most active market participants

Traders in this market include large banks, central banks, institutional investors, currency speculators, corporations, governments, other financial institutions, and retail investors.

Rank	Name	Market share
<i>1</i>	Deutsche Bank	15.18%
<i>2</i>	Citi	14.90%
<i>3</i>	Barclays Investment Bank	10.24%
<i>4</i>	UBS AG	10.11%
<i>5</i>	HSBC	6.93%
<i>6</i>	JPMorgan	6.07%
<i>7</i>	Royal Bank of Scotland	5.62%
<i>8</i>	Credit Suisse	3.70%
<i>9</i>	Morgan Stanley	3.15%
<i>10</i>	Bank of America Merrill Lynch	3.08%
	Total	78.98%

Table 2: This table shows top 10 currency traders in May 2013 (Euromoney 2013).

As we can see the top 10 dealers account for 78.98 % of the overall volume of May 2013. The main reason why these dealers are at the top is because the FX market is divided into levels of access. At the top we find the interbank market.

2.2 Market changes in the foreign exchange market

Before the 1990s, the FX market was primarily broker-dealer driven, i.e. most transactions took place in the inter-dealer core of the market. The market was characterized by high entry barriers, limited competition and the fact that most customers often paid large spreads on their trades. These large spreads can be explained by the use of second or outer tier activity in the market rather than the inter-dealer market. Further, since electronic trading was not available both quotes and transactions were requested by phone (Bank for International Settlements 2011). Later in 1992 electronic trading became available in the FX market when Reuters launched the first electronic brokering system for trading spot foreign exchange (Bekaert and Hodrick, 2009). Even though the emergence of electronic trading took place early in the FX market it was only available in the inter-dealer market, and not the customer market. This boundary disappeared in the early 2000s when FX dealing banks offered trading services to clients through electronic platforms (Bank for International Settlements 2011).

The introduction of electronic brokering and multi-bank trading systems changed the characteristics of the market. The market was now characterized by new customer classes, increased transparency and reduced transaction costs. Further, after the boundary was revoked top foreign exchange dealers launched single-bank trading systems for their customers. First off was Barclay in 2001 with BARX, Deutsche Bank in 2002 with Autobahn and Citigroup in 2006 with Velocity. This made it possible for major traders, such as hedge funds, to gain access to inter-dealer markets through prime brokerage account. This market is the most liquid and deepest part of the FX market (Bank for International Settlements 2010).

Furthermore, since the FX market has high liquidity and tighter spreads it is unprofitable for smaller dealers to compete for customers in major currency pairs. Instead, smaller dealers act as clients of top dealers for these currencies, while they provide markets for customers in local currencies. However, today we can observe a trend toward a more concentrated activity in the FX market with a few global banks which drives currency pairs to become more diversified (Bank for International Settlements 2010). Lastly, due to this breakthrough in information technology, both FX and the equity market have entered into a new era with high-frequency traders as the most active participant.

2.3 EBS platform

The EBS is owned by ICAP Company. Through their system traders are able to submit firm quotes, i.e. limit order, and firm quotes are shown at their screens, i.e. best bid and best ask. The EBS market platform offers trade-platform data, whose translatability and accuracy of quotes are highly reliable. In the EBS system quotes are always continuously available, even though certain days have rather low volumes, i.e. on national holidays (Ito et al. 2012).

Market shares in USD/JPY, EUR/USD and EUR/JPY are strong in the EBS. Contrary, the Reuters trading system, Reuter Xtra, has significant market shares in currency pairs related to GBP, CAD and AUD. Usually, EBS cover about 90 % of the USD/JPY and EUR/USD trade (Ito et al. 2012). As a result, it is safe to assume that our dataset represent more or less all spot deals of these currency pairs. Also, USD/CHF and EUR/CHF are well represented in our dataset.

3.0 Literature review

HFT is a rather young and recent phenomenon. Although the topic has got more and more attention lately, both among researchers and academic communities, there is just a small group of researcher addressing questions explicitly regarding HFT. Most previous studies of HFT effects are focused on the equity market. Questions addressing market quality and efficiency, co-location, market penetration, volatility, HFT activity and profitability are widely common. Since HFT has received most attention recently, research papers we present in this section will be rather new, and are partly working papers still waiting to be published.

3.1 Research papers investigating HFT effects in the equity market

Cvitanic and Kirilenko (2010) constructed the first theoretical model to address how market conditions or market quality is affected by HFT. They illustrate an electronic model by adding HFT, i.e. a computer or a machine, to an already existing market consisting of low frequency traders (LFT), i.e. humans. The only difference between the two investors in the model is the time horizons, i.e. the speed advantage of the machine. Cvitanic and Kirilenko (2010) find that when HFT is accounted for; transaction prices differ from the distribution of transaction prices. This implies that transaction prices have lower volatility and are more concentrated around the mean. Further, they find that liquidity increase when humans increase their trading volume and intertrade duration.

Jonathan A. Brogaard (2011a) investigates the relationship between HFT and the volatility of stock returns. He argues that one of the main concerns regarding HFT is that this new type of trader may contribute to destabilize financial markets and exacerbates volatility. This is the reason why it is crucial to understand how volatility impacts HFT activity. Firstly, he shows a strong relationship between HFT and volatility in a Granger causality context. The relationship goes both ways – HFT activity causes volatility, and volatility causes HFT activity. Secondly, he shows that both macro and stock specific news has an impact on volatility periods. During stock specific news periods HFTs tend to increase their supply of liquidity and decrease their liquidity demand. The opposite effect is true for macro specific news.

Further, Jonathan A. Brogaard (2011b) examines the role or the activity of HFT in the U.S equity market. He shows that since 2008 HFTs have been a large market participant, i.e. involved in almost 70 % of the dollar - volume traded. HFT activity tends to focus on large and liquid stocks where intraday HFT activity is driven by returns, past liquidity and other HFT activity. Gross annual trading profit generate by HFTs is estimated to be between 2.8 - 4.1 USD billion in the equity market.

While Brogaard's first papers describe the dynamics of HFT trading and the link between HFT and volatility, they do not evaluate to what extent HFTs are contributing to market quality, i.e. does the quality increase or decrease?

The last paper from Jonathan A. Brogaard (2011c) investigates the liquidity and price discovery role of HFTs in the U.S equity market, i.e. the link between HFT and market quality. Since the ability of market participants to receive, analyze and react to data in milliseconds, the question of speed and quality have risen. Brogaard shows that HFTs are adding to the market quality of the U.S equity market. They both provide a sizeable amount of liquidity depth and to the permanent price process. However, the role it plays varies periodically with systematic and idiosyncratic volatility.

Further, Menkveld (2011) shows that if you launch a new trading platform like the Chi-X, you will benefit from having HFT market makers. The reason for this is because they will decrease the spreads which implies an increase in the volume. When Chi-X were launched in the Dutch equity market they initially only generated 1-2% of all trades. After one month, a modern HFT market maker started using their platform, and suddenly they generated double-digit shares of all trades in the Dutch equity market.

Hendershott et al. (2011) finds results that Algorithmic Trading (AT) decreases the amount of price discovery correlated with trading, and lowers adverse selection. Further, they suggest that AT reduces trading costs and increases the informativeness of quotes. They also find temporary evidence that AT trading increases revenues to liquidity suppliers. Lastly, Hendershott et al. suggests that AT can improve the linkages between markets, e.g. The FX and equity market.

3.2 Research papers investigating HFT effects in the foreign exchange market

Chaboud et al. (2009) is the only major contribution that investigates AT in FX markets. Their empirical results conclude that algorithmic trades are more correlated and less diverse than trades made by humans. Most have argued that this will increase volatility. However, Chaboud et al (2009) does not find empirical evidence that an increase in algorithmic trading do increase the volatility. Further, they show evidence that algorithmic traders reduce their activity before important news releases when the volatility usually is very high, but they increase their activity again in the hours after the release, which shows that algorithmic trading provides liquidity during volatile market periods.

Further, Chaboud et al. (2009) finds evidence that the informed traders are driving price discovery in the exchange rate EUR/USD, while in USD/YEN it is the non-algorithmic traders. In the last exchange rate EUR/YEN they concludes that since a large proportion of algorithmic trades are searching for triangular arbitrage, both the non-algorithmic and algorithmic traders are equally informed. Lastly, they show evidence that when algorithmic traders place their limit orders, they impact the price less than human traders. Controversy, they concludes by stating that given this research and data, the growth of algorithmic trading does not reduce the quality of the market like many of the headlines in the international press states.

The Bank for International Settlements (2011) compares similarities between HFT effects in the FX and equity market. They find that there are a wide range of similarities regarding the impact on the two markets. For instance; more frequent trades, tighter spreads, smaller quote size/life and shorter holding time period. Further, they show that HFTs tend to focus on the most liquid exchange rates. Likewise, HFTs tend to focus on the most liquid stocks in the equity market. Furthermore, they argue that the growing trend in HFT and algorithmic trading in the FX market will most likely provide implications for the how the market is structured and being functioned globally. In order to keep up with the changes policymakers are recommended to stay alert. In some instances, this is carried out through the participation of policymakers in the Foreign Exchange Committees in various jurisdictions. Lastly, they refer to empirical literature and conclude that algorithmic and HFT is neutral to beneficial for market quality, in that volatility has declined and the spreads has become tighter.

3.3 Research papers investigating arbitrage in the foreign exchange market

Kollias and Metaxas (2001) discuss the use of triangular arbitrage as a measure of efficiency in the FX market. They find evidence that arbitrage opportunities exist, but since they involve a degree of risk, they cannot be interpreted as an indication of market inefficiency. Further, they show that a great deal of the mispricing is also not possible to exploit because of the short duration. Lastly, they find evidence that when the magnitude of the mispricing is increasing, the timeframe to exploit it is decreasing.

Further, Aiba et al. (2002) investigated triangular arbitrage as an interaction among foreign exchange rates. In particular they examine triangular arbitrage for two months in 1999 of the following currency pairs EUR/USD, USD/JPY and EUR/JPY. By analyzing the time dependence of EUR/USD, USD/JPY and EUR/JPY they show that arbitrage opportunities existed for up to 90 minutes in each trading day, i.e. 6.4 % of the time. Furthermore, they introduce a model that includes the interaction which is caused by triangular arbitrage transactions. Aiba et al find that this interaction explains the sharp peaks and the fat-tail property among the above currency pairs.

Akram et al. (2005) working paper for the Norwegian Bank (Norges Bank) explores if arbitrage opportunities exist in the three major FX markets and capital markets over a period of 151 trading days in 2004. Their results shows that there exist temporary arbitrage periods in these markets, and that these periods are on average long enough for HFTs to take advantage of them.

Marshall et al. (2008) examine triangular arbitrage opportunities on the EBS trading platform in 2005, by investigating three roundtrips: EUR/USD, USD/CHF and EUR/CHF, EUR/GBP, GBP/USD and EUR/USD and EUR/USD, USD/JPY and EUR/JPY. They show evidence of small fluctuating arbitrage opportunities through the entire trading day. When trading volume declines they find a larger number of arbitrage opportunities, which sounds reasonable given less competition. Further, they find that when the volume is low market makers tend to reduce their activity and let arbitrageurs help out keeping the currency rate in place. Furthermore, they show that arbitrage profit increases as trading activity decreases.

In the same year, Fenn et al (2008) investigated triangular arbitrage opportunities for EUR/USD, USD/CHF and EUR/CHF along with EUR/USD, USD/JPY and EUR/JPY. These roundtrips were examined within the spot FX market using high frequency executable prices. They found evidence that arbitrage opportunities do exist. However, the majority of opportunities persisted less than one second and with a profit potential of one basis point.

Further, they show that during periods of high liquidity more arbitrage opportunities occurred. This is unquestionably counter intuitively, but these opportunities tend to be removed rather fast. Furthermore, they demonstrate that the number of arbitrage opportunities has decreased in recent years, due to an increase in price efficiency. Another argument explaining this is the fact that use of electronic trading platforms, i.e. more HFT, has gone up. Finally, they find that in order to make profit on triangular arbitrage opportunities, a trader need to beat other markets participants in the long run. Therefore they conclude that the FX market appears to be internally self-consistent.

More recently, Ito et al. (2012) investigates triangular arbitrage opportunities in the FX market. They examine EUR/USD, USD/JPY and EUR/JPY in a 12 year time period ranging from 1999 to 2010. Their concept of risk free arbitrage opportunities are referred as “Free lunch”. They define it in two ways (1) negative spreads in a currency pair and (2) triangular arbitrage relationship involving three currency pairs. Likewise, they make use of firm quotes obtained from the tick-by-tick EBS data. Further, they show that triangular arbitrage opportunities occur more often than negative spreads. These opportunities, however, typically only last for a few seconds and tend to occur when the markets are volatile and active. This result is consistent with Fenn et al. (2008), and inconsistent with Marshall et al. (2008). Furthermore, the number of free lunch opportunities does decline dramatically throughout their time period. Also, the probability of the opportunities disappearing within one second steadily increases throughout the years. They argue that changes in microstructures have contributed to this, i.e. banks are allowed to directly connect to the EBS computer. In other words, HFT trading is a primary cause of this change. In fact, evidence show that machines have made the market more efficient by almost eliminating triangular arbitrage opportunities and negative spreads.

4.0 Data

The historical data used in this analysis is provided by EBS data mine. The time horizon of the data collected is from 1997 to 2007 with a time slice interval of one second. The data consist of three mine levels which includes both information on EBS Best prices and the dealt prices in the EBS Market. The EBS best prices include Best Bid (Disregarding credit, the highest bid price in the EBS market at the time) and Best offer (Disregarding credit, the lowest offer price in the EBS market at the time). The dealt prices include the highest buying deal price, i.e. the highest paid at the time, and the lowest selling deal price, i.e. the lowest given at the time.

Our original dataset contain quotes for 35 currency pairs. However, the majority are only quoted against either EUR or USD, making it possible to only use 11 currency pairs for triangular and multi-currency arbitrage. We examining the following currency pairs; DEM/CHF, DEM/JPY, EUR/CHF, EUR/GBP, EUR/JPY, EUR/USD, GBP/DEM, GBP/USD, USD/CHF, USD/DEM and USD/JPY. These currency pairs make us able to search for the following eight triangular and multi-currency roundtrips;

- 1) USD/DEM – DEM/CHF – USD/CHF
- 2) USD/DEM – DEM/JPY – USD/JPY
- 3) GBP/USD – USD/DEM – GBP/DEM
- 4) EUR/GBP – GBP/USD – EUR/USD
- 5) EUR/USD – USD/JPY – EUR/JPY
- 6) EUR/USD – USD/CHF – EUR/CHF
- 7) EUR/GBP – GBP/USD – USD/JPY – EUR/JPY
- 8) EUR/GBP – GBP/USD – USD/CHF – EUR/CHF

For each transaction, the corresponding reverse roundtrip will be included, resulting in 16 roundtrips in total. Further, we divide our data in three sets.

4.1 Data set 1

Our first data set contains information of EBS Best price, i.e. Best Bid and Best Offer. This data set consists of mine level 1.0 only. Further, the time slice interval is set at a frequency of one second, from December 29, 1996 to December 31,

1999. This indicates that three out of eleven years are included. In order to see what this signifies, table 3, illustrate this explicitly.

Date and Time	Currency Pair	Bid	Ask
10/31/1999 17:59:29	EUR/CHF	1.6037	1.605
10/31/1999 17:59:44	USD/JPY	104.05	105.8
10/31/1999 18:05:15	EUR/USD	1.054	1.055

Table 3: Gives an example of quotes recorded in data set 1.

4.2 Data set 2

Our second data set contains information of EBS Best price with masked volume ranging from A to G. This data set consists of mine level 1.0 and level 1.5. Further, the time slice interval is set at a frequency of one second, from January 1, 2000 to January 3, 2003. This indicates that three out of eleven years are included. In order to see what this signifies, table 4, illustrate this explicitly.

Date and Time	Currency Pair	Bid	Ask	Bid Size	Ask Size
12/22/2002 17:55:03	EUR/USD	1.0254	1.0275	A	A
12/22/2002 17:55:05	EUR/JPY	123.3	123.8	A	B
12/22/2002 18:22:14	USD/JPY	120.32	120.35	E	A

Table 4: Gives an example of quotes recorded in data set 2.

4.3 Data set 3

Our third data set contains information of EBS Best price with unmasked (actual) volume. This data set consists of mine level 1.0, level 1.5 and level 2.0. Further, the time slice interval is set at a frequency of one second, from January 3, 2003 to January 4, 2008. This indicates that five out of eleven years are included. In order to see what this signifies, table 5, illustrate this explicitly.

Date and Time	Currency Pair	Bid	Ask	Bid Size	Ask Size
1/2/2008 19:23:05	GBP/JPY	217.22	217.32	1	1
1/4/2008 22:45:15	EUR/USD	1.4725	1.4745	3	1
1/4/2008 22:45:35	USD/JPY	108.6	108.74	5	1

Table 5: Gives an example of quotes recorded in data set 3.

5.0 Methodology

In this section we outline how we will conduct and test our research question. As we have mentioned the arbitrage we consider in this thesis is triangular and multi-currency arbitrage. This type of arbitrage represent in several ways one of the simplest method to test in practice.

5.1 Triangular arbitrage

Triangular arbitrage is an arbitrage strategy where you search for price deviations between currency pairs, i.e. a process in order to exploit a state of disequilibrium by converting currencies. As the name implies, this process involves three currency pairs. If a price deviation between three currency pairs occurs it is possible to take advantage of these differences to lock in a risk free profit. Arbitrage is per definition risk free. This implies that it has to be done simultaneously since foreign exchange rates fluctuate frequently. We identify triangular arbitrage opportunities by the following definition

$$(1) \quad y(t) = \prod_{i=1}^3 r_i(t)$$

where $r_i(t)$ denotes an exchange rate at time t . There is a triangular arbitrage opportunity whenever $y(t)$ is greater than one. This definition can be used to calculate two types of the rate product, i.e. the ordinary and reverse roundtrip. Perhaps the easiest way of explaining triangular arbitrage is through the means of a simple example.

Picture the rates of EUR/USD, USD/JPY and EUR/ JPY. Suppose one initially holds the Euro in both trips. First option is to convert your EUR into USD, then convert your USD into JPY, and finally convert your JPY into EUR. The other one is based on the transaction in the opposite direction. Convert your EUR into JPY, then convert your JPY into USD, and finally convert your USD into EUR. If the amount of EUR is larger than the amount of EUR you started with then an arbitrage opportunity exists. As described above you will have two possible triangular arbitrage opportunities depending on which currency pair you start with.

Suppose you observe these quotes on your trading platform:

Date and Time	Currency Pair	Bid	Ask
10/31/1999 17:59:29	EUR/USD	1.304	1.3044
10/31/1999 17:59:29	USD/JPY	87.88	87.92
10/31/1999 17:59:29	EUR/JPY	114.458	114.562

Table 6: Gives an example of quotes recorded.

Ordinary roundtrip: EUR → USD → JPY → EUR

$$(2) \quad y_1(t) = \frac{EUR}{USD_{bid}}(t) \times \frac{USD}{JPY_{bid}}(t) \times \frac{1}{\frac{EUR}{JPY}_{ask}}(t)$$

$$(2.1) \quad y_1(t) = 1.304 \times 87.88 \times \frac{1}{114.562}$$

$$(2.2) \quad y_1(t) = 1.0029$$

Reverse roundtrip: EUR → JPY → USD → EUR

$$(3) \quad y_2(t) = \frac{EUR}{JPY_{bid}}(t) \times \frac{1}{\frac{USD}{JPY}_{ask}}(t) \times \frac{1}{\frac{EUR}{USD}_{ask}}(t)$$

$$(3.1) \quad y_2(t) = 114.458 \times \frac{1}{87.92} \times \frac{1}{1.3044}$$

$$(3.2) \quad y_2(t) = 0.9988$$

If $y(t)$ is greater than one we have an arbitrage opportunity. As we can see from the example above there would be an arbitrage opportunity by conducting the ordinary roundtrip. These two roundtrips define all possible arbitrage transaction using this set of currency pairs. This approach is similar to what Aiba et al. (2002) and Fenn et al. (2008) use in order to calculate triangular arbitrage.

5.2 Multi-currency arbitrage

Similar, to triangular arbitrage, multi-currency arbitrage is an arbitrage strategy where you search for price deviations between currency pairs. However, this process involves four or more currency pairs. We identify multi-currency arbitrage opportunities by the following definition

$$(4) \quad y(t) = \prod_{i=1}^4 r_i(t)$$

where $r_i(t)$ denotes an exchange rate at time t . There is a multi-currency arbitrage opportunity whenever $y(t)$ is greater than one. This definition can be used to calculate two types of the rate product, i.e. the ordinary and reverse roundtrip.

Picture the rates of EUR/GBP, GBP/USD, USD/JPY and EUR/JPY. Suppose one initially holds the Euro in both trips. First option is to convert your EUR into GBP, then convert your GBP into USD, then convert your USD into JPY, and finally convert your JPY into EUR. The other one is based on the transaction in the opposite direction. Convert your EUR into JPY, then convert your JPY into USD, then convert your USD into GBP, and finally convert your GBP into EUR. If the amount of EUR is larger than the amount of EUR you started with then an arbitrage opportunity exists.

Suppose you observe these quotes on your trading platform:

Date and Time	Currency Pair	Bid	Ask
10/31/2005 20:28:37	EUR/GBP	0.6792	0.6793
10/31/2005 20:28:37	GBP/USD	1.7789	1.7793
10/31/2005 20:28:37	USD/JPY	115.57	115.58
10/31/2005 20:28:37	EUR/JPY	139.620	139.630

Table 7: Gives an example of quotes recorded.

Ordinary roundtrip: EUR → GBP → USD → JPY → EUR

$$(5) \quad y_1(t) = \frac{EUR}{GBP_{bid}}(t) \times \frac{GBP}{USD_{bid}}(t) \times \frac{USD}{JPY_{bid}}(t) \times \frac{1}{\frac{EUR}{JPY}_{ask}}(t)$$

$$(5.1) \quad y_1(t) = 0.6792 \times 1.7789 \times 115.57 \times \frac{1}{139.630}$$

$$(5.2) \quad y_1(t) = 1.0000359$$

Reverse roundtrip: EUR → JPY → USD → GBP → EUR

$$(6) \quad y_2(t) = \frac{EUR}{JPY_{bid}}(t) \times \frac{1}{\frac{USD}{JPY}_{ask}}(t) \times \frac{1}{\frac{GBP}{USD}_{ask}}(t) \times \frac{1}{\frac{EUR}{GBP}_{ask}}(t)$$

$$(6.1) \quad y_2(t) = 139.620 \times \frac{1}{115.58} \times \frac{1}{1.7793} \times \frac{1}{0.6793}$$

$$(6.2) \quad y_2(t) = 0.99943407$$

If $y(t)$ is greater than one we have an arbitrage opportunity. As we can see from the example above there would be an arbitrage opportunity by conducting the ordinary roundtrip. These two roundtrips define all possible arbitrage transaction using this set of currency pairs.

5.3 Application

We identify triangular and multi-currency arbitrage opportunities on a weekly basis. Since our dataset allows us to gain firsthand information regarding which currency pairs that is available for every week roundtrips can differ from year to year. We sort the quotes in each week by their time stamp. We then identify an arbitrage opportunity as follows:

5.3.1 Data set 1

- 1) Identify possible roundtrips by examine each currency pair available for that particular week.
- 2) Sort does currency pairs required for each roundtrip with their respective bid and ask. Further, connect the pairs into a weekly timeline with a time slice interval of one second.
- 3) Use formula (2) and (3) to detect opportunities.
- 4) Count all $y(t)$ which are greater than one for every roundtrip.

5.3.2 Data set 2

- 1) Identify possible roundtrips by examine each currency pair available for that particular week.
- 2) Sort does currency pairs required for each roundtrip with their respective bid and ask along with volume (masked). Further, connect the pairs into a weekly timeline with a time slice interval of one second. Taking volume into account makes the counting of occurrence more realistic. The reason for this is because without volume we are not able to eliminate constant roundtrips, i.e. constant bid/ask quotes with unchanged volume. By adding volume to equation (2) and (3) all constant roundtrips are counted as one.
- 3) Use formula (2) and (3) to detect opportunities both with and without volume.
- 4) Count all $y(t)$ which are greater than one for every roundtrip.

5.3.3 Data set 3

- 1) Everything under section 5.3.2, however with unmasked volume.
- 2) Since we have actual volume available we calculate the profit potential for each roundtrip. This is done by multiplying the maximum volume of the first leg of the roundtrip with the respected rate product, minus one and subtract for transaction cost.

5.4 Limitations

- 1) Execution risk:
 - We assume that it is possible to buy maximum volume at the first leg of each roundtrip and exit the roundtrip with no position in the FX market
- 2) Implementation cost:
 - Do not take costs of having a trading program monitoring the market and placing arbitrage trades automatically when the opportunity arises
- 3) Similarly to Fenn et al (2008) we assume that the trading cost is equal to two euro per trade, i.e. six euro per triangular roundtrip, and eight euro per multi-currency roundtrip.

6.0 Results and analysis

In this section we analyze and present the results of our study. The main focus will be to show how often triangular and multi-currency arbitrage emerged, by counting the number of occurrence. From 2003 and onwards (Dataset 3) we will provide further insights into the profitability of both triangular and multi-currency arbitrage. The number of arbitrage opportunities will be analyzed in the perspective of with and without volume. The roundtrips we consider in this thesis will be compared yearly allowing us to investigate whether the number of arbitrage opportunities has increased or decreased. However, in order to distinguish our analysis from previous research we will provide details down to each trading week in our appendices. Further, we begin by analyzing triangular arbitrage, then multi-currency arbitrage.

6.1 Triangular arbitrage

6.1.1 USD/DEM – DEM/CHF – USD/CHF

This roundtrip did only occur in the first two years of our dataset, i.e. 1997 and 1998. This is due to the introduction of the Euro in the early 1999s, which made the German Mark (DEM) withdrawn from the FX market. As mentioned before these years are in dataset 1 which only contains best bid and best ask, indicating that we will not be able to take volume into account when counting the number of triangular arbitrage opportunities for this roundtrip. Hence, our results may be spurious or at least unrealistic.

Year	No. Of Arbitrage	Descriptive Statistics			
		Median *	Mean *	Maximum *	Minimum *
1997	1 896 158	20 297	35 777	347 156	4 054
1998	788 440	13 985	15 162	50 288	4 478

Table 8: Shows the No. of Triangular arbitrage opportunities, as well as the descriptive statistics, for USD/DEM – DEM/CHF – USD/CHF (without volume). * Weekly.

Table 8 shows that the total number of arbitrage opportunities per year decreased from 1997 to 1998. As of year 1997 the total number of arbitrage opportunities was 1 896 158 and 788 440 in 1998. This is a reduction of 58 %. In appendix 1 we see that week 17, 26 and 33 stands out in 1997, with a maximum of 347 156 in week 33, suggesting that our results may be driven by outliers. These extreme observations can be explained by the fact that we do not take volume into account and/or market imperfections. Turning to the weekly median we see that it is 20 297 in 1997 and 13 985 in 1998. This is a decrease of 31 %. Further, by

comparing the weekly mean and median we observe that they are closer in 1998, than in 1997. This indicates that there was less outliers in 1998.

6.1.2 USD/CHF – DEM/CHF – USD/DEM

This roundtrip is the reverse of USD/DEM – DEM/CHF – USD/CHF.

Year	No. Of Arbitrage	Descriptive Statistics			
		Median *	Mean *	Maximum *	Minimum *
1997	1 962 569	17 671	37 030	394 273	7 323
1998	875 720	13 107	16 841	61 331	5 992

Table 9: Shows the No. of Triangular arbitrage opportunities, as well as the descriptive statistics, for USD/CHF – DEM/CHF – USD/DEM (without volume). * Weekly.

Similar to table 8, table 9 shows that the total number of arbitrage opportunities per year decreased from 1997 to 1998. In 1997 the total number of arbitrage opportunities was 1 962 569, and 875 720 in 1998. As we can see the spread between the weekly median and mean is larger in 1997 compare to 1998, suggesting that the weekly median is a proper measure of occurrence. Appendix 2 shows the same trend as appendix 1. The weekly median is 17 671 in 1997 and 13 107 in 1998, resulting in a reduction of 25 % in opportunities.

6.1.3 USD/DEM – DEM/JPY – USD/JPY

This roundtrip, similar to our first roundtrip did only occur in the years 1997-1998. Once again, we are not able to take volume into account. Hence, our results may be spurious or at least unrealistic.

Year	No. Of Arbitrage	Descriptive Statistics			
		Median *	Mean *	Maximum *	Minimum *
1997	1 511 278	11 147	28 515	351 889	1 513
1998	765 008	13 483	14 712	43 243	5 112

Table 10: Shows the No. of Triangular arbitrage opportunities, as well as the descriptive statistics, for USD/DEM – DEM/JPY – USD/JPY (without volume). * Weekly.

Table 10 shows that the total number of arbitrage opportunities per year decreased from 1997 to 1998. In 1997 the total number of opportunities was 1 511 278 and 765 008 in 1998. This is a decrease of 49 %. Once more, we observe that the spread between the weekly median and mean is greater in 1997 than in 1998, suggesting that there are more extreme observations in 1997. Appendix 3 confirms these observations. Further, contrary to the total number of arbitrage opportunities per year, the weekly median was 11 147 in 1997 and 13 483 in 1998, which is an increase of 20 %. This, however, is not surprising. In appendix 3 we observe that the four largest outliers in 1997 account for almost 900 000 opportunities or 60 % of the total number of arbitrage opportunities.

6.1.4 USD/JPY – DEM/JPY – USD/DEM

This roundtrip is the reverse trip of USD/DEM – DEM/JPY – USD/JPY.

Year	No. Of Arbitrage	Descriptive Statistics			
		Median *	Mean *	Maximum *	Minimum *
1997	2 172 224	12 902	40 985	352 874	2 456
1998	1 228 545	14 597	23 626	141 143	7 078

Table 11: Shows the No. of Triangular arbitrage opportunities, as well as the descriptive statistics, for USD/JPY – DEM/JPY – USD/DEM (without volume). * Weekly.

In table 11 we see the same trend as in table 10. In 1997 the total number of arbitrage opportunities per year was 2 172 224 and 1228 545 in 1998. This is a reduction of 43 %. Turning to the weekly median we see that it was 12 902 in 1997 and 14 597 in 1998. This is an increase of 13 %. Again, appendix 4 confirms this.

6.1.5 GBP/USD – USD/DEM – GBP/DEM

Likewise, to the previous roundtrips, this roundtrip did only occur in 1997 and 1998. And once again, we are not able to take volume into account. Hence, our results may be spurious or at least unrealistic.

Year	No. Of Arbitrage	Descriptive Statistics			
		Median *	Mean *	Maximum *	Minimum *
1997	5 862 963	96 614	110 622	398 781	27 912
1998	6 178 280	103 610	118 813	271 195	33 611

Table 12: Shows the No. of Triangular arbitrage opportunities, as well as the descriptive statistics, for GBP/USD– USD/DEM –GBP/DEM (without volume). * Weekly.

Contrary, to the preceding roundtrips in year 1997 and 1998, table 12 shows that the total number of arbitrage opportunities per year has increased with 5 %. In 1997 the total number of arbitrage opportunities per year was 5 862 963, and 6 178 280 in 1998. Further, as mentioned under section 2.3 the EBS platform does not have a large market share in GBP trading, which makes bid/ask quotes stay constant for a longer period of time. This may result in an unrealistic total number of arbitrage opportunities compared to roundtrips which excludes GBP. From year 2000, when we include volume in our estimations, this will no longer be a problem. The weekly median was 96 614 in 1997 and 103 610 in 1998, which is an increase of 7 %, confirming our argument. Furthermore, by looking at the spread between the weekly median and mean we see that this increase is not driven by any large outliers, but rather a steady rise per week. In appendix 5 we observe that the total number of arbitrage opportunities per week do not spike.

6.1.6 GBP/DEM – USD/DEM – GBP/USD

This roundtrip is the reverse trip of GBP/USD – USD/DEM – GBP/DEM.

Year	No. Of Arbitrage	Descriptive Statistics			
		Median *	Mean *	Maximum *	Minimum *
1997	5 456 488	83 561	102 953	324 351	0
1998	7 154 440	129 133	137 585	272 873	31 327

Table 13: Shows the No. of Triangular arbitrage opportunities, as well as the descriptive statistics, for GBP/DEM– USD/DEM –GBP/USD (without volume). * Weekly.

Similar, to table 12, table 13 shows an increase in the total number of arbitrage opportunities per year from 1997 to 1998. We see that the total number of arbitrage opportunities is 5 456 488 in 1997 and 7 154 440 in 1998. This is an increase of 31 %. As mentioned above this is an unrealistic large number. Further, the weekly median is 83 561 in 1997 and 129 133 in 1998, resulting in an incline of 54 %. In appendix 6 we see a steady increase. Overall, we see that two last roundtrips have by far the largest total number of arbitrage opportunities before the introduction of the Euro in 1999. All other roundtrips downward contain the euro.

Contrary, to all the roundtrips above, the roundtrips downward will contain volume. As mentioned before data included in year 2000 – 2002 contain masked volumes, while data included in year 2003 – 2007 contain unmasked volume. By taking the volume into account when searching for arbitrage opportunities our results will be much more realistic than above, since we are able to remove “fictive” arbitrage opportunities as discussed under section 5.3. Further, from now on profits will be included in our analysis. Each roundtrip from here and onwards will only be analyzed in the perspective of volume¹.

We have calculated two different profits, one based on actual numbers, and one based on a median estimation (*). The reason for this is due to some extreme outliers in the actual numbers, therefore the estimated numbers may give a more realistic result. Both trading incomes is calculated as the volume in the first leg times the rate product. For instance if you get a rate product of 1.002 and the volume in the first leg is 2 million, we have calculated a profit of 2 million times $(1.002-1) = 0.004$ million EUR for that specific trade. For the estimated trading income (*) we use the median of the weekly trading incomes times the number of

¹ In our data folder named “Appendices – Master thesis” we will provide both perspectives.

weeks for that specific year. As mentioned the last calculation might be most realistic due to extreme observations in our actual calculation, which is due to lack of liquidity and abnormal bid/ask quotes outside normal trading hours in our data.

6.1.7 EUR/GBP – GBP/USD – EUR/USD

This roundtrip, contrary to all the above, contains volume.

Year	No. Of Arbitrage	Descriptive Statistics			
		Median *	Mean *	Maximum *	Minimum *
2000	36 340	668	699	982	435
2001	38 605	737	742	1 130	471
2002	32 579	585	627	1 100	329
2003	28 376	509	535	976	180
2004	21 065	371	397	808	170
2005	16 111	292	310	636	130
2006	12 465	207	240	631	73
2007	8 873	103	167	1 356	46

Table 14: Shows the No. of Triangular arbitrage opportunities, as well as the descriptive statistics, for EUR/GBP– GBP/USD –EUR/USD (with volume). * Weekly.

As we can see from table 14 the total number of arbitrage opportunities per year has decreased from 2000 to 2007. The reduction is 77 %, with a total number of 36 340 arbitrage opportunities in 2000 and 8 873 in 2007. The weekly median was 668 in 2000 and 103 in 2007. This is a decrease of 84 %. Furthermore, we observe that the weekly median and mean are nearly identical in value. This indicates that we are able to eliminate extreme observation by including volume in our counting process. In appendix 7 we see that this is correct. These results are consisted with Marshall et al (2008). As mentioned under section 3.3 they find that arbitrage opportunities exist through the entire trading day for the similar roundtrip in 2005. However, since Marshall et al. (2008) only search for arbitrage opportunities in 2005, we cannot compare our trend.

Year	No. Of Arbitrage	Descriptive Statistics						
		Trading income	Trading income*	Trading cost**	Trading profit	Trading profit*	Profit per trade	Profit per trade*
2003	28 376	€ 9.64	€ 7.50	€ 0.17	€ 9.47	€ 7.33	€ 0.00033	€ 0.00026
2004	21 065	€ 3.81	€ 3.01	€ 0.13	€ 3.68	€ 2.88	€ 0.00018	€ 0.00014
2005	16 111	€ 1.77	€ 1.44	€ 0.10	€ 1.67	€ 1.35	€ 0.00011	€ 0.00008
2006	12 465	€ 1.09	€ 0.79	€ 0.07	€ 1.01	€ 0.72	€ 0.00009	€ 0.00006
2007	8 873	€ 2.21	€ 0.32	€ 0.05	€ 2.15	€ 0.26	€ 0.00025	€ 0.00003

Table 15: Shows the profit statistics for EUR/GBP– GBP/USD –EUR/USD. All calculations are reported in millions of Euros. *Estimated: weekly median x weeks per year ** Estimated: EUR 2 per trade, EUR 6 per roundtrip

Table 15 shows that the two trading incomes have decreased by 77 % (EUR 9.64 and EUR 2.21) and 95 % (EUR 7.50 to EUR 0.32) from 2003 to 2007. Further, we observe that the spread between the two is rather small, indicating few outliers.

However, we see that from 2006 to 2007 there is a small increase in the actual number. From appendix 8 we see that this is due to week 46 – 49 in 2007. Furthermore, we see that actual trading profit has decreased by 77 % from 2003 to 2007 (EUR 9.47 to EUR 2.15). Trading profit (*) follows the same trend, decreasing by 96 % from 2003 to 2007 (EUR 7.33 to EUR 0.26). It worth noticing that both trading profits have been decreasing dramatically, and that trading profit (*) is only EUR 260 000 in 2007. If the trading profits follows the same trend, there may not be possible to obtain any profit for this roundtrip in the future. Keeping in mind first assumption under section 5.4 the trading profits may be overestimated, suggesting even less profit.

6.1.8 EUR/USD – GBP/USD – EUR/GBP

This roundtrip is the reverse trip of EUR/GBP – GBP/USD – EUR/USD.

Year	No. Of Arbitrage	Descriptive Statistics			
		Median *	Mean *	Maximum *	Minimum *
2000	309 852	5 326	5 959	13 079	2 179
2001	230 692	4 122	4 436	8 158	1 860
2002	228 676	4 264	4 398	14 131	1 491
2003	563 427	8 442	10 631	27 817	3 636
2004	191 734	2 896	3 618	11 745	217
2005	53 761	800	1 034	2 850	71
2006	41 617	458	800	3 523	79
2007	29 611	118	559	5 372	41

Table 16: Shows the No. of Triangular arbitrage opportunities, as well as the descriptive statistics, for EUR/USD– GBP/USD –EUR/GBP (with volume). * Weekly.

Table 16 shows the same trend as the ordinary roundtrip. We see that the total number of arbitrage opportunities was 309 852 in 2000 and 29 611 in 2007. This is a decrease of 90 %. There is a spike in 2003. In appendix 9 we see that there are a few weeks motivating this increase. Further, we see that the weekly median was 5 326 in 2000 and 118 in 2007, estimating a decrease of 97 %.

Year	No. Of Arbitrage	Descriptive Statistics						
		Trading income	Trading income*	Trading cost**	Trading profit	Trading profit*	Profit per trade	Profit per trade*
2003	563 427	€ 4 271.66	€ 2 353.90	€ 3.38	€ 4 268.28	€ 2 350.52	€ 0.00758	€ 0.00417
2004	191 734	€ 739.05	€ 462.24	€ 1.15	€ 737.90	€ 461.09	€ 0.00385	€ 0.00240
2005	53 761	€ 71.20	€ 43.85	€ 0.32	€ 70.88	€ 43.53	€ 0.00132	€ 0.00081
2006	41 617	€ 77.27	€ 20.01	€ 0.25	€ 77.02	€ 19.76	€ 0.00186	€ 0.00047
2007	29 611	€ 83.00	€ 3.19	€ 0.18	€ 82.82	€ 3.01	€ 0.00280	€ 0.00010

Table 17: Shows the profit statistics for EUR/USD– GBP/USD –EUR/GBP. All calculations are reported in millions of Euros. *Estimated: weekly median x weeks per year ** Estimated: EUR 2 per trade, EUR 6 per roundtrip

Table 17 show that the two trading income decreased by respectively 98 % (EUR 4 271 to EUR 83 million) and 99 % (EUR 2 353 to EUR 3.19) from 2003 to 2007. We observe that there is a huge spread between the two trading incomes,

indicating that there is some extreme outliers in this roundtrip. Trading profit has decreased by 98 % from 2003 to 2007 (EUR 4 268 to EUR 82). Trading profit (*) follows the same trend, decreasing by 99 % from 2003 to 2007 (EUR 2 350 to EUR 3). We see that this roundtrip shows massive profits in the first years of trading, compared to the other roundtrips, even when we use the median estimate. Their can be several reasons for this result. Firstly, we see an enourmous amount of trades in 2003 (563 427) and 2004 (193 734). Further, we observe an increase in profit per trade compared to the other roundtrips. In 2003 profit per trade was EUR 7 500 and EUR 4 100 (*). This is the only case where we observe a profit per trade larger than EUR 1 000. In appendix 10 we see that several weeks follows this trend. From 2005 to 2007 we observe more “normal” results, indicating that their might be some lack of liquidity and abnormal bid/ask quotes outside normal trading hours in the first two years. Marshall et al. (2008) argues the same by showing evidence that roundtrips involving GBP have considerably higher profits.

6.1.9 EUR/USD – USD/JPY – EUR/JPY

This roundtrip, similar to roundtrip EUR/GBP – GBP/USD – EUR/USD, contains masked and unmasked volume.

Year	No. Of Arbitrage	Descriptive Statistics			
		Median *	Mean *	Maximum *	Minimum *
2000	139 997	2 323	2 692	12 464	1 017
2001	151 960	2 588	2 922	12 471	1 604
2002	136 877	2 213	2 632	10 874	1 541
2003	187 982	3 143	3 547	12 871	1 982
2004	150 595	2 668	2 841	10 285	1 359
2005	120 921	1 928	2 325	20 369	833
2006	144 552	1 627	2 780	26 032	523
2007	186 408	1 624	3 517	53 273	381

Table 18: Shows the No. of Triangular arbitrage opportunities, as well as the descriptive statistics, for EUR/USD– USD/JPY–EUR/JPY (with volume). * Weekly.

In table 18 we that the total number of arbitrage opportunities per year increased. In 2000 it was 139 997 opportunities and 186 408 in 2007. This is an increase of roughly 32 %. From appendix 11 we that year 2003 and 2007 are influenced by outliers. Further, the weekly median shows a different result. It shows a decrease of 30 % from 2000 to 2007. Starting with 2 323 in 2000 and ending with 1 624 in 2007. Since the weekly median is not influenced by outliers it may give a more realistic picture of how many arbitrage opportunities you can expect on a weekly basis for this particular roundtrip. Our result based on the weekly median is

almost identical to what Ito et.al (2012) find for the same roundtrip. With an even longer time period they show that the total number of arbitrage opportunities decline dramatically. Further, this is consistent with the result of Fenn et al. (2008), although their time span is shorter. Furthermore, both Aiba et al (2002) and Marshall et al. (2008) find proof of arbitrage opportunities throughout the entire trading day in 1999 and 2005 for this roundtrip, respectively.

Year	No. Of Arbitrage	Descriptive Statistics						
		Trading income	Trading income*	Trading cost**	Trading profit	Trading profit*	Profit per trade	Profit per trade*
2003	187 982	€ 90.27	€ 71.91	€ 1.13	€ 89.14	€ 70.78	€ 0.00047	€ 0.00038
2004	150 595	€ 65.17	€ 58.93	€ 0.90	€ 64.27	€ 58.03	€ 0.00043	€ 0.00039
2005	120 921	€ 48.32	€ 30.44	€ 0.73	€ 47.59	€ 29.71	€ 0.00040	€ 0.00025
2006	144 552	€ 151.83	€ 20.07	€ 0.87	€ 150.97	€ 19.20	€ 0.00105	€ 0.00013
2007	138 408	€ 574.43	€ 18.38	€ 0.83	€ 573.59	€ 17.55	€ 0.00415	€ 0.00013

Table 19: Shows the profit statistics for EUR/USD– USD/JPY –EUR/JPY. All calculations are reported in millions of Euros. *Estimated: weekly median x weeks per year ** Estimated: EUR 2 per trade, EUR 6 per roundtrip

Table 19 show that the trading income has increased by 637 % from 2003 to 2007 (EUR 90 to EUR 574), while trading income (*) has decreased by 75 % (EUR 71 to EUR 18). Trading profit follows the same pattern, with an increase of 637 % from 2003 to 2007 (EUR 89 to EUR 573), while trading profit (*) decreased by 75 % (EUR 70 million to EUR 17 million) in the same period. This is the only observation where trading profit has increased from 2003 to 2007. Further, we observe that the trading profit along with trading profit (*) followed the same downward trend until 2005. From that point on actual trading profit increased massively. In appendix 12 we observe that in year 2006 and 2007 several weeks generate extreme profits, indicating that (*) is a proper measure. The downward trend in trading profit (*) is consistent with Ito et al. (2012). Also, Aiba et al (2002), Marshall et al. (2008) and Fenn et al. (2008) find evidence of profit potential for this roundtrip.

6.1.10 EUR/JPY – USD/JPY – EUR/USD

This roundtrip is the reverse trip of EUR/USD – USD/JPY – EUR/JPY

Year	No. Of Arbitrage	Descriptive Statistics			
		Median *	Mean *	Maximum *	Minimum *
2000	106 212	1 925	2 043	6 446	899
2001	101 048	1 863	1 943	3 199	582
2002	81 690	1 599	1 571	2 534	260
2003	99 317	1 997	1 874	2 710	126
2004	104 541	1 908	1 972	2 884	405
2005	126 947	1 959	2 441	6 870	847
2006	128 816	1 678	2 477	25 283	445
2007	119 154	1 661	2 248	13 772	365

Table 20: Shows the No. of Triangular arbitrage opportunities, as well as the descriptive statistics, for EUR/JPY– USD/JPY –EUR/USD (with volume). * Weekly.

Table 20 shows that the total number of arbitrage opportunities was 106 212 in 2000 and 119 154 in 2007. This is an increase of 8 %. However, from appendix 13 we observe the same trend as in the ordinary roundtrip. The weekly median shows that the total number of arbitrage opportunities per week decreases with 15 %, with 1 925 and 1 161 in 2000 and 2007, respectively. This suggests that a declining trend is the case.

Year	No. Of Arbitrage	Descriptive Statistics						
		Trading income	Trading income*	Trading cost**	Trading profit	Trading profit*	Profit per trade	Profit per trade*
2003	99 317	€ 19.38	€ 20.19	€ 0.60	€ 18.78	€ 19.59	€ 0.000189	€ 0.000197
2004	104 541	€ 18.68	€ 17.09	€ 0.63	€ 18.05	€ 16.46	€ 0.000179	€ 0.000157
2005	126 947	€ 19.05	€ 14.01	€ 0.76	€ 18.28	€ 13.25	€ 0.000150	€ 0.000104
2006	128 816	€ 24.31	€ 10.51	€ 0.77	€ 23.53	€ 9.74	€ 0.000189	€ 0.000076
2007	119 154	€ 15.68	€ 9.10	€ 0.71	€ 14.97	€ 8.39	€ 0.000132	€ 0.000070

Table 21: Shows the profit statistics for EUR/JPY– USD/JPY –EUR/USD. All calculations are reported in millions of Euros. *Estimated: weekly median x weeks per year ** Estimated: EUR 2 per trade, EUR 6 per roundtrip

Table 21 shows that the two trading incomes decreased by respectively 21% (EUR 19 to EUR 15) and 55% (EUR 20 to EUR 9) from 2003 to 2007. Trading profit has decreased by 22% from 2003 to 2007 (EUR 18 to EUR 14). Trading profit (*) have been following the same trend, decreasing by 57% from 2003 to 2007 (EUR 19 to EUR 8). We observe that even though the number of arbitrage opportunities increased through our time period, the trading profits decreased. This is counterintuitively since one would expect the oposite. Appendix 14 provide further details. Moreover, this observation is confirmed by the 34 % and 64 % decrease in profit per trade (EUR 189 to EUR 125) and profit per trade (*) (EUR 197 to EUR 70) from 2003 to 2007, respectively.

6.1.11 EUR/USD – USD/CHF – EUR/CHF

The last triangular roundtrip we detected did also occur in dataset 2 and 3

Year	No. Of Arbitrage	Descriptive Statistics			
		Median *	Mean *	Maximum *	Minimum *
2000	117 466	2 249	2 259	3 260	941
2001	105 687	2 099	2 032	2 894	1 060
2002	84 460	1 534	1 624	3 050	663
2003	130 809	2 484	2 468	3 592	808
2004	119 509	2 231	2 255	3 740	1 201
2005	87 958	1 693	1 692	3 078	811
2006	57 525	1 100	1 106	1 813	494
2007	48 762	888	920	1 948	433

Table 22: Shows the No. of Triangular arbitrage opportunities, as well as the descriptive statistics, for EUR/USD– USD/CHF –EUR/CHF (with volume). * Weekly.

Table 22 indicate that the total number of arbitrage opportunities per year was 117 466 in 2000 and 48 752 in 2007. This is a reduction 59 %. Further, turning to the weekly median we see that is was 2 249 in 2000 and 888 in 2007, resulting in a 60 % decrease. Furthermore, we see that the total number of arbitrage opportunities

per year do increase in year 2003 and 2004. By comparing the weekly median and mean we observe that they are close, suggesting that we have few outliers.

Appendix 15 confirms this. These results are both consistent with Marshall et al. (2008) and Fenn et al. (2008). Marshall et al. (2008) find evidence in 2005, while the latter from 2003 – 2005. Fenn et al. (2008), however, do not have data throughout each year only a few weeks.

Year	No. Of Arbitrage	Descriptive Statistics						
		Trading income	Trading income*	Trading cost**	Trading profit	Trading profit*	Profit per trade	Profit per trade*
2003	130 809	€ 68.09	€ 62.75	€ 0.78	€ 67.30	€ 61.96	€ 0.0005145	€ 0.00047
2004	119 509	€ 51.53	€ 48.83	€ 0.72	€ 50.81	€ 48.11	€ 0.0004312	€ 0.00040
2005	87 958	€ 28.88	€ 27.26	€ 0.53	€ 28.36	€ 26.73	€ 0.0003284	€ 0.00030
2006	57 525	€ 14.81	€ 13.98	€ 0.35	€ 14.46	€ 13.64	€ 0.0002574	€ 0.00024
2007	48 762	€ 11.14	€ 9.97	€ 0.29	€ 10.85	€ 9.68	€ 0.0002285	€ 0.00020

Table 23: Shows the profit statistics for EUR/USD– USD/CHF –EUR/CHF. All calculations are reported in millions of Euros. *Estimated: weekly median x weeks per year ** Estimated: EUR 2 per trade, EUR 6 per roundtrip

Table 23 show that both trading income (EUR 68 to EUR 11) and trading income (*) (EUR 62 to EUR 9.99) decreased by 83 % from 2003 to 2007. Trading profit (EUR 67 to EUR 10) and trading profit (*) (EUR 61 to EUR 9) has both decreased by 83 % from 2003 to 2007. We observe that there is only a minor spread between the two trading incomes and profits, indicating that there is few outliers in this roundtrip. Appendix 16 which contains weekly profit information confirms these observations. These results are both consistent with Marshall et al. (2008) and Fenn et al. (2008) which find evidence of declining profits for this roundtrip.

6.1.12 EUR/CHF – USD/CHF – EUR/USD

This roundtrip is the reverse trip of EUR/USD – USD/CHF – EUR/CHF.

Year	No. Of Arbitrage	Descriptive Statistics			
		Median *	Mean *	Maximum *	Minimum *
2000	112 585	2 146	2 165	3 537	1 223
2001	96 724	1 775	1 860	3 046	597
2002	79 408	1 506	1 527	2 454	782
2003	101 492	1 916	1 915	2 899	688
2004	103 166	1 984	1 947	2 832	688
2005	83 645	1 596	1 609	2 342	803
2006	70 334	1 064	1 353	9 069	682
2007	52 933	873	999	3 821	604

Table 24: Shows the No. of Triangular arbitrage opportunities, as well as the descriptive statistics, for EUR/CHF – USD/CHF – EUR/USD (with volume). * Weekly.

Similar, to table 22, table 24 indicates the same trend. We observe that the total number of arbitrage opportunities was 112 585 in 2000 and 52 933 in 2007. This gives a reduction of 53 %. Appendix 17 indicates the same as appendix 15. Further, we see that the weekly median is 2 146 in 2000 and 873 in 2007, resulting in a reduction of 59 %. The weekly mean has the equal reduction in

percentage points. Furthermore, we see that the spread between the weekly median and mean is small, similar to the ordinary roundtrip, suggesting that we have few extreme observations.

Year	No. Of Arbitrage	Descriptive Statistics						
		Trading income	Trading income*	Trading cost**	Trading profit	Trading profit*	Profit per trade	Profit per trade*
2003	101 492	€ 24.08	€ 22.56	€ 0.61	€ 23.47	€ 21.95	€ 0.00023	€ 0.00022
2004	103 166	€ 24.99	€ 23.30	€ 0.62	€ 24.37	€ 22.68	€ 0.00024	€ 0.00022
2005	83 645	€ 17.98	€ 17.26	€ 0.50	€ 17.48	€ 16.76	€ 0.00021	€ 0.00020
2006	70 334	€ 13.20	€ 8.42	€ 0.42	€ 12.78	€ 8.00	€ 0.00019	€ 0.00011
2007	52 933	€ 7.66	€ 6.04	€ 0.32	€ 7.35	€ 5.72	€ 0.00014	€ 0.00011

Table 25: Shows the profit statistics for EUR/CHF – USD/CHF – EUR/USD. All calculations are reported in millions of Euros. *Estimated: weekly median x weeks per year ** Estimated: EUR 2 per trade, EUR 6 per roundtrip

Table 25 shows that the two trading incomes have decreased by 68 % (EUR 24.08 to EUR 7.66) and 73 % (EUR 22.56 to EUR 6.04) from 2003 to 2007. Both trading profits also decreases by the same amounts, respectively 68 % (EUR 23.4 to EUR 7.3) and 73 % (EUR 21.9 to EUR 5.7), from 2003 to 2007. The spread between the trading incomes and profits is minor, indicating that there is very few outliers in this roundtrip. Appendix 18 confirms these indications by providing weekly details for this time period.

6.2 Multi-currency arbitrage

In the same manner as the triangular arbitrage roundtrips with euro, each multi-currency roundtrip contains masked and unmasked volumes. Further, we expect to find less arbitrage opportunities due to the fact that we need to obtain price deviations between four currency pairs. As far as our knowledge goes there is no empirical research investigating multi-currency arbitrage in HFT.

6.2.1 EUR/GBP – GBP/USD – USD/JPY – EUR/JPY

This roundtrip we were able to detect from 2000 to 2007.

Year	No. Of Arbitrage	Descriptive Statistics			
		Median *	Mean *	Maximum *	Minimum *
2000	42 847	803	824	2 086	274
2001	39 548	715	761	1 683	338
2002	36 365	698	699	1 693	213
2003	35 409	686	668	1 143	184
2004	23 331	405	440	1 078	93
2005	11 952	173	230	1 997	53
2006	23 415	126	450	6 829	28
2007	35 517	86	670	16 989	28

Table 26: Shows the No. of Triangular arbitrage opportunities, as well as the descriptive statistics, for EUR/GBP – GBP/USD – USD/JPY – EUR/JPY (with volume). * Weekly.

From table 26 we see that the total number of arbitrage opportunities per year was 42 847 in 2000 and 35 157 in 2007, respectively. This is a decline of 16 %. In appendix 19 we see that in year 2007 we have a few extreme observations,

especially week 16 with 16 989 opportunities. This implies that the weekly median is a more proper measure. Further, we observe that the weekly median is 803 in 2000 and 86 in 2007, resulting in a decrease of 89 %. Compared to any of the triangular roundtrips we see that the total number of arbitrage opportunities per year is lower.

Year	No. Of Arbitrage	Descriptive Statistics						
		Trading income	Trading income*	Trading cost**	Trading profit	Trading profit*	Profit per trade	Profit per trade*
2003	35 409	€ 18.37	€ 15.40	€ 0.28	€ 18.09	€ 15.11	€ 0.000511	€ 0.000427
2004	23 331	€ 9.24	€ 5.89	€ 0.19	€ 9.06	€ 5.70	€ 0.000396	€ 0.000244
2005	11 952	€ 1.95	€ 0.98	€ 0.10	€ 1.85	€ 0.89	€ 0.000163	€ 0.000074
2006	23 415	€ 6.29	€ 0.67	€ 0.19	€ 6.10	€ 0.48	€ 0.000269	€ 0.000021
2007	35 517	€ 14 945.77	€ 0.34	€ 0.28	€ 14 945.49	€ 0.05	€ 0.420806	€ 0.000001

Table 27: Shows the profit statistics for EUR/GBP – GBP/USD – USD/JPY – EUR/JPY. All calculations are reported in millions of Euros. *Estimated: weekly median x weeks per year ** Estimated: EUR 2 per trade, EUR 8 per roundtrip

Table 27 shows that trading income have been decreasing from 2003 to 2005 (EUR 18 to EUR 1.95), while in 2007 we see an extreme increase to EUR 14 945. By looking at appendix 20 we see that this result is due to week 16, which has a trading income of EUR 14 939. This result is probably due to either lack of liquidity and bid/ask spreads, or an error in the data provided by EBS. We will therefore focus on (*) results. Further, we observe that trading income (*) have been decreasing by 97 % from 2003 to 2007 (EUR 15.4 to EUR 340 000). This gives a more realistic understanding of what kind of trading income one can be able to get from the multi-currency arbitrage over this time period. Trading profit (*) has decreased by 99 % from 2003 to 2007 (EUR 15 to EUR 50 000). This results show that multicurrency arbitrage has become less profitable in the last couple of years, with almost no profit potential from 2005 to 2007, i.e. increased efficiency in the FX market. One reason for these results can be due to the rapidly growing number of HFTs operating in the currency market, which makes is tougher for arbitrageurs to find opportunities.

6.2.2 EUR/JPY – USD/JPY – GBP/USD – EUR/GBP

This roundtrip is the reverse trip of EUR/GBP – GBP/USD – USD/JPY – EUR/JPY.

Year	No. Of Arbitrage	Descriptive Statistics			
		Median *	Mean *	Maximum *	Minimum *
2000	104 186	1 814	2 004	4 737	600
2001	85 826	1 457	1 651	3 476	599
2002	73 522	1 296	1 414	3 342	483
2003	158 399	2 353	2 989	7 934	741
2004	55 869	960	1 054	3 072	60
2005	21 345	406	410	1 592	67
2006	31 907	240	614	8 185	49
2007	26 951	108	509	5 358	17

Table 28: Shows the No. of Triangular arbitrage opportunities, as well as the descriptive statistics, for EUR/JPY – USD/JPY – GBP/USD – EUR/GBP (with volume). * Weekly.

Table 28 shows that the total number of arbitrage opportunities per year was 104 186 in 2000 and 26 951 in 2007, i.e. decline of 75 %. We see a downward sloping trend in the numbers except for in 2003, where there is an increase of over 100 % (73 522 to 158 399) from previous year. We observe that both the mean and the median also increase from 2002 to 2003, indicating that the result is driven by steady growth in opportunities, rather than extreme observations. These indications are backed up by looking at appendix 21, where we show weekly numbers for the sample period. Contrary, to the ordinary roundtrip, we see that the extreme observation in week 16 (2007) is eliminated. Further, we observe that the weekly median is decreasing by 94 % (1 814 to 108) over the entire time period.

Year	No. Of Arbitrage	Descriptive Statistics						
		Trading income	Trading income*	Trading cost**	Trading profit	Trading profit*	Profit per trade	Profit per trade*
2003	158 399	€ 631.18	€ 326.70	€ 1.27	€ 629.91	€ 325.44	€ 0.00398	€ 0.00205
2004	55 869	€ 127.01	€ 52.06	€ 0.45	€ 126.56	€ 51.62	€ 0.00227	€ 0.00092
2005	21 345	€ 11.37	€ 8.69	€ 0.17	€ 11.20	€ 8.52	€ 0.00053	€ 0.00040
2006	31 907	€ 19.24	€ 3.27	€ 0.26	€ 18.99	€ 3.01	€ 0.00060	€ 0.00009
2007	26 951	€ 28.43	€ 1.23	€ 0.22	€ 28.22	€ 1.02	€ 0.00106	€ 0.00004

Table 29: Shows the profit statistics for EUR/JPY – USD/JPY – GBP/USD – EUR/GBP. All calculations are reported in millions of Euros. *Estimated: weekly median x weeks per year ** Estimated: EUR 2 per trade, EUR 8 per roundtrip

Table 29 shows that trading income has decreased by 95 % from 2003 to 2007 (EUR 631 to EUR 28.4), while trading income (*) has decreased by 99 % (EUR 326 to EUR 1.2) for the same time period. Further, we observe that trading profit have been decreasing by 95 % (EUR 629 to EUR 28.2), and trading profit (*) by 99 % (EUR 325 to EUR 1.02), however we see an increase in the actual trading profit in 2006 and 2007 (EUR 18.9 and EUR 28.2). In appendix 22 we observe that some few weeks accounts for most of these profit increases, for example week 1, 3, 46 and 47 in 2007. Trading profit (*) in 2007 is only EUR 1 000 000,

indicating that multicurrency arbitrage has become, less to almost, not profitable in the last couple of years.

6.2.3 EUR/GBP – GBP/USD – USD/CHF – EUR/CHF

Similar to the multi-currency roundtrip under section 6.1.2, we were able to detect this one from 2000 to 2007.

Year	No. Of Arbitrage	Descriptive Statistics			
		Median *	Mean *	Maximum *	Minimum *
2000	31 532	630	606	971	201
2001	26 130	473	503	917	310
2002	23 750	413	457	881	192
2003	28 083	506	530	1 022	94
2004	16 533	284	312	863	68
2005	8 051	134	155	444	32
2006	6 133	92	118	456	28
2007	5 148	51	97	749	23

Table 30: Shows the No. of Triangular arbitrage opportunities, as well as the descriptive statistics, for EUR/GBP – GBP/USD – USD/CHF – EUR/CHF (with volume). * Weekly.

From table 30 we see that the total number of arbitrage opportunities was 31 532 in 2000 and 5 148 in 2007. This is a reduction of 83 % in opportunities. Further, we observe that the weekly median is 630 in 2000 and 51 in 2007, resulting in a reduction 91 %. There is a reduction in the number of opportunities, median and mean for every year except for in 2003 where we observe an increase, mainly driven by an overall steady growth in number of opportunities per week (see appendix 23).

Year	No. Of Arbitrage	Descriptive Statistics						
		Trading income	Trading income*	Trading cost**	Trading profit	Trading profit*	Profit per trade	Profit per trade*
2003	28 083	€ 19.80	€ 17.92	€ 0.22	€ 19.57	€ 17.70	€ 0.0007	€ 0.0006
2004	16 533	€ 7.76	€ 3.83	€ 0.13	€ 7.63	€ 3.70	€ 0.0005	€ 0.0002
2005	8 051	€ 1.47	€ 1.13	€ 0.06	€ 1.40	€ 1.07	€ 0.0002	€ 0.0001
2006	6 133	€ 0.68	€ 0.41	€ 0.05	€ 0.63	€ 0.36	€ 0.0001	€ 0.0001
2007	5 148	€ 1.44	€ 0.22	€ 0.04	€ 1.40	€ 0.18	€ 0.0003	€ 0.0000

Table 31: Shows the profit statistics for EUR/GBP – GBP/USD – USD/CHF – EUR/CHF. All calculations are reported in millions of Euros. *Estimated: weekly median x weeks per year ** Estimated: EUR 2 per trade, EUR 8 per roundtrip

Table 31 shows that the number of arbitrage opportunities has decreased by 81 % (28 083 to 5 148) from 2003 to 2007. Trading income has decreased by 92 % (EUR 19.8 to EUR 1.44), while trading income (*) has decreased by 98 % (EUR 17.9 to EUR 0.22) in the same time period. Trading profit has decreased by 92 % from 2003 to 2007 (EUR 19.57 to EUR 1.4), while trading profit (*) has decreased by 99 % (EUR 17.7 to EUR 0.18) in the same time period. Overall we see that trading profit decreases every year except from 2006 to 2007 where we observe an increase. We do not observe the same increase in trading profit (*)

from 2006 to 2007, which indicates that this is driven by weekly outliers (appendix 24).

6.2.4 EUR/CHF – USD/CHF – GBP/USD – EUR/GBP

This roundtrip is the reverse trip of EUR/GBP – GBP/USD – USD/CHF – EUR/CHF.

Year	No. Of Arbitrage	Descriptive Statistics			
		Median *	Mean *	Maximum *	Minimum *
2000	68 797	1 200	1 323	2 649	491
2001	50 052	992	963	2 127	487
2002	47 836	890	920	2 042	414
2003	107 244	1 696	2 023	5 745	506
2004	29 538	438	557	2 046	84
2005	11 381	185	219	580	26
2006	12 398	118	238	2 026	19
2007	9 129	65	172	1 327	11

Table 32: Shows the No. of Triangular arbitrage opportunities, as well as the descriptive statistics, for EUR/CHF – USD/CHF – GBP/USD – EUR/GBP (with volume). * Weekly.

Similar, to table 30, table 32 indicates a declining trend. We see that the total number of arbitrage opportunities per year was 68 707 in 2000 and 9 129 in 2007. This is a reduction of 86 %. Further, we observe that the spread between the weekly median and mean is low, suggesting that we have a flat and downward trend. Appendix 25 confirms this. Moreover, we see that the weekly median was 1 200 in 2000 and 65 in 2007, resulting in a decrease of 94 %. Compared to reverse roundtrips under section 6.1 we notice that the total number of arbitrage opportunities per year is lower in a multi-currency arbitrage.

Year	No. Of Arbitrage	Descriptive Statistics						
		Trading income	Trading income*	Trading cost**	Trading profit	Trading profit*	Profit per trade	Profit per trade*
2003	107 244	€ 479.89	€ 227.23	€ 0.86	€ 479.03	€ 226.38	€ 0.00447	€ 0.00211
2004	29 538	€ 76.70	€ 29.48	€ 0.24	€ 76.46	€ 29.25	€ 0.00260	€ 0.00099
2005	11 381	€ 8.06	€ 5.62	€ 0.09	€ 7.97	€ 5.53	€ 0.00071	€ 0.00049
2006	12 398	€ 9.90	€ 1.73	€ 0.10	€ 9.80	€ 1.63	€ 0.00080	€ 0.00013
2007	9 129	€ 7.97	€ 1.02	€ 0.07	€ 7.90	€ 0.94	€ 0.00087	€ 0.00010

Table 33: Shows the profit statistics for EUR/CHF – USD/CHF – GBP/USD – EUR/GBP. All calculations are reported in millions of Euros. *Estimated: weekly median x weeks per year ** Estimated: EUR 2 per trade, EUR 8 per roundtrip

Table 33 shows that trading income has decreased by 98 % (EUR 479 to EUR 7.9) from 2003 to 2007, while trading income (*) has decreased by 99 % (EUR 227 to EUR 1 million) in the same time period. Trading profit has decreased by 98 % from 2003 to 2007 (EUR 479 million to EUR 7.9 million), while trading profit (*) has decreased by 99 % (EUR 226 million to EUR 940 000) in the same time period. Again we see a small increase in trading profit from 2005 to 2006, but not in trading profit (*) which declines every year (see appendix 26).

7.0 Conclusion

In this thesis we have been investigating the efficiency of the FX market by searching for triangular and multi-currency arbitrage opportunities from 1997 to 2007. The arbitrage opportunities we investigate are on Japanese Yen, British pounds and Swiss Francs in contrast to Euros (Deutsche Mark) and US dollars. We show that both triangular and multi-currency arbitrage opportunities exist in the FX market.

Further, we find evidence of a decreasing trend in relation to the total number of arbitrage opportunities per year. This is true for all multi-currency roundtrips, and all triangular roundtrips, with the exception of transactions in Yen against Euros and US dollars, and British pounds against Deutsche Mark. Especially from 2003/2004 when EBS allowed both the main banks and non-bank financial institutions to connect their algorithm trading systems directly to the EBS platform. In most cases we see a decrease of over 50 % and all the way up to 80 – 90 %. Finally, we used actual unmasked volume data to investigate the profit potential of these arbitrage opportunities. Our results show the same negative tendency, i.e. the profit potential has been reduced sharply in recent years with a decrease of over 50 % for all triangular roundtrips, and as high as 99 % for multi-currency roundtrips. We show that profits with respect to triangular arbitrage opportunities is ranging from EUR 0 to EUR 10 million in 2007, while profits in regard to multi-currency arbitrage opportunities are even lower, being in the range of EUR 0 to EUR 1 million in 2007. Our evidence of an advantage to those traders engaged in arbitrage activity support the idea of Grossman and Stiglitz (1976, 1980) “arbitrage paradox”.

Due to EBS’s strong market share in currencies involving USD, JPY and EUR, we are confident in our results for their respective roundtrips. However, our results regarding CHF and especially GBP need to be treated with some scepticism, due to EBS’s lack of market share in these currencies.

Changes in the microstructure of the FX market have contributed to this downward trend, i.e. the massive increase of high frequency traders from the early 2000s. Subsequently, as the market entered into a new era with high frequency traders being the most active participant, the FX market is more efficient than ever

at eliminating mis-pricings. Furthermore, the growing trend of HFT in the FX market will most likely provide implications for how the market is structured and being functioned globally. In order to keep up with the new environment policymakers are recommended to be updated. In some instances, this is carried out through the participation of policymakers in the Foreign Exchange Committees in various jurisdictions.

8.0 Further research

Our research outlines some areas of further research. Since, our focus in arbitrage has been in the form of triangular and multi-currency, it would be interesting to include other arbitrage strategies as well. There is a number of different arbitrage strategies pursued by HFT firms in the FX market. One strategy that could be tested is latency arbitrage. Latency arbitrage refers to the idea that firms receive different market data at different times, i.e. the time lag between when market – makers update their quoted prices and market – moving trades take place. As a HFT firm it is possible to earn a profit by using their received market data in order to detect potential price moves (Bank for International Settlements 2011). Another strategy could be to exploit discrepancies across trading platforms and order book imbalances i.e. liquidity providing.

Further, the data provided by EBS ends in 2007. By expanding our dataset it would be possible to see if the declining trend continuous. Especially, to see the impact of the global financial crisis would be of high interest. Furthermore, if possible, it would be exciting to add one or more currency pair to multi-currency roundtrips.

Finally, as mentioned in the introduction, HFT has the potential to spread to other traded currencies, including some emerging market currencies. To investigate triangular and multi-currency arbitrage in the perspective of emerging currencies such as the Indian rupee is an interesting topic.

9.0 Bibliography

Aiba, Yukihiro, Hatano, Naomichi, Takayasu, Hideki, Kouhei Marumo and Tokiko Shimizu. 2002. “Triangular arbitrage as an interaction among foreign exchange rates.” *Physica A* 310: 467-479.

Akram, Farooq, Dagfinn Rime and Lucio Sarno. 2005. “Arbitrage in the foreign exchange market: Turning on the microscope.”

Working Paper, Research Department – Norges Bank (NB).

Bank for International Settlements. 2010. “Triennial Central Bank Survey: Report on global foreign exchange market activity in 2010.”

Accessed 11.10.2012.

<http://www.bis.org/publ/rpfx10t.pdf>

Bank for International Settlements. 2011. “High-frequency trading in the foreign exchange market.”

Accessed 11.10.2012.

<http://www.bis.org/publ/mktc05.pdf>

Bekaert, Geert and Robert J. Hodrick. 2009. *International financial management*. Upper Saddle River, N.J: Pearson Prentice Hall.

Brogaard, Jonathan A. 2011a. “High Frequency Trading and Volatility.”

Working paper, Foster School of Business – University of Washington.

Brogaard, Jonathan A. 2011b. “The Activity of High Frequency Traders.”

Working paper, Foster School of Business – University of Washington.

Brogaard, Jonathan A. 2011c. “High Frequency Trading and Market Quality.”

Working paper, Foster School of Business – University of Washington.

Chaboud, Alain, Chiquoine, Benjamin, Erik Hjalmarsson and Clara Vega. 2009.

“Rise of the Machines: Algorithmic Trading in the Foreign Exchange.”

Federal Reserve International Finance Discussion Paper 980.

Cvitanic, Jaksa and Andrei A. Kirilenko. 2010. “High Frequency Traders and Asset Prices.”

Working paper, California Institute of Technology – MIT Sloan School of Management.

Euromoney. 2013. “Euromoney Foreign Exchange survey.”

Accessed 03.06.2013.

<http://www.euromoney.com/poll/3301/PollsAndAwards/Foreign-Exchange.html>

Fenn, J. Daniel, Howison D. Sam, McDonald, Mark, Stacy Williams and Neil F. Johnson. 2008. “The mirage of triangular arbitrage in the spot foreign exchange market.”

Working paper, University of Oxford – HSBC Bank – University of Miami.

Gomber, Peter, Arndt, Bjørn, Marco Lutat and Tim Uhle. ”High-Frequency Trading.”

Working paper, Goethe University.

Grossman J. Sanford and Joseph E. Stiglitz. 1980. “On the Impossibility of Informationally Efficient Markets.” *American Economic Review* 70 (3): 393-408.

Grossman J. Sanford and Joseph E. Stiglitz. 1976. “Information and Competitive Price Systems.” *American Economic Review* 66 (2): 246-253.

Hendershott, Terrence, Charles M. Jones and Albert J. Menkveld. 2011. “Does Algorithmic Trading Improve Liquidity?.” *Journal of Finance* 66 (1): 1-33.

Ito, Takatoshi, Yamada, Kenta, Misako Takayasu and Hideki Takayasu. 2012. “Free lunch! Arbitrage opportunities in the foreign exchange markets.”

Working paper, National Bureau of Economic Research.

King, Michael and Dagfinn Rime. 2010. “The \$4 trillion question: what explains FX growth since the 2007 Survey?.” *BIS Quarterly Review*, Dec. 2010: 27-42

Kollias, Christos and Kostantinos Metaxas. 2001. “How efficient are FX markets? Empirical evidence of arbitrage opportunities using high-frequency data.” *Applied Financial Economics* 11: 435-444.

Marshall, R. Ben, Sirimon Treepongkaruna and Martin Young. 2008. “Exploitable Arbitrage Opportunities Exist in the Foreign Exchange Market.”
Working paper, Australia National University – Massey University.

Menkveld, Albert J. 2011. “High Frequency Trading and The *New-Market* Makers.”
Working paper, University Amsterdam.

The Economist. 2005. “Guide to Financial Markets”.

Accessed 03.12.2012.

https://docs.google.com/file/d/0B_Qxj5U7eaJTZTJkODYzN2ItZjE3Yy00Y2M0LTk2ZmUtZGU0NzA3NGI4Y2Y5/edit?pli=1&hl=en

The Huffington Post. 2010. “What is High-Frequency Trading, Afterall?.”

Accessed 11.12.2012.

http://www.huffingtonpost.com/irene-aldrige/what-is-high-frequency-tr_b_639203.html

Appendices

Appendix 1:

USD/DEM – DEM/CHF – USD/CHF		
	1997	1998
<i>Week</i>	<i>Without Volume</i>	<i>Without Volume</i>
Week 1	9 555	16 106
Week 2	14 754	11 239
Week 3	13 269	15 872
Week 4	27 264	15 938
Week 5	29 402	22 859
Week 6	15 110	21 843
Week 7	25 616	11 124
Week 8	24 125	15 605
Week 9	23 796	16 598
Week 10	15 769	12 173
Week 11	28 048	19 724
Week 12	29 380	10 776
Week 13	34 749	11 887
Week 14	17 260	21 266
Week 15	20 294	16 375
Week 16	16 615	14 247
Week 17	346 671	4 478
Week 18	13 328	15 544
Week 19	15 681	5 040
Week 20	29 764	15 756
Week 21	32 295	11 977
Week 22	41 220	10 544
Week 23	24 955	4 742
Week 24	22 234	12 594
Week 25	11 076	13 312
Week 26	114 079	15 853
Week 27	9 570	6 924
Week 28	15 849	11 486
Week 29	23 100	14 805
Week 30	14 849	35 230
Week 31	21 993	15 686
Week 32	21 824	9 317
Week 33	347 156	12 826
Week 34	20 297	9 647
Week 35	18 149	50 288
Week 36	13 857	24 309
Week 37	17 089	11 528
Week 38	25 335	22 440
Week 39	45 648	17 311
Week 40	34 788	28 739
Week 41	16 429	16 394
Week 42	12 712	21 462
Week 43	22 593	17 512
Week 44	21 473	9 239
Week 45	17 510	12 053
Week 46	28 530	6 702
Week 47	16 585	12 456
Week 48	93 305	13 723
Week 49	8 552	7 417
Week 50	14 323	22 527
Week 51	7 515	9 894
Week 52	4 054	5 053
Week 53	6 764	

Appendix 2:

USD/CHF – DEM/CHF – USD/DEM		
	1997	1998
<i>Week</i>	<i>Without Volume</i>	<i>Without Volume</i>
Week 1	7 323	16 795
Week 2	16 234	11 418
Week 3	8 957	13 665
Week 4	27 159	19 305
Week 5	18 430	12 016
Week 6	14 789	10 134
Week 7	28 100	13 315
Week 8	14 786	13 498
Week 9	26 890	12 650
Week 10	24 475	18 865
Week 11	11 390	11 310
Week 12	23 122	6 686
Week 13	16 871	9 594
Week 14	35 749	14 890
Week 15	15 792	9 639
Week 16	11 377	12 777
Week 17	341 847	57 662
Week 18	50 286	10 172
Week 19	24 077	5 992
Week 20	12 675	8 677
Week 21	33 150	18 776
Week 22	59 833	8 240
Week 23	16 335	50 490
Week 24	17 671	12 705
Week 25	8 040	15 151
Week 26	102 780	9 055
Week 27	15 053	9 084
Week 28	8 611	11 091
Week 29	26 051	7 075
Week 30	17 377	8 064
Week 31	10 829	9 466
Week 32	10 668	7 879
Week 33	394 273	16 581
Week 34	17 883	9 245
Week 35	22 705	21 322
Week 36	17 552	21 440
Week 37	25 983	14 245
Week 38	21 382	24 323
Week 39	16 186	13 993
Week 40	48 048	35 194
Week 41	11 406	28 778
Week 42	12 104	16 077
Week 43	16 776	17 412
Week 44	20 555	26 127
Week 45	29 893	14 591
Week 46	18 961	8 864
Week 47	16 606	12 899
Week 48	87 354	27 340
Week 49	7 996	8 564
Week 50	12 627	10 529
Week 51	12 261	30 729
Week 52	64 186	61 331
Week 53	31 105	

Appendix 3:

USD/DEM – DEM/JPY – USD/JPY		
	1997	1998
<i>Week</i>	<i>Without Volume</i>	<i>Without Volume</i>
Week 1	4 236	12 682
Week 2	7 697	43 243
Week 3	12 076	15 686
Week 4	10 051	18 781
Week 5	8 838	12 980
Week 6	8 606	20 803
Week 7	10 193	12 841
Week 8	9 632	14 336
Week 9	9 798	14 913
Week 10	7 483	13 464
Week 11	8 755	12 914
Week 12	29 399	12 544
Week 13	4 030	15 172
Week 14	9 717	9 458
Week 15	8 366	11 418
Week 16	7 579	10 375
Week 17	351 889	23 120
Week 18	12 381	13 057
Week 19	10 165	10 803
Week 20	13 231	8 196
Week 21	11 147	11 025
Week 22	7 243	11 219
Week 23	8 847	8 101
Week 24	13 320	19 863
Week 25	8 110	12 332
Week 26	107 548	15 863
Week 27	12 389	11 204
Week 28	10 469	18 729
Week 29	14 786	10 296
Week 30	8 493	12 701
Week 31	10 010	13 682
Week 32	13 600	13 910
Week 33	345 843	17 445
Week 34	9 572	13 502
Week 35	12 540	19 541
Week 36	14 831	24 621
Week 37	17 301	14 346
Week 38	12 446	21 771
Week 39	16 112	17 592
Week 40	7 250	27 370
Week 41	52 398	15 788
Week 42	11 526	14 080
Week 43	12 741	14 398
Week 44	25 909	11 172
Week 45	13 853	11 571
Week 46	16 016	14 645
Week 47	17 240	10 520
Week 48	95 856	11 186
Week 49	10 833	9 650
Week 50	12 310	11 385
Week 51	10 997	5 112
Week 52	1 513	13 602
Week 53	24 107	

Appendix 4:

USD/JPY – DEM/JPY – USD/DEM		
	1997	1998
<i>Week</i>	<i>Without Volume</i>	<i>Without Volume</i>
Week 1	2456	15374
Week 2	7957	10537
Week 3	6623	20601
Week 4	11342	20132
Week 5	12902	16289
Week 6	9953	12326
Week 7	12768	12461
Week 8	11718	18429
Week 9	11643	13667
Week 10	9206	14977
Week 11	8847	14958
Week 12	7939	10660
Week 13	140540	12251
Week 14	9667	121797
Week 15	11219	14503
Week 16	8655	16629
Week 17	352874	141143
Week 18	98623	14081
Week 19	96222	8911
Week 20	30100	109674
Week 21	14528	45058
Week 22	78275	13848
Week 23	10038	100417
Week 24	16016	19237
Week 25	8929	15141
Week 26	110924	15419
Week 27	8472	13897
Week 28	12028	13351
Week 29	9442	10262
Week 30	9663	12662
Week 31	12420	14691
Week 32	12871	16055
Week 33	350037	14715
Week 34	12016	18308
Week 35	17063	21545
Week 36	14016	17990
Week 37	15502	13580
Week 38	14470	14018
Week 39	15306	18171
Week 40	68634	32404
Week 41	11120	16661
Week 42	11787	12941
Week 43	13179	11419
Week 44	16651	13019
Week 45	20556	14310
Week 46	16778	12810
Week 47	14227	8927
Week 48	97543	14406
Week 49	11702	11233
Week 50	16902	11877
Week 51	44827	33695
Week 52	145460	7078
Week 53	79588	

Appendix 5:

GBP/USD– USD/DEM –GBP/DEM		
	1997	1998
<i>Week</i>	<i>Without Volume</i>	<i>Without Volume</i>
Week 1	27912	142915
Week 2	57306	184285
Week 3	78568	56059
Week 4	135324	223619
Week 5	154450	68944
Week 6	48247	82687
Week 7	116549	78922
Week 8	37837	138889
Week 9	135476	98089
Week 10	37430	97049
Week 11	59924	200314
Week 12	55751	101641
Week 13	49882	129530
Week 14	96614	228683
Week 15	56001	101538
Week 16	67139	52205
Week 17	112282	131143
Week 18	115594	100458
Week 19	79393	216569
Week 20	91827	73163
Week 21	60367	223560
Week 22	44929	110777
Week 23	64295	271195
Week 24	31924	137723
Week 25	38553	233859
Week 26	102777	92361
Week 27	112228	101125
Week 28	75619	49729
Week 29	109548	109155
Week 30	180012	102765
Week 31	92421	135178
Week 32	69148	160076
Week 33	281079	94961
Week 34	155567	116466
Week 35	186894	58083
Week 36	93446	107699
Week 37	49321	155509
Week 38	184633	129371
Week 39	398781	101012
Week 40	144354	122945
Week 41	72112	72601
Week 42	102842	85186
Week 43	134726	104455
Week 44	113570	140611
Week 45	117311	46251
Week 46	162677	149417
Week 47	164823	33611
Week 48	223914	124876
Week 49	197530	67175
Week 50	194368	75777
Week 51	159368	87376
Week 52	93563	70693
Week 53	36757	

Appendix 6:

GBP/DEM– USD/DEM –GBP/USD		
	1997	1998
<i>Week</i>	<i>Without Volume</i>	<i>Without Volume</i>
Week 1	49914	137741
Week 2	71147	108379
Week 3	73090	245512
Week 4	202166	96809
Week 5	47721	188294
Week 6	131359	210506
Week 7	37179	182756
Week 8	92642	146652
Week 9	79151	129494
Week 10	94890	119961
Week 11	86263	138063
Week 12	81381	119533
Week 13	95955	176787
Week 14	74085	95237
Week 15	37187	128772
Week 16	50452	272873
Week 17	324351	149490
Week 18	40627	213510
Week 19	77031	106720
Week 20	60758	230480
Week 21	97516	61119
Week 22	78812	201221
Week 23	81853	32965
Week 24	65247	197342
Week 25	94613	89497
Week 26	72173	200995
Week 27	82911	133383
Week 28	83561	163868
Week 29	70076	69748
Week 30	74399	80086
Week 31	111605	74293
Week 32	115933	70319
Week 33	212637	96961
Week 34	67103	101160
Week 35	56172	238670
Week 36	112659	213255
Week 37	123229	92568
Week 38	62759	156865
Week 39	0	195020
Week 40	81818	201206
Week 41	159452	217801
Week 42	156928	182964
Week 43	125201	75401
Week 44	199800	52873
Week 45	179793	122106
Week 46	101367	31327
Week 47	106548	111648
Week 48	42018	102205
Week 49	124998	94369
Week 50	127583	54928
Week 51	171193	79458
Week 52	196061	161250
Week 53	213121	

Appendix 7:

EUR/GBP– GBP/USD –EUR/USD								
	2000	2001	2002	2003	2004	2005	2006	2007
<i>Week</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>
Week 1	520	735	511	424	180	556	107	158
Week 2	641	1004	590	864	456	273	89	491
Week 3	557	852	394	667	671	465	111	275
Week 4	514	1130	437	668	579	400	96	182
Week 5	627	843	797	976	413	381	130	356
Week 6	781	834	646	799	371	355	73	138
Week 7	492	955	622	621	502	535	115	93
Week 8	904	840	501	650	371	460	170	75
Week 9	899	838	485	919	502	309	195	156
Week 10	656	653	573	843	504	383	147	132
Week 11	796	837	508	749	745	289	438	108
Week 12	504	944	531	780	646	478	463	90
Week 13	798	645	415	590	571	423	242	198
Week 14	832	727	481	883	629	377	342	139
Week 15	736	813	495	757	430	421	170	111
Week 16	718	802	438	500	542	329	311	61
Week 17	628	1126	549	508	715	346	300	88
Week 18	619	821	452	522	384	398	403	150
Week 19	672	651	495	380	808	414	331	61
Week 20	749	655	526	526	415	404	463	64
Week 21	692	760	756	541	591	290	354	103
Week 22	817	765	504	500	370	376	447	46
Week 23	688	719	396	526	370	264	339	100
Week 24	528	858	568	577	622	373	247	107
Week 25	892	598	384	495	374	360	298	73
Week 26	656	664	919	496	247	424	353	90
Week 27	511	562	955	545	406	373	194	47
Week 28	531	712	695	677	193	406	226	90
Week 29	473	748	954	517	342	636	261	86
Week 30	532	785	1100	419	269	264	183	68
Week 31	644	589	984	607	437	294	209	66
Week 32	609	815	928	363	224	159	308	59
Week 33	607	692	590	346	233	138	189	154
Week 34	619	834	786	509	182	163	219	143
Week 35	545	691	587	399	370	252	219	66
Week 36	969	695	654	283	285	258	125	86
Week 37	873	739	947	355	170	241	159	116
Week 38	753	757	886	528	173	208	98	116
Week 39	810	811	726	489	287	216	133	78
Week 40	597	710	799	413	175	248	128	89
Week 41	663	503	693	480	209	147	132	66
Week 42	831	666	493	460	214	193	162	125
Week 43	932	630	492	564	301	190	127	103
Week 44	901	561	559	528	344	182	136	72
Week 45	760	621	535	455	341	227	156	109
Week 46	779	781	677	218	239	176	204	1356
Week 47	633	511	758	468	185	175	199	972
Week 48	650	646	582	379	187	245	482	380
Week 49	839	492	636	495	344	130	349	323
Week 50	982	670	641	450	357	141	631	198
Week 51	946	844	620	269	620	135	255	107
Week 52	435	471	329	219	376	231	247	57
Week 53				180	594			96

Appendix 8:

EUR/GBP– GBP/USD –EUR/USD					
	2003	2004	2005	2006	2007
Week	Total Profit	Total Profit	Total Profit	Total Profit	Total Profit
Week 1	€ 0.1416	€ 0.0255	€ 0.0866	€ 0.0118	€ 0.0135
Week 2	€ 0.3446	€ 0.0767	€ 0.0344	€ 0.0052	€ 0.0456
Week 3	€ 0.1703	€ 0.1348	€ 0.0725	€ 0.0142	€ 0.0157
Week 4	€ 0.2373	€ 0.0709	€ 0.0335	€ 0.0072	€ 0.0166
Week 5	€ 0.8228	€ 0.2833	€ 0.0399	€ 0.0116	€ 0.0158
Week 6	€ 0.3427	€ 0.0521	€ 0.0455	€ 0.0058	€ 0.0070
Week 7	€ 0.2357	€ 0.0774	€ 0.0763	€ 0.0061	€ 0.0052
Week 8	€ 0.2167	€ 0.0521	€ 0.0485	€ 0.0153	€ 0.0047
Week 9	€ 0.4571	€ 0.0774	€ 0.0260	€ 0.0142	€ 0.0097
Week 10	€ 0.2496	€ 0.0785	€ 0.0560	€ 0.0143	€ 0.0080
Week 11	€ 0.2490	€ 0.1612	€ 0.0208	€ 0.0303	€ 0.0065
Week 12	€ 0.3397	€ 0.1345	€ 0.0506	€ 0.0255	€ 0.0043
Week 13	€ 0.1848	€ 0.0944	€ 0.0543	€ 0.0260	€ 0.0112
Week 14	€ 0.3630	€ 0.1521	€ 0.0562	€ 0.0353	€ 0.0111
Week 15	€ 0.1991	€ 0.0766	€ 0.1450	€ 0.0152	€ 0.0053
Week 16	€ 0.1952	€ 0.1033	€ 0.0233	€ 0.0259	€ 0.0032
Week 17	€ 0.2094	€ 0.1611	€ 0.0271	€ 0.0275	€ 0.0045
Week 18	€ 0.1371	€ 0.0623	€ 0.0374	€ 0.0500	€ 0.0087
Week 19	€ 0.2516	€ 0.1558	€ 0.0501	€ 0.0832	€ 0.0030
Week 20	€ 0.1234	€ 0.0828	€ 0.0325	€ 0.1066	€ 0.0024
Week 21	€ 0.1741	€ 0.1047	€ 0.0236	€ 0.0312	€ 0.0054
Week 22	€ 0.1546	€ 0.0491	€ 0.0333	€ 0.0323	€ 0.0016
Week 23	€ 0.2237	€ 0.0568	€ 0.0191	€ 0.0379	€ 0.0047
Week 24	€ 0.3949	€ 0.3119	€ 0.0386	€ 0.0188	€ 0.0036
Week 25	€ 0.0793	€ 0.0627	€ 0.0284	€ 0.0271	€ 0.0055
Week 26	€ 0.2580	€ 0.0270	€ 0.0319	€ 0.0249	€ 0.0033
Week 27	€ 0.1451	€ 0.0614	€ 0.0323	€ 0.0119	€ 0.0039
Week 28	€ 0.7741	€ 0.0154	€ 0.0504	€ 0.0120	€ 0.0038
Week 29	€ 0.1283	€ 0.0341	€ 0.0541	€ 0.0191	€ 0.0044
Week 30	€ 0.0807	€ 0.0324	€ 0.0183	€ 0.0114	€ 0.0025
Week 31	€ 0.0993	€ 0.0624	€ 0.0195	€ 0.0131	€ 0.0033
Week 32	€ 0.0466	€ 0.0343	€ 0.0107	€ 0.0213	€ 0.0027
Week 33	€ 0.0567	€ 0.0273	€ 0.0122	€ 0.0197	€ 0.0203
Week 34	€ 0.0726	€ 0.0150	€ 0.0129	€ 0.0161	€ 0.0296
Week 35	€ 0.0880	€ 0.0358	€ 0.0242	€ 0.0161	€ 0.0036
Week 36	€ 0.0730	€ 0.0335	€ 0.0183	€ 0.0078	€ 0.0060
Week 37	€ 0.0498	€ 0.0194	€ 0.0253	€ 0.0096	€ 0.0099
Week 38	€ 0.0878	€ 0.0266	€ 0.0172	€ 0.0036	€ 0.0099
Week 39	€ 0.0922	€ 0.0251	€ 0.0156	€ 0.0102	€ 0.0028
Week 40	€ 0.1110	€ 0.0162	€ 0.0350	€ 0.0098	€ 0.0051
Week 41	€ 0.0739	€ 0.0277	€ 0.0157	€ 0.0075	€ 0.0029
Week 42	€ 0.0929	€ 0.0265	€ 0.0191	€ 0.0098	€ 0.0067
Week 43	€ 0.0592	€ 0.0275	€ 0.0138	€ 0.0131	€ 0.0059
Week 44	€ 0.0902	€ 0.0333	€ 0.0185	€ 0.0154	€ 0.0061
Week 45	€ 0.1629	€ 0.0653	€ 0.0596	€ 0.0114	€ 0.0048
Week 46	€ 0.0221	€ 0.0244	€ 0.0164	€ 0.0126	€ 0.9188
Week 47	€ 0.0659	€ 0.0334	€ 0.0154	€ 0.0129	€ 0.3643
Week 48	€ 0.0831	€ 0.0266	€ 0.0286	€ 0.0238	€ 0.2845
Week 49	€ 0.0513	€ 0.0407	€ 0.0090	€ 0.0203	€ 0.1550
Week 50	€ 0.0659	€ 0.0517	€ 0.0107	€ 0.0415	€ 0.0621
Week 51	€ 0.1495	€ 0.0985	€ 0.0114	€ 0.0143	€ 0.0261
Week 52	€ 0.0399	€ 0.0588	€ 0.0128	€ 0.0222	€ 0.0111
Week 53	€ 0.0255	€ 0.1331			€ 0.0245

Appendix 9:

EUR/USD– GBP/USD –EUR/GBP								
	2000	2001	2002	2003	2004	2005	2006	2007
<i>Week</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>
Week 1	10600	6328	2639	11767	3708	1998	1009	2376
Week 2	13079	5981	2533	8758	4372	775	127	952
Week 3	10789	8158	1491	8601	5849	2850	116	3051
Week 4	8094	6453	2935	7509	4153	1705	172	1756
Week 5	6279	5190	1698	9728	6099	2111	105	1075
Week 6	3118	3310	2682	12885	6255	1801	79	395
Week 7	4758	5812	2008	11071	4958	2166	277	198
Week 8	6638	5263	2055	7854	6255	1872	304	118
Week 9	9642	5605	2423	8442	4958	1444	263	664
Week 10	4639	3592	3441	15256	11745	1898	786	670
Week 11	3207	4818	3368	10170	6894	1136	2448	172
Week 12	5840	4689	1888	13081	3607	2830	2574	249
Week 13	3292	4563	1586	16053	2779	2191	949	297
Week 14	5249	6323	2998	17897	8258	1626	2562	290
Week 15	4403	3470	2144	15350	2034	1594	379	134
Week 16	3876	7392	4279	15877	8468	1788	749	97
Week 17	4406	4818	2263	16497	2896	1353	483	83
Week 18	8882	4103	3488	27817	10321	2239	638	64
Week 19	10034	3264	4886	25555	5304	1304	2463	63
Week 20	3996	2578	3806	16700	7921	1003	1001	101
Week 21	7065	5510	3873	24331	4951	232	1599	85
Week 22	5621	3792	5995	7542	5902	699	1564	62
Week 23	9487	4716	5524	24896	3982	779	554	58
Week 24	5386	7750	4397	18740	1823	1313	428	73
Week 25	4290	3863	5655	16787	4146	960	604	60
Week 26	4172	4125	14131	11468	3535	1144	1780	84
Week 27	3314	2896	5221	8155	2424	1372	454	83
Week 28	2709	4010	3201	4240	5075	875	462	96
Week 29	2659	4730	8300	7309	3159	1189	398	80
Week 30	4996	4118	6192	10355	4042	773	905	153
Week 31	3484	3581	6635	6603	1158	591	787	93
Week 32	4129	2852	5784	7769	4724	448	267	96
Week 33	5813	5307	9439	5052	1341	355	797	417
Week 34	4719	2772	5610	6239	1310	354	215	69
Week 35	5479	3788	6562	6488	466	322	215	65
Week 36	5648	5356	4249	8642	2423	422	245	96
Week 37	7567	5314	3446	10165	1484	353	225	93
Week 38	9929	7910	7108	8183	1316	356	345	93
Week 39	5266	2981	4507	5178	949	282	184	82
Week 40	4234	4525	4684	14445	765	434	344	117
Week 41	3965	3890	4524	7355	589	215	169	84
Week 42	5485	2352	2723	6682	1169	542	193	118
Week 43	5171	1860	2988	4904	1406	586	233	156
Week 44	7816	4616	4798	3640	1591	353	163	132
Week 45	9326	2915	6906	6231	2489	711	141	345
Week 46	2179	3491	4586	6302	778	445	515	5186
Week 47	4914	2402	3445	6075	217	331	1310	5372
Week 48	9694	3213	3224	4443	2167	366	301	327
Week 49	7411	2588	5535	5346	2347	109	3523	766
Week 50	6123	5536	5063	8170	1455	275	1836	399
Week 51	8101	3668	4631	7480	2747	71	1209	350
Week 52	2879	2555	5129	3636	1453	820	2168	41
Week 53				3708	1517			1475

Appendix 10:

EUR/USD– GBP/USD –EUR/GBP					
	2003	2004	2005	2006	2007
Week	Total Profit	Total Profit	Total Profit	Total Profit	Total Profit
Week 1	€ 15.4237	€ 17.4589	€ 3.7049	€ 4.0698	€ 5.6633
Week 2	€ 49.1799	€ 29.4200	€ 1.2082	€ 0.0325	€ 0.7374
Week 3	€ 46.4622	€ 16.4814	€ 5.1387	€ 0.0449	€ 18.5543
Week 4	€ 31.4572	€ 14.6114	€ 1.9256	€ 0.1696	€ 2.5971
Week 5	€ 36.0974	€ 27.4550	€ 2.8609	€ 0.0614	€ 1.7175
Week 6	€ 58.0300	€ 22.3142	€ 1.6995	€ 0.0260	€ 0.2007
Week 7	€ 51.4925	€ 9.5774	€ 2.7775	€ 0.3327	€ 0.1609
Week 8	€ 25.3102	€ 22.3142	€ 1.7934	€ 0.1405	€ 0.0272
Week 9	€ 33.0675	€ 9.5774	€ 1.3858	€ 0.0753	€ 0.9523
Week 10	€ 111.9032	€ 72.4177	€ 1.7297	€ 1.0045	€ 1.6864
Week 11	€ 53.2166	€ 37.7272	€ 0.8368	€ 5.0702	€ 0.0618
Week 12	€ 64.8060	€ 8.7215	€ 7.9638	€ 5.9032	€ 0.3675
Week 13	€ 84.6426	€ 6.0540	€ 7.4812	€ 0.6778	€ 0.3659
Week 14	€ 103.8810	€ 34.2740	€ 1.3318	€ 5.5800	€ 0.1985
Week 15	€ 101.4492	€ 3.9459	€ 1.5999	€ 0.7560	€ 0.0368
Week 16	€ 90.2182	€ 41.1080	€ 1.5427	€ 0.5173	€ 0.0201
Week 17	€ 151.0784	€ 9.3954	€ 0.9925	€ 0.2488	€ 0.0524
Week 18	€ 390.0717	€ 69.4047	€ 3.3057	€ 0.8986	€ 0.0178
Week 19	€ 267.7611	€ 12.5411	€ 3.2970	€ 12.2148	€ 0.0148
Week 20	€ 175.3557	€ 52.1727	€ 1.2940	€ 0.5810	€ 0.0666
Week 21	€ 228.0040	€ 29.9052	€ 0.0717	€ 2.0512	€ 0.0159
Week 22	€ 43.6840	€ 8.8762	€ 0.7745	€ 2.9299	€ 0.0133
Week 23	€ 408.5885	€ 13.3362	€ 0.8497	€ 0.2715	€ 0.0362
Week 24	€ 210.2221	€ 3.5269	€ 2.0459	€ 0.1229	€ 0.0162
Week 25	€ 365.6872	€ 9.0941	€ 0.6826	€ 0.6322	€ 0.0076
Week 26	€ 61.3250	€ 7.0332	€ 1.0848	€ 4.9037	€ 0.0587
Week 27	€ 59.0786	€ 3.6602	€ 1.6428	€ 1.4438	€ 0.0164
Week 28	€ 16.1357	€ 27.9727	€ 0.6019	€ 0.2181	€ 0.0601
Week 29	€ 41.6683	€ 7.3965	€ 1.0940	€ 0.2183	€ 0.0230
Week 30	€ 57.0739	€ 10.9780	€ 0.4271	€ 1.4029	€ 0.0547
Week 31	€ 35.9297	€ 1.2995	€ 0.3524	€ 1.1602	€ 0.0168
Week 32	€ 70.6542	€ 15.5834	€ 0.2261	€ 0.1459	€ 0.0252
Week 33	€ 28.7554	€ 2.3983	€ 0.1881	€ 0.9049	€ 0.9142
Week 34	€ 20.2794	€ 3.0398	€ 0.2433	€ 0.1775	€ 0.0181
Week 35	€ 37.5984	€ 0.4150	€ 0.2008	€ 0.1775	€ 0.0144
Week 36	€ 44.4132	€ 4.9101	€ 0.5735	€ 0.0929	€ 0.0528
Week 37	€ 75.9797	€ 9.7124	€ 0.1945	€ 0.0754	€ 0.0811
Week 38	€ 34.8536	€ 3.1496	€ 0.2412	€ 0.4367	€ 0.0811
Week 39	€ 25.3728	€ 5.8355	€ 0.1211	€ 0.0558	€ 0.0144
Week 40	€ 127.9030	€ 1.1086	€ 0.1963	€ 0.4862	€ 0.0229
Week 41	€ 31.6994	€ 0.9768	€ 0.0964	€ 0.1081	€ 0.0282
Week 42	€ 34.9174	€ 10.3471	€ 0.2200	€ 0.1713	€ 0.0212
Week 43	€ 15.9199	€ 2.2143	€ 0.2922	€ 0.1160	€ 0.0722
Week 44	€ 8.7546	€ 2.6366	€ 0.2902	€ 0.0486	€ 0.0519
Week 45	€ 25.4726	€ 6.8124	€ 2.5933	€ 0.0503	€ 1.2895
Week 46	€ 24.1361	€ 1.4597	€ 0.1575	€ 0.2655	€ 15.5403
Week 47	€ 30.0809	€ 0.1781	€ 0.2174	€ 1.5505	€ 23.5454
Week 48	€ 19.3502	€ 7.1703	€ 0.2308	€ 0.2366	€ 0.2048
Week 49	€ 25.4826	€ 8.2277	€ 0.0510	€ 13.4637	€ 1.4766
Week 50	€ 54.8305	€ 2.9529	€ 0.3820	€ 1.7713	€ 0.3331
Week 51	€ 40.6802	€ 4.5166	€ 0.0165	€ 0.9029	€ 0.3733
Week 52	€ 8.7662	€ 3.0140	€ 0.9751	€ 2.2763	€ 0.0073
Week 53	€ 17.4589	€ 2.3377			€ 5.0157

Appendix 11:

EUR/USD– USD/JPY –EUR/JPY																
Week	2000		2001		2002		2003		2004		2005		2006		2007	
	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume
Week 1	2537	2274	3278	4941	4784	2873	1405	381								
Week 2	2474	3377	2470	3909	3531	2920	2563	1496								
Week 3	2587	3600	1541	2394	3428	2503	1827	1335								
Week 4	2434	3290	2094	2516	2286	2463	2545	1907								
Week 5	2724	2865	2221	2857	2920	1985	2323	1690								
Week 6	1855	2710	2797	3809	3169	2358	1931	1020								
Week 7	2445	2799	1946	3164	3283	2432	1864	1756								
Week 8	2752	2857	1666	2848	3169	2277	1548	1624								
Week 9	3193	3573	1618	2642	3283	1911	1977	2724								
Week 10	2666	3299	2448	2863	3883	2174	1994	2461								
Week 11	2216	2972	1817	2900	3344	2179	1591	2073								
Week 12	1952	2564	4239	6062	3145	20369	1134	1071								
Week 13	2581	2814	4932	2533	2724	2117	2266	1678								
Week 14	2707	3837	1839	2866	2780	1874	2967	28331								
Week 15	2494	12471	1557	3004	4587	2546	26032	1238								
Week 16	12464	3109	1779	8209	2686	2566	2168	53273								
Week 17	10185	4690	3380	3808	2847	1485	22867	2986								
Week 18	1017	6646	10874	12871	10285	833	523	14433								
Week 19	2941	1822	1902	4303	3512	1981	2665	1178								
Week 20	2406	2052	2172	3756	3329	1547	3194	1168								
Week 21	2655	2642	2693	4053	3526	1303	2409	1203								
Week 22	2990	2446	2370	1982	2476	2217	1815	1084								
Week 23	2955	2296	2444	3652	2934	1829	2140	1514								
Week 24	2187	2599	2917	2686	2664	2543	1497	1271								
Week 25	1963	2122	2415	3143	2871	2086	1343	1097								
Week 26	2438	2270	3636	3173	2246	2061	1516	1635								
Week 27	2240	1643	2125	3212	3023	1715	1657	1162								
Week 28	1861	2232	2198	3138	2058	1857	1102	990								
Week 29	1112	3844	2441	3856	2579	2855	1571	1061								
Week 30	1991	1958	2530	2537	2031	1874	1640	2461								
Week 31	1906	2163	2195	2577	2504	2428	1488	2411								
Week 32	1884	2003	2204	2159	2055	1898	1410	2325								
Week 33	1802	2576	2167	2314	2250	1542	996	5140								
Week 34	1673	2004	1973	3232	1919	1921	1638	3037								
Week 35	1889	2308	1585	2939	2413	2243	1638	2351								
Week 36	2599	2897	2131	3431	1939	1482	1667	1419								
Week 37	1998	2394	3426	4070	1897	1550	910	815								
Week 38	2906	3140	4801	3124	1824	953	1615	815								
Week 39	2122	2709	2577	3668	2939	1877	1382	1067								
Week 40	1599	2698	2191	3495	2501	1744	1279	1011								
Week 41	1537	1604	2705	3725	1830	1556	928	1199								
Week 42	2031	1665	1761	3543	1832	1739	1190	1743								
Week 43	1773	1646	2091	3029	2075	2104	1083	2254								
Week 44	2236	2232	2304	3254	2726	1242	732	1832								
Week 45	1987	2079	1994	2696	2401	1861	1304	2672								
Week 46	1208	2124	1736	2984	2472	1790	1373	3117								
Week 47	1437	3469	2319	3710	2542	1417	1300	1169								
Week 48	3783	2367	1655	2291	2197	1935	2070	2391								
Week 49	2607	2507	3261	2464	2510	1649	1457	1181								
Week 50	2892	2575	1836	2459	2920	3037	1732	1537								
Week 51	7556	4487	3572	2016	2668	2146	14718	5692								
Week 52	1550	2640	4054	6331	1439	1074	568	2864								
Week 53				4784	1359			1065								

Appendix 12:

EUR/USD– USD/JPY –EUR/JPY					
	2003	2004	2005	2006	2007
Week	Total Profit	Total Profit	Total Profit	Total Profit	Total Profit
Week 1	€ 3.0746	€ 1.6936	€ 1.2154	€ 0.5821	€ 0.0816
Week 2	€ 1.9692	€ 2.8112	€ 1.1045	€ 0.7753	€ 0.2760
Week 3	€ 1.7416	€ 1.6778	€ 0.6988	€ 0.4322	€ 0.2415
Week 4	€ 1.1951	€ 1.1120	€ 0.7399	€ 0.7222	€ 0.3650
Week 5	€ 1.3372	€ 1.2270	€ 0.8791	€ 0.5084	€ 0.3708
Week 6	€ 1.8867	€ 1.5074	€ 0.9339	€ 0.3994	€ 0.2371
Week 7	€ 1.2185	€ 1.2750	€ 0.7498	€ 0.4621	€ 0.4664
Week 8	€ 1.1820	€ 1.5074	€ 0.5728	€ 0.3183	€ 0.3960
Week 9	€ 1.3416	€ 1.2750	€ 0.5235	€ 0.4852	€ 0.6585
Week 10	€ 1.4865	€ 2.7213	€ 0.6546	€ 0.4608	€ 0.5445
Week 11	€ 1.1577	€ 1.4652	€ 0.6013	€ 0.3394	€ 0.4051
Week 12	€ 2.9107	€ 1.2857	€ 16.1657	€ 0.2635	€ 0.2323
Week 13	€ 1.2615	€ 1.0663	€ 0.8710	€ 0.5641	€ 0.3207
Week 14	€ 1.1612	€ 1.4104	€ 0.4981	€ 0.9708	€ 97.5194
Week 15	€ 1.4623	€ 1.6032	€ 0.7086	€ 66.3874	€ 0.2610
Week 16	€ 4.0689	€ 1.1905	€ 0.6779	€ 0.6281	€ 383.8911
Week 17	€ 1.4007	€ 1.0126	€ 0.4461	€ 53.8447	€ 0.8252
Week 18	€ 7.6453	€ 4.7792	€ 0.2518	€ 0.1930	€ 69.0440
Week 19	€ 2.4034	€ 1.5715	€ 0.6899	€ 0.9267	€ 0.2058
Week 20	€ 1.8885	€ 1.3411	€ 0.4257	€ 0.8293	€ 0.2675
Week 21	€ 3.2249	€ 1.2145	€ 0.3448	€ 0.5794	€ 0.2863
Week 22	€ 0.7603	€ 0.9177	€ 0.7151	€ 0.4066	€ 0.1961
Week 23	€ 1.6344	€ 1.1302	€ 0.5218	€ 0.4856	€ 0.3287
Week 24	€ 1.1422	€ 0.9121	€ 0.8928	€ 0.3481	€ 0.3462
Week 25	€ 1.1141	€ 1.0047	€ 0.6352	€ 0.2723	€ 0.2388
Week 26	€ 1.0584	€ 0.7052	€ 0.7187	€ 0.3763	€ 0.3467
Week 27	€ 1.3567	€ 1.2422	€ 0.8003	€ 0.5470	€ 0.2562
Week 28	€ 1.6327	€ 0.5994	€ 0.7579	€ 0.2713	€ 0.2645
Week 29	€ 1.6538	€ 0.9333	€ 1.0490	€ 0.3742	€ 0.1983
Week 30	€ 1.1092	€ 0.5514	€ 0.5181	€ 0.3439	€ 0.5303
Week 31	€ 1.1506	€ 0.9012	€ 0.8979	€ 0.3955	€ 0.4909
Week 32	€ 0.8861	€ 2.3893	€ 0.4950	€ 0.3306	€ 0.7156
Week 33	€ 0.7495	€ 0.9603	€ 0.4020	€ 0.1829	€ 1.9273
Week 34	€ 1.1329	€ 0.5725	€ 0.5931	€ 0.3653	€ 0.7732
Week 35	€ 1.1827	€ 0.7651	€ 0.7536	€ 0.3653	€ 0.4966
Week 36	€ 1.7774	€ 0.7435	€ 0.3482	€ 0.4566	€ 0.3096
Week 37	€ 3.0702	€ 0.7470	€ 0.4568	€ 0.1941	€ 0.2317
Week 38	€ 1.2247	€ 0.6827	€ 0.3669	€ 0.3682	€ 0.2317
Week 39	€ 1.5758	€ 1.5438	€ 0.5730	€ 0.2940	€ 0.2328
Week 40	€ 2.0907	€ 0.9634	€ 0.5626	€ 0.2601	€ 0.1942
Week 41	€ 1.5242	€ 0.7826	€ 0.3860	€ 0.1722	€ 0.2035
Week 42	€ 1.7790	€ 1.2009	€ 0.5323	€ 0.2095	€ 0.3512
Week 43	€ 1.1642	€ 0.7210	€ 0.5628	€ 0.2303	€ 0.4754
Week 44	€ 1.0858	€ 1.0466	€ 0.3850	€ 0.1766	€ 0.7002
Week 45	€ 1.3341	€ 1.2321	€ 0.4809	€ 0.2652	€ 0.8178
Week 46	€ 1.2191	€ 0.7709	€ 0.5750	€ 0.2631	€ 0.7408
Week 47	€ 1.7923	€ 1.0735	€ 0.4219	€ 0.4967	€ 0.4871
Week 48	€ 1.1375	€ 1.1109	€ 0.7121	€ 0.6281	€ 0.6039
Week 49	€ 1.2802	€ 1.2466	€ 0.5776	€ 0.3175	€ 0.2187
Week 50	€ 1.4829	€ 1.2165	€ 1.0891	€ 0.4322	€ 0.2827
Week 51	€ 0.7096	€ 0.8655	€ 0.5407	€ 11.1922	€ 2.3446
Week 52	€ 2.7463	€ 0.4060	€ 0.2415	€ 0.1393	€ 1.7582
Week 53	€ 1.6936	€ 0.4856			€ 0.2360

Appendix 13:

EUR/JPY– USD/JPY –EUR/USD								
Week	2000	2001	2002	2003	2004	2005	2006	2007
	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>
Week 1	2034	3199	802	339	405	2485	2833	4679
Week 2	2020	3023	1659	1519	1514	2652	1915	1661
Week 3	1692	2972	1363	1629	2516	2449	1821	1319
Week 4	1945	3033	1790	1588	1836	2155	1894	1764
Week 5	2024	2169	2381	1950	1577	1930	1805	1523
Week 6	4113	2553	1467	2196	1908	2051	2019	3249
Week 7	1882	2793	1591	1794	2123	1785	1680	1555
Week 8	2276	2316	1244	1997	1908	1974	1676	1444
Week 9	2975	2415	1583	2003	2123	1933	1720	2285
Week 10	2098	2300	2302	1833	2589	1896	1835	2472
Week 11	2654	3100	1694	2118	2392	2028	2568	1818
Week 12	1524	2410	1120	1765	2721	847	2332	3058
Week 13	2690	2191	641	1771	2608	1710	1671	1787
Week 14	1595	2648	1354	2290	2613	1481	2344	517
Week 15	1873	1063	1276	2142	1593	2019	445	1104
Week 16	899	2105	1323	947	2307	2517	1669	365
Week 17	929	1900	941	1646	2388	6870	1595	1039
Week 18	6446	1374	284	813	1123	5951	25283	13772
Week 19	2188	1691	1385	2710	1602	1867	2365	1294
Week 20	2043	1615	1764	2581	2660	1695	2762	1280
Week 21	1760	2613	1874	2060	2884	1310	2095	1247
Week 22	1904	1902	1506	1148	2080	2402	1842	1292
Week 23	2090	1628	1322	2401	2346	1923	1977	1515
Week 24	1627	1719	2116	1937	2800	2127	1592	1318
Week 25	2020	1687	1734	2372	2366	1845	1650	968
Week 26	1617	1798	2534	2055	2203	2163	1365	1444
Week 27	1628	1446	1702	2095	2652	1710	1524	889
Week 28	2053	1871	1904	2262	1718	2344	4110	2154
Week 29	2898	1824	1883	1808	1820	2536	1297	980
Week 30	2244	1426	2043	1703	1754	1793	1306	2630
Week 31	2106	1854	1843	2167	2105	1848	1470	1972
Week 32	1745	1541	1837	1757	1776	1814	1460	2339
Week 33	1424	2211	1902	1658	1853	1946	1034	4692
Week 34	1587	1594	1520	2604	1635	1780	1431	2612
Week 35	1769	1947	1439	1938	1997	1812	1431	2443
Week 36	2048	2059	1508	2131	1604	1788	1809	1451
Week 37	2660	1845	1606	1910	1561	3061	3409	2065
Week 38	1822	1872	1814	2162	1532	5655	1447	2065
Week 39	1809	1884	2188	2111	1644	1827	1351	941
Week 40	1611	2165	1872	2405	1773	1995	2340	1554
Week 41	1382	1497	1717	2425	1604	1364	1310	940
Week 42	1597	1669	1935	2313	1621	1677	1100	1775
Week 43	1592	1365	1657	2341	1598	1793	957	2183
Week 44	2806	1532	1264	2026	2225	6662	7379	1605
Week 45	1463	2147	1442	2182	2039	2162	1144	2336
Week 46	1379	1458	1462	1949	1893	1897	1228	3251
Week 47	2326	787	1453	2471	1861	4099	7627	5902
Week 48	2055	1460	1521	1713	1827	1971	2045	2523
Week 49	2080	1420	1911	2046	2100	1500	1467	1158
Week 50	2066	1806	1839	1529	2353	2815	1639	1496
Week 51	1309	1569	1118	1476	2216	6616	781	876
Week 52	1835	582	260	126	1235	2417	3967	6877
Week 53				405	1360			3676

Appendix 14:

EUR/JPY– USD/JPY –EUR/USD					
	2003	2004	2005	2006	2007
Week	Total Profit	Total Profit	Total Profit	Total Profit	Total Profit
Week 1	€ 0.1164	€ 0.1437	€ 0.4433	€ 0.3883	€ 0.7224
Week 2	€ 0.2841	€ 0.3839	€ 0.4087	€ 0.2623	€ 0.1350
Week 3	€ 0.2466	€ 0.5605	€ 0.3498	€ 0.1757	€ 0.1224
Week 4	€ 0.2436	€ 0.3224	€ 0.3036	€ 0.2074	€ 0.2101
Week 5	€ 0.3788	€ 0.2802	€ 0.3648	€ 0.1870	€ 0.1644
Week 6	€ 0.4576	€ 0.2833	€ 0.2585	€ 0.2798	€ 0.4121
Week 7	€ 0.2917	€ 0.3554	€ 0.2045	€ 0.1632	€ 0.1905
Week 8	€ 0.3282	€ 0.2833	€ 0.2149	€ 0.2103	€ 0.1601
Week 9	€ 0.3745	€ 0.3554	€ 0.2368	€ 0.2556	€ 0.2787
Week 10	€ 0.3646	€ 0.6076	€ 0.2700	€ 0.2110	€ 0.3057
Week 11	€ 0.5562	€ 0.5865	€ 0.2620	€ 0.2794	€ 0.1715
Week 12	€ 0.4165	€ 0.9116	€ 0.1651	€ 0.2564	€ 0.2939
Week 13	€ 0.2891	€ 0.4188	€ 0.2017	€ 0.1872	€ 0.1681
Week 14	€ 0.3940	€ 0.6164	€ 0.1352	€ 0.3259	€ 0.0372
Week 15	€ 0.4447	€ 0.3172	€ 0.2602	€ 0.0342	€ 0.1001
Week 16	€ 0.2431	€ 0.4073	€ 0.3074	€ 0.1833	€ 0.0324
Week 17	€ 0.2898	€ 0.4044	€ 1.3529	€ 0.4158	€ 0.1181
Week 18	€ 0.2365	€ 0.1955	€ 1.0824	€ 9.7182	€ 2.9040
Week 19	€ 0.6307	€ 0.3090	€ 0.3864	€ 0.2779	€ 0.1425
Week 20	€ 0.5260	€ 0.4979	€ 0.2690	€ 0.3865	€ 0.1140
Week 21	€ 0.3809	€ 0.5352	€ 0.1422	€ 0.2469	€ 0.1355
Week 22	€ 0.1863	€ 0.3165	€ 0.4853	€ 0.5275	€ 0.1778
Week 23	€ 0.4129	€ 0.4269	€ 0.2128	€ 0.2995	€ 0.1717
Week 24	€ 0.3015	€ 0.6422	€ 0.3296	€ 0.1614	€ 0.1195
Week 25	€ 0.4810	€ 0.4281	€ 0.2606	€ 0.1969	€ 0.1146
Week 26	€ 0.4278	€ 0.3990	€ 0.3014	€ 0.1441	€ 0.1646
Week 27	€ 0.4168	€ 0.5116	€ 0.2770	€ 0.1711	€ 0.0812
Week 28	€ 0.4284	€ 0.2157	€ 0.3816	€ 0.5275	€ 0.2124
Week 29	€ 0.3680	€ 0.3244	€ 0.5234	€ 0.1128	€ 0.0817
Week 30	€ 0.2729	€ 0.2663	€ 0.1885	€ 0.1616	€ 0.3767
Week 31	€ 0.4152	€ 0.3029	€ 0.2246	€ 0.1633	€ 0.2334
Week 32	€ 0.3014	€ 0.3442	€ 0.2871	€ 0.1847	€ 0.2394
Week 33	€ 0.2342	€ 0.2738	€ 0.2687	€ 0.1077	€ 1.1248
Week 34	€ 0.6271	€ 0.2195	€ 0.2705	€ 0.2680	€ 0.2523
Week 35	€ 0.3153	€ 0.3318	€ 0.1786	€ 0.2680	€ 0.2433
Week 36	€ 0.4033	€ 0.2877	€ 0.2173	€ 0.1955	€ 0.1353
Week 37	€ 0.5443	€ 0.2090	€ 0.4408	€ 0.3933	€ 0.2063
Week 38	€ 0.4304	€ 0.2537	€ 0.7596	€ 0.1632	€ 0.2063
Week 39	€ 0.4516	€ 0.2516	€ 0.2345	€ 0.1557	€ 0.0733
Week 40	€ 0.4743	€ 0.2671	€ 0.2345	€ 0.2710	€ 0.1445
Week 41	€ 0.4371	€ 0.2251	€ 0.1252	€ 0.1148	€ 0.0817
Week 42	€ 0.4042	€ 0.2005	€ 0.1738	€ 0.1272	€ 0.1550
Week 43	€ 0.3977	€ 0.2569	€ 0.2121	€ 0.1317	€ 0.2502
Week 44	€ 0.4422	€ 0.3702	€ 1.1741	€ 1.2685	€ 0.1800
Week 45	€ 0.4098	€ 0.3660	€ 0.3304	€ 0.1530	€ 0.2360
Week 46	€ 0.3763	€ 0.3387	€ 0.2104	€ 0.1245	€ 0.6498
Week 47	€ 0.5133	€ 0.2871	€ 0.6328	€ 1.9451	€ 0.6540
Week 48	€ 0.3539	€ 0.2514	€ 0.2576	€ 0.3126	€ 0.2459
Week 49	€ 0.3931	€ 0.3253	€ 0.1741	€ 0.1771	€ 0.0938
Week 50	€ 0.2475	€ 0.3439	€ 0.4295	€ 0.1925	€ 0.1326
Week 51	€ 0.2456	€ 0.2994	€ 1.2714	€ 0.0821	€ 0.0891
Week 52	€ 0.0250	€ 0.1464	€ 0.3584	€ 0.5536	€ 1.0595
Week 53	€ 0.1437	€ 0.2208			€ 0.5760

Appendix 15:

EUR/USD– USD/CHF –EUR/CHF																
Week	2000		2001		2002		2003		2004		2005		2006		2007	
	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume	With Volume
Week 1	2502		2285		795		1161		1570		3078		1158		918	
Week 2	2150		2377		1522		1800		2805		2342		1162		1050	
Week 3	2043		2100		1371		1949		2753		2068		1339		1083	
Week 4	2506		2629		1443		1622		2007		1776		1650		1161	
Week 5	2777		2894		1894		2329		2379		2059		1536		979	
Week 6	2910		2315		2040		2262		3503		2007		1087		950	
Week 7	2190		2251		1749		1858		3274		1551		1289		917	
Week 8	2725		2611		1346		1713		3503		1800		1199		803	
Week 9	3254		2476		1266		1856		3274		1553		1281		1300	
Week 10	2627		1859		2001		2187		3740		1907		1381		1134	
Week 11	2273		2619		1436		2348		2961		1830		1434		1137	
Week 12	2001		2397		1340		2846		2549		1659		1215		1258	
Week 13	2505		2567		948		2184		3196		1867		1323		1338	
Week 14	2145		2809		1442		2563		2555		1604		1753		817	
Week 15	1860		1309		1135		2884		2050		2306		996		1128	
Week 16	2325		2336		1290		1905		2551		1870		1342		1073	
Week 17	2163		2216		1552		1901		2236		1673		1266		888	
Week 18	2983		2073		1474		2310		2495		1147		1229		918	
Week 19	2347		1457		2640		2330		2294		1718		1528		708	
Week 20	2953		1714		1975		2799		2390		1414		1813		485	
Week 21	2119		2180		1926		2889		3244		1127		1127		594	
Week 22	2528		1494		1772		3442		2555		1851		1013		804	
Week 23	2091		1814		1669		3592		1672		1597		1357		879	
Week 24	1770		2296		2173		2463		2251		2007		1728		902	
Week 25	2225		1398		1447		3579		2343		1322		1099		749	
Week 26	1724		2016		2608		3203		1856		1750		970		995	
Week 27	1947		1469		1570		2777		2525		2079		1025		718	
Week 28	1730		2092		1937		2870		1323		1991		1151		726	
Week 29	1446		2679		1701		2886		1853		2350		1158		798	
Week 30	1722		2094		1989		2162		2682		1721		844		1177	
Week 31	1744		1606		3050		2959		2468		1861		769		765	
Week 32	1568		1628		1891		2163		1945		1388		1100		1069	
Week 33	1841		2255		1759		2201		1941		1379		754		1948	
Week 34	1778		1633		1790		2699		2174		1381		812		1093	
Week 35	2809		1484		1410		2368		1945		2236		812		866	
Week 36	3219		2231		1411		2520		1573		1416		878		697	
Week 37	2306		2221		1910		3129		1646		1750		1062		633	
Week 38	1788		2622		1937		2923		1544		1734		819		633	
Week 39	1850		2432		1847		2484		1948		1718		862		642	
Week 40	2519		2146		1531		3075		1805		1712		662		870	
Week 41	2331		2264		1408		2726		1778		1457		945		923	
Week 42	3260		1610		1449		3146		1663		1516		707		885	
Week 43	2649		1646		1276		2533		1704		1365		703		798	
Week 44	1701		2142		1404		2539		2315		1567		778		806	
Week 45	1591		1385		1682		3555		2153		1549		767		1002	
Week 46	2774		2045		1412		2497		1861		1545		832		946	
Week 47	3051		1060		1523		2672		1673		1335		1008		887	
Week 48	2290		2098		1536		2372		1905		1558		1403		1161	
Week 49	2987		1584		1713		2683		2355		1021		937		881	
Week 50	941		1926		1427		2431		2231		1503		1127		1003	
Week 51	2987		1539		980		2086		2015		1132		841		797	
Week 52	941		1304		663		808		1201		811		494		433	
Week 53							1570		1277						637	

Appendix 16:

EUR/USD– USD/CHF –EUR/CHF					
	2003	2004	2005	2006	2007
Week	Total Profit	Total Profit	Total Profit	Total Profit	Total Profit
Week 1	€ 0.6003	€ 0.6070	€ 1.1971	€ 0.5279	€ 0.1693
Week 2	€ 0.9657	€ 1.6501	€ 0.7555	€ 0.3550	€ 0.1918
Week 3	€ 0.9293	€ 1.0735	€ 0.5285	€ 0.3082	€ 0.1831
Week 4	€ 0.8210	€ 0.8332	€ 0.5672	€ 0.7383	€ 0.2573
Week 5	€ 1.1677	€ 1.0977	€ 1.1034	€ 0.3948	€ 0.2390
Week 6	€ 1.2744	€ 1.9188	€ 0.7026	€ 0.2667	€ 0.2123
Week 7	€ 0.7741	€ 1.4499	€ 0.5306	€ 0.3380	€ 0.1941
Week 8	€ 0.6997	€ 1.9188	€ 0.4877	€ 0.2318	€ 0.1674
Week 9	€ 0.7563	€ 1.4499	€ 0.6990	€ 0.2838	€ 0.3450
Week 10	€ 1.2929	€ 2.1300	€ 0.4713	€ 0.2782	€ 0.2431
Week 11	€ 1.3652	€ 1.0562	€ 0.6197	€ 0.2790	€ 0.2327
Week 12	€ 1.4586	€ 1.0538	€ 0.7143	€ 0.2113	€ 0.3290
Week 13	€ 1.5225	€ 1.3019	€ 0.7050	€ 0.3189	€ 0.3256
Week 14	€ 1.0110	€ 1.1201	€ 0.4722	€ 0.4088	€ 0.1818
Week 15	€ 1.3710	€ 0.7777	€ 0.9706	€ 0.2047	€ 0.3268
Week 16	€ 0.7625	€ 1.0814	€ 0.4903	€ 0.3056	€ 0.2232
Week 17	€ 0.7466	€ 0.9878	€ 0.5199	€ 0.3076	€ 0.1703
Week 18	€ 1.2578	€ 1.1367	€ 0.4146	€ 0.3033	€ 0.1825
Week 19	€ 1.3271	€ 1.0715	€ 0.5624	€ 0.4246	€ 0.1146
Week 20	€ 2.2764	€ 0.9728	€ 0.3870	€ 0.4057	€ 0.1117
Week 21	€ 1.9530	€ 1.0989	€ 0.2763	€ 0.3204	€ 0.1412
Week 22	€ 1.8960	€ 0.9593	€ 0.7025	€ 0.3812	€ 0.1827
Week 23	€ 1.7061	€ 0.7787	€ 0.5843	€ 0.3375	€ 0.2007
Week 24	€ 0.9941	€ 0.8083	€ 0.7922	€ 0.4162	€ 0.1656
Week 25	€ 1.6798	€ 0.8375	€ 0.4395	€ 0.2313	€ 0.1882
Week 26	€ 1.3965	€ 0.6458	€ 0.5992	€ 0.2462	€ 0.2303
Week 27	€ 1.4464	€ 1.2183	€ 0.9096	€ 0.3067	€ 0.2317
Week 28	€ 1.3776	€ 0.3632	€ 0.8383	€ 0.2664	€ 0.1751
Week 29	€ 4.3870	€ 0.6584	€ 0.6796	€ 0.2560	€ 0.1592
Week 30	€ 0.9415	€ 1.1437	€ 0.5406	€ 0.2039	€ 0.2604
Week 31	€ 1.4079	€ 1.0714	€ 0.6296	€ 0.1902	€ 0.1400
Week 32	€ 0.9424	€ 1.4393	€ 0.4670	€ 0.2589	€ 0.2483
Week 33	€ 1.0025	€ 0.8039	€ 0.4204	€ 0.1308	€ 0.5295
Week 34	€ 1.1105	€ 0.8457	€ 0.3569	€ 0.2246	€ 0.1832
Week 35	€ 1.0068	€ 0.6194	€ 0.6868	€ 0.2246	€ 0.1949
Week 36	€ 1.4664	€ 0.5558	€ 0.3520	€ 0.3473	€ 0.1847
Week 37	€ 2.4187	€ 0.5738	€ 0.4875	€ 0.2912	€ 0.1508
Week 38	€ 1.2385	€ 0.7644	€ 0.8077	€ 0.2326	€ 0.1508
Week 39	€ 1.1021	€ 0.8559	€ 0.4994	€ 0.1831	€ 0.1373
Week 40	€ 1.7423	€ 0.5739	€ 0.5295	€ 0.1577	€ 0.1794
Week 41	€ 1.1839	€ 0.9310	€ 0.3486	€ 0.2234	€ 0.2101
Week 42	€ 1.4259	€ 0.7177	€ 0.3924	€ 0.1093	€ 0.1623
Week 43	€ 1.0685	€ 0.5396	€ 0.3426	€ 0.1286	€ 0.2346
Week 44	€ 1.1398	€ 0.8054	€ 0.5410	€ 0.1979	€ 0.1881
Week 45	€ 2.0359	€ 0.8708	€ 0.3456	€ 0.1873	€ 0.2975
Week 46	€ 0.8498	€ 0.6795	€ 0.3698	€ 0.1442	€ 0.1832
Week 47	€ 1.5873	€ 0.6126	€ 0.3746	€ 0.2854	€ 0.3731
Week 48	€ 1.1018	€ 0.9212	€ 0.4672	€ 0.5132	€ 0.2933
Week 49	€ 1.4749	€ 1.3208	€ 0.2632	€ 0.2566	€ 0.1457
Week 50	€ 0.9165	€ 1.1162	€ 0.4478	€ 0.2711	€ 0.2141
Week 51	€ 0.7184	€ 0.7339	€ 0.2498	€ 0.2079	€ 0.1450
Week 52	€ 0.3839	€ 0.2487	€ 0.2433	€ 0.1824	€ 0.1080
Week 53	€ 0.6070	€ 0.7286			€ 0.1546

Appendix 17:

EUR/CHF – USD/CHF – EUR/USD								
Week	2000	2001	2002	2003	2004	2005	2006	2007
	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>
Week 1	2047	1796	1037	789	688	2342	1584	820
Week 2	1774	2068	1794	1593	2261	1839	1078	1051
Week 3	1983	2442	1444	1709	2450	1721	1255	899
Week 4	2605	2743	1523	1408	2042	1735	1444	1072
Week 5	2598	1978	1704	1896	1977	1841	1170	923
Week 6	2180	2017	1702	2409	2271	1853	1131	728
Week 7	2089	2282	1525	1640	2832	1997	864	995
Week 8	2148	2045	1297	1657	2271	2056	970	974
Week 9	2745	2203	1355	1840	2832	1614	1109	1524
Week 10	1931	1683	1911	1872	2792	1547	1050	1301
Week 11	1812	2734	1617	2140	2632	1682	1323	1238
Week 12	2475	2295	1549	2115	2552	1388	1015	890
Week 13	2306	2153	1095	1807	2499	1717	1174	938
Week 14	2406	2245	1269	1835	2041	1524	1841	615
Week 15	1811	1479	1001	2321	2100	1806	682	811
Week 16	2439	2119	1292	1413	1927	2177	1474	735
Week 17	2375	1976	1304	1567	2202	1778	1574	704
Week 18	2373	1661	1756	1944	2346	1805	1563	604
Week 19	2515	1648	1085	2012	1984	1694	2290	652
Week 20	2596	1814	1495	2010	2247	1174	2146	3821
Week 21	3537	1861	1517	1916	2108	969	9069	986
Week 22	3319	1619	1429	691	2202	2023	3239	665
Week 23	2144	1682	1457	2324	1835	1581	1461	961
Week 24	2076	1955	1628	2307	2097	1748	1184	748
Week 25	2100	1507	1657	2363	2091	1470	1070	723
Week 26	1728	1617	2431	2417	1486	1639	1058	1119
Week 27	1910	1461	1890	2004	2074	1934	951	975
Week 28	1495	2267	1552	2335	1210	1724	978	859
Week 29	1836	2368	2041	2457	1590	1982	897	792
Week 30	2213	1624	2454	1806	1713	2102	1493	1173
Week 31	1725	1473	1328	1622	1993	1863	1888	2125
Week 32	1633	1333	1969	1724	1575	1417	841	1101
Week 33	1633	1626	1249	1425	1505	1344	774	2133
Week 34	2335	1679	1477	2147	1388	1557	1045	841
Week 35	1823	1791	1354	1742	1741	2136	1045	856
Week 36	2375	1653	1679	2152	1701	1252	806	688
Week 37	2514	2086	1735	2071	1444	1574	994	859
Week 38	2548	3046	2147	2455	1482	1393	1074	859
Week 39	1795	2516	1559	2802	1939	1349	897	651
Week 40	1788	1904	1751	2749	1467	1611	782	642
Week 41	2010	1803	1380	2266	1628	1331	690	655
Week 42	2529	1599	1298	2245	1979	1424	991	873
Week 43	1916	1653	1215	1947	1820	1527	752	750
Week 44	2655	1575	1415	1816	2392	1376	729	827
Week 45	2205	1435	1709	2257	1938	1440	904	1356
Week 46	1633	1758	1411	2005	1839	1216	793	1124
Week 47	1721	1589	1260	2899	2114	1149	1271	995
Week 48	2345	1505	1172	1755	1558	1546	1284	985
Week 49	2450	1452	1672	1916	2143	1321	1004	876
Week 50	2167	1672	1466	1856	1798	1516	1055	775
Week 51	1996	1637	1569	1656	2057	803	855	768
Week 52	1223	597	782	700	1176	1038	1723	629
Week 53				688	1137			1269

Appendix 18:

EUR/CHF – USD/CHF – EUR/USD					
	2003	2004	2005	2006	2007
Week	Total Profit	Total Profit	Total Profit	Total Profit	Total Profit
Week 1	€ 0.1395	€ 0.1245	€ 0.4440	€ 0.3615	€ 0.1354
Week 2	€ 0.3489	€ 0.5223	€ 0.3336	€ 0.1844	€ 0.1251
Week 3	€ 0.4833	€ 0.6386	€ 0.3435	€ 0.2252	€ 0.1130
Week 4	€ 0.2742	€ 0.5202	€ 0.3320	€ 0.2123	€ 0.1459
Week 5	€ 0.4024	€ 0.4986	€ 0.3396	€ 0.1943	€ 0.1256
Week 6	€ 0.6898	€ 0.5373	€ 0.3546	€ 0.2023	€ 0.0997
Week 7	€ 0.4112	€ 0.6788	€ 0.5299	€ 0.0987	€ 0.1174
Week 8	€ 0.3937	€ 0.5373	€ 0.4881	€ 0.1337	€ 0.1208
Week 9	€ 0.5345	€ 0.6788	€ 0.3038	€ 0.1495	€ 0.1984
Week 10	€ 0.6365	€ 0.6732	€ 0.2895	€ 0.2304	€ 0.1861
Week 11	€ 0.5200	€ 1.0304	€ 0.2753	€ 0.1761	€ 0.1560
Week 12	€ 0.4982	€ 0.5949	€ 0.2447	€ 0.1157	€ 0.0774
Week 13	€ 0.4557	€ 0.4862	€ 0.4020	€ 0.1678	€ 0.1329
Week 14	€ 0.3722	€ 0.4726	€ 0.2697	€ 0.2715	€ 0.0831
Week 15	€ 0.5184	€ 0.5370	€ 0.3438	€ 0.1133	€ 0.2572
Week 16	€ 0.3201	€ 0.3482	€ 0.4589	€ 0.2797	€ 0.0996
Week 17	€ 0.3102	€ 0.4540	€ 0.3678	€ 0.4303	€ 0.0631
Week 18	€ 0.4446	€ 0.6131	€ 0.3588	€ 0.3951	€ 0.0781
Week 19	€ 0.4499	€ 1.0282	€ 0.3557	€ 0.4202	€ 0.0922
Week 20	€ 0.4173	€ 0.7178	€ 0.1890	€ 0.5858	€ 0.6861
Week 21	€ 0.3669	€ 0.7169	€ 0.1832	€ 3.1242	€ 0.1178
Week 22	€ 0.1554	€ 0.9566	€ 0.8073	€ 0.5589	€ 0.0804
Week 23	€ 0.6018	€ 0.3551	€ 0.4117	€ 0.1871	€ 0.0953
Week 24	€ 0.7008	€ 0.7601	€ 0.4262	€ 0.1304	€ 0.0903
Week 25	€ 0.9327	€ 0.5290	€ 0.3318	€ 0.1116	€ 0.1053
Week 26	€ 0.5601	€ 0.3098	€ 0.3004	€ 0.1352	€ 0.1498
Week 27	€ 0.3654	€ 0.5108	€ 0.6634	€ 0.1474	€ 0.1175
Week 28	€ 0.5261	€ 0.2229	€ 0.2653	€ 0.1608	€ 0.0997
Week 29	€ 0.8533	€ 0.3445	€ 0.3679	€ 0.1282	€ 0.1198
Week 30	€ 0.3944	€ 0.3145	€ 0.3277	€ 0.1858	€ 0.1438
Week 31	€ 0.3531	€ 0.4395	€ 0.4187	€ 0.2758	€ 0.3226
Week 32	€ 0.3360	€ 0.3613	€ 0.3365	€ 0.1235	€ 0.2002
Week 33	€ 0.3003	€ 0.3308	€ 0.2162	€ 0.1162	€ 0.5025
Week 34	€ 0.4772	€ 0.2198	€ 0.3594	€ 0.1491	€ 0.0816
Week 35	€ 0.3172	€ 0.3090	€ 0.6791	€ 0.1491	€ 0.1047
Week 36	€ 0.5303	€ 0.4360	€ 0.1772	€ 0.0973	€ 0.0939
Week 37	€ 0.3614	€ 0.2852	€ 0.5697	€ 0.1785	€ 0.1714
Week 38	€ 0.6016	€ 0.2680	€ 0.2621	€ 0.1761	€ 0.1714
Week 39	€ 0.6671	€ 0.3804	€ 0.2469	€ 0.1090	€ 0.0924
Week 40	€ 0.7816	€ 0.2758	€ 0.3307	€ 0.1221	€ 0.0757
Week 41	€ 0.4890	€ 0.3986	€ 0.2514	€ 0.0957	€ 0.0654
Week 42	€ 0.4891	€ 0.4651	€ 0.4977	€ 0.1282	€ 0.0972
Week 43	€ 0.4103	€ 0.2871	€ 0.2236	€ 0.0814	€ 0.0771
Week 44	€ 0.3751	€ 0.5683	€ 0.2521	€ 0.1165	€ 0.1004
Week 45	€ 0.5890	€ 0.3533	€ 0.2580	€ 0.1881	€ 0.3550
Week 46	€ 0.4384	€ 0.3420	€ 0.2030	€ 0.1623	€ 0.1558
Week 47	€ 0.7391	€ 0.6706	€ 0.2012	€ 0.2422	€ 0.1602
Week 48	€ 0.3623	€ 0.3239	€ 0.2765	€ 0.1615	€ 0.1140
Week 49	€ 0.4256	€ 0.4056	€ 0.4968	€ 0.1256	€ 0.1103
Week 50	€ 0.3586	€ 0.3165	€ 0.3048	€ 0.1274	€ 0.0714
Week 51	€ 0.3150	€ 0.3961	€ 0.1242	€ 0.1156	€ 0.0740
Week 52	€ 0.1592	€ 0.1908	€ 0.1846	€ 0.3408	€ 0.0630
Week 53	€ 0.1245	€ 0.2564			€ 0.1907

Appendix 19:

EUR/GBP – GBP/USD – USD/JPY – EUR/JPY								
Week	2000	2001	2002	2003	2004	2005	2006	2007
	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>
Week 1	1478	559	678	680	243	425	46	56
Week 2	1171	1107	483	826	447	182	87	542
Week 3	1031	1017	311	797	717	358	69	228
Week 4	884	912	646	635	1000	301	47	259
Week 5	948	866	796	1061	786	220	67	531
Week 6	695	947	523	864	613	328	28	68
Week 7	509	801	543	793	374	340	63	73
Week 8	1106	848	513	737	466	312	80	112
Week 9	1018	717	395	971	383	209	130	191
Week 10	969	759	603	853	483	374	124	143
Week 11	722	1119	548	903	691	182	345	110
Week 12	367	839	889	1061	1034	1997	374	50
Week 13	1093	985	935	712	772	521	285	174
Week 14	935	626	501	1143	716	363	246	5264
Week 15	1018	1683	724	858	580	318	6829	89
Week 16	2086	876	372	641	572	194	193	16989
Week 17	1080	1210	755	737	825	208	5953	183
Week 18	655	1135	1693	998	756	318	47	4949
Week 19	770	597	451	546	1078	421	307	48
Week 20	882	468	588	845	411	330	316	53
Week 21	628	713	913	841	780	216	263	82
Week 22	1086	848	504	848	405	216	283	30
Week 23	859	848	441	702	349	155	193	55
Week 24	888	879	588	1078	988	173	143	58
Week 25	1178	648	213	888	558	144	212	49
Week 26	600	585	935	875	177	207	220	71
Week 27	544	338	765	686	480	173	123	35
Week 28	622	602	768	802	161	168	91	69
Week 29	274	805	849	515	577	399	166	50
Week 30	452	654	1051	383	219	109	111	100
Week 31	681	697	914	691	532	127	128	63
Week 32	467	820	1030	354	116	81	145	77
Week 33	745	804	564	369	292	65	118	230
Week 34	775	794	785	773	228	131	93	207
Week 35	672	630	488	611	491	137	93	86
Week 36	1181	643	547	358	210	186	111	96
Week 37	776	515	1066	455	138	94	63	45
Week 38	857	1031	1277	601	227	81	66	45
Week 39	944	920	770	531	258	82	75	38
Week 40	622	653	719	377	124	136	75	42
Week 41	932	437	805	451	154	65	94	28
Week 42	831	575	525	629	109	111	91	70
Week 43	835	509	721	712	194	86	78	72
Week 44	717	440	623	575	297	53	81	76
Week 45	629	453	507	614	214	75	89	93
Week 46	525	708	718	184	105	74	232	1478
Week 47	433	552	776	456	136	63	186	928
Week 48	716	496	612	314	93	110	538	400
Week 49	695	457	841	592	219	68	275	225
Week 50	829	669	752	554	231	97	803	158
Week 51	969	1044	903	367	517	103	2331	141
Week 52	468	710	448	319	316	66	209	168
Week 53				243	489			40

Appendix 20:

EUR/GBP – GBP/USD – USD/JPY – EUR/JPY					
	2003	2004	2005	2006	2007
Week	Total Profit	Total Profit	Total Profit	Total Profit	Total Profit
Week 1	€ 0.2375	€ 0.1110	€ 0.0698	€ 0.0036	€ 0.0074
Week 2	€ 0.3677	€ 0.2396	€ 0.0313	€ 0.0134	€ 0.0588
Week 3	€ 0.2637	€ 0.3242	€ 0.0640	€ 0.0079	€ 0.0117
Week 4	€ 0.2170	€ 0.3291	€ 0.0378	€ 0.0071	€ 0.0228
Week 5	€ 0.8910	€ 0.3555	€ 0.0254	€ 0.0057	€ 0.0250
Week 6	€ 0.4906	€ 0.4961	€ 0.0406	€ 0.0019	€ 0.0053
Week 7	€ 0.3710	€ 0.4711	€ 0.0556	€ 0.0058	€ 0.0040
Week 8	€ 0.2278	€ 0.2701	€ 0.0350	€ 0.0063	€ 0.0073
Week 9	€ 0.5831	€ 0.1136	€ 0.0206	€ 0.0126	€ 0.0144
Week 10	€ 0.4790	€ 0.2463	€ 0.0509	€ 0.0110	€ 0.0140
Week 11	€ 0.4172	€ 0.4830	€ 0.0192	€ 0.0230	€ 0.0095
Week 12	€ 0.7084	€ 0.6871	€ 0.2901	€ 0.0305	€ 0.0027
Week 13	€ 0.6527	€ 0.4312	€ 0.4263	€ 0.0478	€ 0.0146
Week 14	€ 1.0587	€ 0.7876	€ 0.0523	€ 0.0333	€ 2.1456
Week 15	€ 0.3937	€ 0.2217	€ 0.1053	€ 2.6922	€ 0.0063
Week 16	€ 0.2493	€ 0.2293	€ 0.0162	€ 0.0256	€ 14 939.3741
Week 17	€ 0.2834	€ 0.3567	€ 0.0199	€ 2.5381	€ 0.0156
Week 18	€ 0.4212	€ 0.1289	€ 0.0378	€ 0.0111	€ 2.4031
Week 19	€ 0.3126	€ 0.3393	€ 0.0634	€ 0.0754	€ 0.0025
Week 20	€ 0.3713	€ 0.1881	€ 0.0311	€ 0.0703	€ 0.0031
Week 21	€ 0.5510	€ 0.2140	€ 0.0199	€ 0.0227	€ 0.0046
Week 22	€ 0.4125	€ 0.1696	€ 0.0188	€ 0.0214	€ 0.0010
Week 23	€ 0.4187	€ 0.0566	€ 0.0110	€ 0.0310	€ 0.0024
Week 24	€ 0.8751	€ 0.4470	€ 0.0171	€ 0.0131	€ 0.0044
Week 25	€ 0.5972	€ 0.2226	€ 0.0106	€ 0.0200	€ 0.0034
Week 26	€ 0.3608	€ 0.0244	€ 0.0186	€ 0.0251	€ 0.0042
Week 27	€ 0.2905	€ 0.1324	€ 0.0249	€ 0.0100	€ 0.0033
Week 28	€ 0.8920	€ 0.0221	€ 0.0207	€ 0.0061	€ 0.0043
Week 29	€ 0.1648	€ 0.0675	€ 0.0431	€ 0.0145	€ 0.0026
Week 30	€ 0.1864	€ 0.0422	€ 0.0100	€ 0.0112	€ 0.0053
Week 31	€ 0.2239	€ 0.1282	€ 0.0117	€ 0.0123	€ 0.0053
Week 32	€ 0.0751	€ 0.0378	€ 0.0076	€ 0.0111	€ 0.0051
Week 33	€ 0.1163	€ 0.0546	€ 0.0102	€ 0.0081	€ 0.0397
Week 34	€ 0.2591	€ 0.0564	€ 0.0105	€ 0.0062	€ 0.0260
Week 35	€ 0.3485	€ 0.0595	€ 0.0133	€ 0.0062	€ 0.0044
Week 36	€ 0.2739	€ 0.0260	€ 0.0191	€ 0.0139	€ 0.0103
Week 37	€ 0.2455	€ 0.0392	€ 0.0139	€ 0.0045	€ 0.0044
Week 38	€ 0.1603	€ 0.0447	€ 0.0096	€ 0.0034	€ 0.0044
Week 39	€ 0.3361	€ 0.0405	€ 0.0067	€ 0.0084	€ 0.0015
Week 40	€ 0.1721	€ 0.0145	€ 0.0230	€ 0.0044	€ 0.0035
Week 41	€ 0.1454	€ 0.0234	€ 0.0070	€ 0.0066	€ 0.0013
Week 42	€ 0.2937	€ 0.0133	€ 0.0114	€ 0.0051	€ 0.0046
Week 43	€ 0.2199	€ 0.0240	€ 0.0052	€ 0.0149	€ 0.0044
Week 44	€ 0.2848	€ 0.0400	€ 0.0055	€ 0.0105	€ 0.0058
Week 45	€ 0.3544	€ 0.0420	€ 0.0429	€ 0.0091	€ 0.0080
Week 46	€ 0.0380	€ 0.0107	€ 0.0107	€ 0.0133	€ 0.7700
Week 47	€ 0.1530	€ 0.0150	€ 0.0053	€ 0.0146	€ 0.2263
Week 48	€ 0.0681	€ 0.0166	€ 0.0149	€ 0.0305	€ 0.2616
Week 49	€ 0.1514	€ 0.0297	€ 0.0059	€ 0.0212	€ 0.0939
Week 50	€ 0.1445	€ 0.0362	€ 0.0080	€ 0.0642	€ 0.0418
Week 51	€ 0.3950	€ 0.1011	€ 0.0121	€ 0.2077	€ 0.0284
Week 52	€ 0.0540	€ 0.0360	€ 0.0046	€ 0.0158	€ 0.0294
Week 53	€ 0.1110	€ 0.1452			€ 0.0072

Appendix 21:

EUR/JPY – USD/JPY – GBP/USD – EUR/GBP								
Week	2000	2001	2002	2003	2004	2005	2006	2007
	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>
Week 1	3738	2711	857	2053	741	482	229	2226
Week 2	4737	2725	965	2351	1614	274	65	523
Week 3	3726	3246	558	2503	1154	816	55	2172
Week 4	2562	2304	1331	2062	1558	575	54	1592
Week 5	1668	1823	634	2269	1692	884	51	995
Week 6	1213	1188	598	3367	1223	774	49	450
Week 7	1924	2356	704	2938	1665	830	143	109
Week 8	2894	1308	694	2205	1876	679	123	110
Week 9	2900	2192	794	2505	1088	582	118	627
Week 10	1543	1483	1611	4539	3072	751	420	610
Week 11	1283	1885	1594	2712	1440	434	1638	134
Week 12	1693	1637	483	3407	1036	514	1635	235
Week 13	1304	1702	651	4211	772	624	364	173
Week 14	1129	2092	1214	4804	2369	442	1526	97
Week 15	1259	1341	860	3942	365	524	72	77
Week 16	966	3145	1649	4002	2631	622	269	17
Week 17	1214	1430	597	4870	872	765	128	49
Week 18	2998	1184	816	7633	2870	1592	8185	2433
Week 19	3115	1387	1915	7934	1247	510	1202	43
Week 20	1595	973	1301	5286	2668	462	405	72
Week 21	1833	2401	1116	7366	1568	99	619	40
Week 22	2014	1606	1707	1700	1956	231	483	54
Week 23	3213	1844	2069	7346	1310	206	260	72
Week 24	1795	3476	1673	5454	656	532	125	55
Week 25	1242	1768	2309	4429	1525	242	266	31
Week 26	1534	1902	3342	3442	1033	450	711	68
Week 27	1439	1102	1250	2641	1025	428	215	34
Week 28	841	1618	845	1233	2029	348	250	111
Week 29	819	1623	2135	1613	962	479	115	56
Week 30	2316	1211	1444	3506	1391	209	358	154
Week 31	1090	1321	1712	1896	363	123	314	93
Week 32	1457	902	1366	2189	1821	161	107	74
Week 33	2378	2241	2615	1361	524	157	296	457
Week 34	1734	849	1246	1454	558	113	100	72
Week 35	2228	1328	1952	2299	106	134	100	89
Week 36	1983	1865	1181	2614	779	154	118	71
Week 37	2434	937	1042	3489	289	187	168	103
Week 38	3433	2251	2360	2675	325	450	214	103
Week 39	1733	855	1731	1530	219	103	96	37
Week 40	1563	2230	1745	4026	187	130	299	108
Week 41	1034	1346	1649	2261	128	75	90	27
Week 42	1756	785	1118	1744	502	193	91	95
Week 43	1935	599	1310	1578	421	206	104	72
Week 44	2324	1402	1528	829	350	495	1069	84
Week 45	2550	1038	2244	1771	494	271	58	202
Week 46	600	1070	1291	1844	219	120	282	4301
Week 47	1844	829	1220	1778	60	346	2376	5358
Week 48	3405	1167	1125	1598	390	188	159	262
Week 49	2449	1040	2955	1082	529	67	2330	394
Week 50	2551	2842	1894	1902	412	174	1034	146
Week 51	2268	1275	1282	2353	960	755	318	310
Week 52	930	991	1240	1062	362	383	2051	162
Week 53				741	463			912

Appendix 22:

EUR/JPY – USD/JPY – GBP/USD – EUR/GBP					
	2003	2004	2005	2006	2007
Week	Total Profit	Total Profit	Total Profit	Total Profit	Total Profit
Week 1	€ 7.3717	€ 3.5694	€ 0.4422	€ 0.1879	€ 3.4882
Week 2	€ 8.1224	€ 7.3665	€ 0.1930	€ 0.0187	€ 0.1485
Week 3	€ 6.2907	€ 2.4485	€ 0.5997	€ 0.0066	€ 3.3420
Week 4	€ 3.2319	€ 2.2435	€ 0.1928	€ 0.0162	€ 1.4770
Week 5	€ 3.1106	€ 2.6055	€ 0.3805	€ 0.0112	€ 1.2385
Week 6	€ 5.5194	€ 2.2433	€ 0.3770	€ 0.0162	€ 0.0879
Week 7	€ 6.5459	€ 4.1973	€ 0.4388	€ 0.0322	€ 0.0365
Week 8	€ 2.6210	€ 3.0094	€ 0.2506	€ 0.0346	€ 0.0234
Week 9	€ 3.9622	€ 0.9354	€ 0.3288	€ 0.0457	€ 0.2488
Week 10	€ 16.4878	€ 14.2729	€ 0.2282	€ 0.1916	€ 1.0061
Week 11	€ 5.2516	€ 4.8337	€ 0.1389	€ 1.8652	€ 0.0194
Week 12	€ 6.1642	€ 3.1394	€ 0.9426	€ 1.9662	€ 0.0439
Week 13	€ 10.3406	€ 0.8896	€ 0.4906	€ 0.0777	€ 0.0481
Week 14	€ 14.0678	€ 8.0195	€ 0.1413	€ 1.5168	€ 0.0267
Week 15	€ 10.9974	€ 0.2894	€ 0.2055	€ 0.0612	€ 0.0082
Week 16	€ 13.5882	€ 7.2668	€ 0.2086	€ 0.0686	€ 0.0032
Week 17	€ 18.8740	€ 2.8330	€ 0.2369	€ 0.0382	€ 0.0152
Week 18	€ 56.6814	€ 12.7987	€ 0.7771	€ 1.9012	€ 0.3429
Week 19	€ 43.6303	€ 1.0607	€ 0.8260	€ 1.9196	€ 0.0097
Week 20	€ 27.6340	€ 9.8155	€ 0.3394	€ 0.0969	€ 0.0126
Week 21	€ 31.2627	€ 6.0785	€ 0.0125	€ 0.3045	€ 0.0049
Week 22	€ 4.1738	€ 1.7866	€ 0.2165	€ 0.4891	€ 0.0567
Week 23	€ 66.9786	€ 2.0808	€ 0.1070	€ 0.0644	€ 0.0233
Week 24	€ 26.6847	€ 0.5072	€ 0.4602	€ 0.0185	€ 0.0140
Week 25	€ 47.8653	€ 2.1341	€ 0.0896	€ 0.0558	€ 0.0081
Week 26	€ 11.7216	€ 0.8158	€ 0.2940	€ 0.4739	€ 0.0158
Week 27	€ 10.9054	€ 0.6155	€ 0.3384	€ 0.0977	€ 0.0026
Week 28	€ 1.9193	€ 3.8215	€ 0.1039	€ 0.0738	€ 0.0170
Week 29	€ 3.6521	€ 0.9824	€ 0.2446	€ 0.0219	€ 0.0048
Week 30	€ 10.7506	€ 1.7851	€ 0.0534	€ 0.1045	€ 0.0241
Week 31	€ 4.9229	€ 0.3209	€ 0.0161	€ 0.1020	€ 0.0159
Week 32	€ 14.2781	€ 3.0084	€ 0.0446	€ 0.0249	€ 0.0211
Week 33	€ 4.4264	€ 0.5432	€ 0.0798	€ 0.0749	€ 0.6313
Week 34	€ 4.6418	€ 0.5616	€ 0.0522	€ 0.0254	€ 0.0084
Week 35	€ 5.1024	€ 0.0374	€ 0.0617	€ 0.0254	€ 0.0094
Week 36	€ 6.7344	€ 0.7763	€ 0.0585	€ 0.0176	€ 0.0167
Week 37	€ 15.7561	€ 0.4987	€ 0.0435	€ 0.0252	€ 0.0221
Week 38	€ 4.9841	€ 0.3206	€ 0.2196	€ 0.0793	€ 0.0221
Week 39	€ 4.5760	€ 0.8056	€ 0.0204	€ 0.0102	€ 0.0047
Week 40	€ 22.3469	€ 0.0957	€ 0.0290	€ 0.2604	€ 0.0250
Week 41	€ 5.3714	€ 0.1534	€ 0.0124	€ 0.0211	€ 0.0074
Week 42	€ 3.2761	€ 1.9461	€ 0.0236	€ 0.0210	€ 0.0132
Week 43	€ 3.1414	€ 0.1904	€ 0.0536	€ 0.0332	€ 0.0205
Week 44	€ 0.5836	€ 0.2843	€ 0.1112	€ 0.1423	€ 0.0248
Week 45	€ 5.5480	€ 0.3247	€ 0.3204	€ 0.0298	€ 0.1374
Week 46	€ 3.7513	€ 0.1176	€ 0.0150	€ 0.0495	€ 4.3821
Week 47	€ 5.3243	€ 0.0164	€ 0.0885	€ 0.6015	€ 9.5906
Week 48	€ 3.7710	€ 0.3179	€ 0.0429	€ 0.0417	€ 0.0497
Week 49	€ 1.5201	€ 1.0404	€ 0.0168	€ 4.2186	€ 0.1660
Week 50	€ 9.5261	€ 0.2092	€ 0.0422	€ 0.2845	€ 0.0232
Week 51	€ 10.2570	€ 0.5925	€ 0.1403	€ 0.0483	€ 0.1188
Week 52	€ 1.3618	€ 0.1592	€ 0.2222	€ 1.3293	€ 0.0220
Week 53	€ 3.5694	€ 0.2394			€ 1.3033

Appendix 23:

EUR/GBP – GBP/USD – USD/CHF – EUR/CHF								
Week	2000	2001	2002	2003	2004	2005	2006	2007
	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>
Week 1	901	572	456	451	114	444	44	63
Week 2	644	816	295	481	455	138	30	327
Week 3	655	490	312	493	666	202	52	141
Week 4	657	741	310	517	863	311	38	131
Week 5	619	565	523	855	617	228	56	192
Week 6	619	554	424	667	405	232	28	85
Week 7	378	526	332	533	343	259	56	39
Week 8	748	588	326	474	285	225	66	62
Week 9	669	469	260	812	344	174	76	98
Week 10	483	329	354	675	312	194	49	79
Week 11	490	732	345	793	441	140	224	50
Week 12	297	544	352	820	599	237	263	46
Week 13	746	479	222	587	538	344	140	146
Week 14	782	373	192	1022	593	215	159	79
Week 15	572	498	326	733	334	302	66	88
Week 16	728	658	201	473	433	180	128	45
Week 17	565	690	397	597	615	201	121	44
Week 18	658	436	368	761	316	220	191	69
Week 19	755	432	387	611	791	184	205	31
Week 20	630	405	405	716	284	216	201	23
Week 21	504	437	651	788	642	188	196	54
Week 22	636	384	391	696	317	218	245	39
Week 23	675	443	356	663	186	129	168	40
Week 24	578	571	429	880	648	119	133	51
Week 25	971	315	209	840	462	94	112	53
Week 26	500	437	881	967	124	191	148	42
Week 27	446	310	743	560	295	226	86	31
Week 28	493	556	663	605	82	169	90	56
Week 29	201	813	692	443	169	355	153	55
Week 30	387	583	860	306	236	80	64	45
Week 31	464	403	801	600	313	119	75	26
Week 32	376	612	776	297	97	61	125	34
Week 33	474	648	439	273	166	87	68	97
Week 34	469	375	597	577	170	51	94	96
Week 35	520	452	472	429	246	101	94	30
Week 36	914	497	397	245	145	119	60	49
Week 37	792	384	600	355	96	100	80	28
Week 38	639	917	804	456	118	97	49	28
Week 39	829	640	535	362	188	66	67	28
Week 40	496	468	440	318	68	90	52	26
Week 41	780	349	453	285	165	53	93	41
Week 42	706	477	399	506	86	84	63	38
Week 43	704	382	340	498	124	47	52	24
Week 44	732	349	375	457	201	72	75	37
Week 45	630	312	346	547	230	61	79	27
Week 46	593	548	521	94	87	51	116	749
Week 47	447	417	596	279	72	78	72	662
Week 48	594	389	421	246	93	71	307	339
Week 49	683	351	522	418	199	32	220	198
Week 50	684	379	434	336	186	61	456	112
Week 51	718	660	582	434	385	61	135	34
Week 52	301	375	238	138	185	74	113	88
Week 53				114	404			53

Appendix 24:

EUR/GBP – GBP/USD – USD/CHF – EUR/CHF					
	2003	2004	2005	2006	2007
Week	Total Profit	Total Profit	Total Profit	Total Profit	Total Profit
Week 1	€ 0.2107	€ 0.0402	€ 0.0849	€ 0.0045	€ 0.0049
Week 2	€ 0.2986	€ 0.2429	€ 0.0259	€ 0.0062	€ 0.0452
Week 3	€ 0.2273	€ 0.3201	€ 0.0642	€ 0.0079	€ 0.0090
Week 4	€ 0.2446	€ 0.3399	€ 0.0545	€ 0.0096	€ 0.0102
Week 5	€ 0.7857	€ 0.6569	€ 0.0566	€ 0.0069	€ 0.0107
Week 6	€ 0.4603	€ 0.2450	€ 0.0314	€ 0.0035	€ 0.0039
Week 7	€ 0.3382	€ 0.5139	€ 0.0516	€ 0.0048	€ 0.0030
Week 8	€ 0.1884	€ 0.0987	€ 0.0365	€ 0.0060	€ 0.0066
Week 9	€ 0.6084	€ 0.1453	€ 0.0239	€ 0.0054	€ 0.0071
Week 10	€ 0.4883	€ 0.1083	€ 0.0364	€ 0.0067	€ 0.0081
Week 11	€ 0.6893	€ 0.2304	€ 0.0283	€ 0.0178	€ 0.0064
Week 12	€ 0.6065	€ 0.3464	€ 0.0510	€ 0.0194	€ 0.0025
Week 13	€ 0.4230	€ 0.3430	€ 0.1756	€ 0.0211	€ 0.0123
Week 14	€ 0.9932	€ 0.7776	€ 0.0443	€ 0.0239	€ 0.0070
Week 15	€ 0.3963	€ 0.1184	€ 0.1469	€ 0.0057	€ 0.0075
Week 16	€ 0.3334	€ 0.1906	€ 0.0218	€ 0.0102	€ 0.0034
Week 17	€ 0.4328	€ 0.2525	€ 0.0241	€ 0.0143	€ 0.0026
Week 18	€ 0.5488	€ 0.0879	€ 0.0338	€ 0.0280	€ 0.0046
Week 19	€ 0.7816	€ 0.3152	€ 0.0307	€ 0.0612	€ 0.0016
Week 20	€ 0.3675	€ 0.1170	€ 0.0234	€ 0.0565	€ 0.0014
Week 21	€ 0.5655	€ 0.2507	€ 0.0189	€ 0.0192	€ 0.0043
Week 22	€ 0.4966	€ 0.0993	€ 0.0229	€ 0.0205	€ 0.0025
Week 23	€ 0.5220	€ 0.0475	€ 0.0144	€ 0.0301	€ 0.0032
Week 24	€ 0.7203	€ 0.4582	€ 0.0111	€ 0.0082	€ 0.0021
Week 25	€ 0.5977	€ 0.2703	€ 0.0081	€ 0.0122	€ 0.0042
Week 26	€ 0.6706	€ 0.0252	€ 0.0178	€ 0.0133	€ 0.0021
Week 27	€ 0.3847	€ 0.1356	€ 0.0255	€ 0.0066	€ 0.0025
Week 28	€ 1.0458	€ 0.0136	€ 0.0230	€ 0.0074	€ 0.0022
Week 29	€ 0.3822	€ 0.0437	€ 0.0331	€ 0.0124	€ 0.0029
Week 30	€ 0.1759	€ 0.0691	€ 0.0076	€ 0.0057	€ 0.0020
Week 31	€ 0.2355	€ 0.0722	€ 0.0093	€ 0.0067	€ 0.0018
Week 32	€ 0.1030	€ 0.0197	€ 0.0056	€ 0.0120	€ 0.0061
Week 33	€ 0.0858	€ 0.0446	€ 0.0217	€ 0.0076	€ 0.0137
Week 34	€ 0.2484	€ 0.0361	€ 0.0037	€ 0.0077	€ 0.0213
Week 35	€ 0.3047	€ 0.0580	€ 0.0117	€ 0.0077	€ 0.0021
Week 36	€ 0.2864	€ 0.0164	€ 0.0127	€ 0.0050	€ 0.0042
Week 37	€ 0.2024	€ 0.0285	€ 0.0214	€ 0.0128	€ 0.0021
Week 38	€ 0.1772	€ 0.0270	€ 0.0143	€ 0.0023	€ 0.0021
Week 39	€ 0.1835	€ 0.0405	€ 0.0072	€ 0.0080	€ 0.0021
Week 40	€ 0.1868	€ 0.0082	€ 0.0230	€ 0.0034	€ 0.0012
Week 41	€ 0.1050	€ 0.0348	€ 0.0054	€ 0.0096	€ 0.0035
Week 42	€ 0.4080	€ 0.0144	€ 0.0107	€ 0.0053	€ 0.0018
Week 43	€ 0.3663	€ 0.0187	€ 0.0035	€ 0.0026	€ 0.0011
Week 44	€ 0.2601	€ 0.0256	€ 0.0054	€ 0.0143	€ 0.0073
Week 45	€ 0.3625	€ 0.0528	€ 0.0423	€ 0.0048	€ 0.0031
Week 46	€ 0.0210	€ 0.0137	€ 0.0049	€ 0.0070	€ 0.6035
Week 47	€ 0.0989	€ 0.0103	€ 0.0096	€ 0.0061	€ 0.2004
Week 48	€ 0.0858	€ 0.0157	€ 0.0131	€ 0.0191	€ 0.2139
Week 49	€ 0.1239	€ 0.0441	€ 0.0016	€ 0.0191	€ 0.0864
Week 50	€ 0.1582	€ 0.0374	€ 0.0038	€ 0.0433	€ 0.0249
Week 51	€ 0.6888	€ 0.0793	€ 0.0051	€ 0.0078	€ 0.0217
Week 52	€ 0.0808	€ 0.0277	€ 0.0036	€ 0.0099	€ 0.0238
Week 53	€ 0.0402	€ 0.1336			€ 0.0081

Appendix 25:

EUR/CHF – USD/CHF – GBP/USD – EUR/GBP								
Week	2000	2001	2002	2003	2004	2005	2006	2007
	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>	<i>With Volume</i>
Week 1	2394	1214	607	2081	547	314	232	690
Week 2	2649	1132	794	1731	753	188	45	174
Week 3	2355	1397	539	1696	999	580	34	824
Week 4	1687	1278	585	1204	876	344	35	493
Week 5	1332	905	452	1663	696	503	34	357
Week 6	620	691	747	2121	521	368	19	130
Week 7	1087	1169	535	1846	564	491	70	81
Week 8	1223	1028	545	1575	628	372	67	62
Week 9	1590	1040	542	1822	898	269	50	275
Week 10	721	655	873	2426	1571	363	191	205
Week 11	573	1114	789	1846	1168	299	651	80
Week 12	1420	1024	550	2504	649	420	739	72
Week 13	847	996	487	2840	270	362	199	119
Week 14	1562	1032	674	2982	1194	343	666	119
Week 15	1079	605	414	2738	438	266	121	82
Week 16	853	1395	906	3108	1251	400	170	46
Week 17	932	1020	549	2760	500	184	179	38
Week 18	2079	912	874	5248	2046	508	179	32
Week 19	2156	716	979	4670	1020	187	783	28
Week 20	900	625	702	3111	1141	181	260	539
Week 21	1507	1073	765	4884	844	60	2026	36
Week 22	1461	585	1235	1117	833	185	416	30
Week 23	2160	1039	1163	5745	696	162	148	50
Week 24	1154	1731	785	4530	296	317	84	49
Week 25	1095	838	1057	4449	611	163	114	30
Week 26	948	823	2042	2483	401	214	446	75
Week 27	711	737	996	1904	374	419	153	42
Week 28	627	1025	600	1173	424	147	133	50
Week 29	569	1271	1289	1407	369	312	76	45
Week 30	1101	832	1256	1788	561	288	223	65
Week 31	735	678	1222	1268	263	159	281	112
Week 32	785	551	932	1549	542	88	60	38
Week 33	1325	1108	1629	808	335	60	251	256
Week 34	1144	579	1232	1082	183	69	73	23
Week 35	1292	707	1059	1207	116	118	73	39
Week 36	1177	1013	957	1489	411	139	64	31
Week 37	2234	1355	722	1860	225	93	67	41
Week 38	2589	2127	1472	1862	199	83	110	41
Week 39	924	1039	1090	883	197	68	79	24
Week 40	1049	1230	1033	2717	185	98	82	21
Week 41	1048	1018	958	1399	87	64	49	29
Week 42	1313	559	581	1211	246	92	74	47
Week 43	1359	487	649	668	273	76	71	43
Week 44	1789	773	1131	576	323	136	51	64
Week 45	1663	667	1347	1298	480	187	73	135
Week 46	491	966	997	1295	146	86	106	992
Week 47	1135	674	646	1351	84	66	346	1327
Week 48	2245	967	793	824	353	81	82	73
Week 49	1607	708	1277	966	435	91	504	286
Week 50	1294	1305	1189	1257	308	94	354	87
Week 51	1518	987	1185	1169	447	26	202	96
Week 52	689	652	1404	506	289	198	803	11
Week 53				547	272			395

Appendix 26:

EUR/CHF – USD/CHF – GBP/USD – EUR/GBP					
	2003	2004	2005	2006	2007
Week	Total Profit	Total Profit	Total Profit	Total Profit	Total Profit
Week 1	€ 7.3391	€ 1.4965	€ 0.2742	€ 0.4760	€ 0.5747
Week 2	€ 5.3834	€ 2.6953	€ 0.0896	€ 0.0142	€ 0.0562
Week 3	€ 5.9708	€ 2.4351	€ 0.5377	€ 0.0079	€ 0.9435
Week 4	€ 2.1175	€ 0.9468	€ 0.2107	€ 0.0327	€ 0.4614
Week 5	€ 2.8033	€ 0.6788	€ 0.3331	€ 0.0153	€ 0.1640
Week 6	€ 4.2875	€ 0.8032	€ 0.1514	€ 0.0023	€ 0.0274
Week 7	€ 4.2390	€ 1.0925	€ 0.3742	€ 0.0196	€ 0.0363
Week 8	€ 2.2365	€ 0.9115	€ 0.2623	€ 0.0166	€ 0.0335
Week 9	€ 3.7553	€ 0.9187	€ 0.1652	€ 0.0106	€ 0.1825
Week 10	€ 10.8421	€ 6.0964	€ 0.1860	€ 0.0621	€ 0.3869
Week 11	€ 4.1027	€ 5.5133	€ 0.1647	€ 0.4819	€ 0.0169
Week 12	€ 5.9170	€ 1.0541	€ 0.6872	€ 2.5114	€ 0.0151
Week 13	€ 6.7669	€ 0.1867	€ 0.5111	€ 0.0648	€ 0.0292
Week 14	€ 7.0909	€ 3.2747	€ 0.1345	€ 0.4794	€ 0.0384
Week 15	€ 8.7288	€ 0.6993	€ 0.1211	€ 0.0484	€ 0.1610
Week 16	€ 7.2650	€ 3.1997	€ 0.1964	€ 0.0641	€ 0.0066
Week 17	€ 10.5199	€ 0.7828	€ 0.0553	€ 0.0795	€ 0.0111
Week 18	€ 38.5920	€ 8.6196	€ 0.3846	€ 0.1260	€ 0.0082
Week 19	€ 20.6311	€ 10.8887	€ 0.1777	€ 1.9419	€ 0.0039
Week 20	€ 13.0032	€ 6.9656	€ 0.1565	€ 0.0772	€ 0.0775
Week 21	€ 21.9904	€ 2.3504	€ 0.0109	€ 0.7404	€ 0.0057
Week 22	€ 3.4485	€ 0.9035	€ 0.1863	€ 0.3966	€ 0.0188
Week 23	€ 59.8257	€ 1.8734	€ 0.1211	€ 0.0213	€ 0.0059
Week 24	€ 27.6470	€ 0.4828	€ 0.1918	€ 0.0241	€ 0.0064
Week 25	€ 82.9278	€ 0.4570	€ 0.0433	€ 0.0255	€ 0.0215
Week 26	€ 6.2810	€ 0.5419	€ 0.0903	€ 0.3184	€ 0.0074
Week 27	€ 5.5507	€ 0.4252	€ 0.2818	€ 0.1784	€ 0.0075
Week 28	€ 2.3654	€ 0.9717	€ 0.0262	€ 0.0338	€ 0.0046
Week 29	€ 4.2204	€ 0.2681	€ 0.1394	€ 0.0231	€ 0.0146
Week 30	€ 4.8743	€ 0.4366	€ 0.0910	€ 0.0390	€ 0.0159
Week 31	€ 3.2814	€ 0.2785	€ 0.0589	€ 0.1447	€ 0.0192
Week 32	€ 15.8301	€ 0.5563	€ 0.0241	€ 0.0160	€ 0.0096
Week 33	€ 3.2345	€ 0.5062	€ 0.0148	€ 0.0585	€ 0.1938
Week 34	€ 1.5780	€ 0.1569	€ 0.0190	€ 0.0243	€ 0.0048
Week 35	€ 2.1551	€ 0.0553	€ 0.0748	€ 0.0243	€ 0.0075
Week 36	€ 4.5552	€ 1.0603	€ 0.0950	€ 0.0084	€ 0.0117
Week 37	€ 6.4440	€ 0.5176	€ 0.0591	€ 0.0186	€ 0.0200
Week 38	€ 3.9800	€ 0.2495	€ 0.0139	€ 0.0621	€ 0.0200
Week 39	€ 2.3984	€ 0.5543	€ 0.0183	€ 0.0114	€ 0.0130
Week 40	€ 13.8481	€ 0.0885	€ 0.0604	€ 0.0308	€ 0.0057
Week 41	€ 4.6335	€ 0.0996	€ 0.0231	€ 0.0117	€ 0.0058
Week 42	€ 2.9307	€ 1.1458	€ 0.2617	€ 0.0206	€ 0.0078
Week 43	€ 0.8986	€ 0.1690	€ 0.0192	€ 0.0109	€ 0.0066
Week 44	€ 0.4386	€ 0.2269	€ 0.2213	€ 0.0124	€ 0.1021
Week 45	€ 2.8656	€ 0.4572	€ 0.5296	€ 0.0302	€ 0.2153
Week 46	€ 2.3750	€ 0.0573	€ 0.0222	€ 0.0218	€ 0.8184
Week 47	€ 4.7334	€ 0.1011	€ 0.0203	€ 0.0735	€ 2.5131
Week 48	€ 1.6913	€ 0.4675	€ 0.0289	€ 0.0144	€ 0.0122
Week 49	€ 2.2037	€ 0.7089	€ 0.0271	€ 0.4276	€ 0.1155
Week 50	€ 4.2504	€ 0.2644	€ 0.0395	€ 0.1403	€ 0.0415
Week 51	€ 2.7841	€ 0.4587	€ 0.0091	€ 0.0648	€ 0.0219
Week 52	€ 0.5597	€ 0.3115	€ 0.0668	€ 0.3424	€ 0.0020
Week 53	€ 1.4965	€ 0.2354			€ 0.4613

Appendix 27:

BI Norwegian Business School – Preliminary Thesis Report

- High frequency arbitrage in FX markets -

Submission date:

15.01.2013

Campus:

BI Oslo

Name of supervisor:

Geir Høidal Bjønnes

Programme:

Master of Science in Business and Economics

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1.0 Introduction

The foreign exchange (FX) market is the world's largest financial market. According to the Bank for International Settlements the global market turnover in the FX market has grown with approximately 20 % from April 2007 until April 2010. The average daily turnover is estimated at \$4.0 trillion as of April 2010 compared to \$3.3 trillion as of April 2007.

During the two last decades the world has evolved into a massively electronic society. Nearly everything from music to financial transactions have gone digital. The development of computerized trading systems has been one of the most important advances in technology in the FX market. Since the late 1980s computerized trading has been present at Wall Street, i.e. electronic trading of financial instruments. Later in 1992 electronic trading became available in the FX market when Reuters launched the first electronic brokering system for trading spot foreign exchange (Bekaert and Hodrick, 2009).

Throughout the years the computers involved in the process, has grown to be powerful sophisticated technological tools and the algorithms which guides the electronic trading more complex (The New York Times, 2012). High frequency trading (HFT) is the use of a computer driven investment strategy whereby futures, options, equities, currencies and all other financial instruments that is capable in electronic trading are held for a very short period, usually seconds or milliseconds (Brogaard 2011).

Even though the emergence of electronic trading took place early in the FX market it was merely available in the inter-dealer market, and not the customer market. This boundary disappeared in the early 2000s when FX dealing banks offered trading services to clients through electronic platforms (Bank for International Settlements, 2011). Due to this breakthrough in information technology, both FX and the equity market trading have entered into a new era with high-frequency traders (HFTs) as the most active participant.

Arbitrage opportunities may exist when one participant have a distinctive advantage. According to financial theory there should not be possible to find risk-free arbitrage opportunities in the financial markets when we account for

transaction cost. This is due to the law of one price, which states that all identical assets will have the same price no matter where the asset is traded, or how the asset is created because of market efficiency

Grossman and Stiglitz (1976, 1980) introduced the well-known theory “arbitrage paradox”, which states that if arbitrage opportunities do not exist, market participants will probably not have sufficient incentives to observe the market, which would lead to arbitrage opportunities. This will again invite short-term arbitrage traders, which will eliminate these arbitrage opportunities.

1.1 Research question

HFT has mostly been study from an equity market point of view. Market quality, i.e. volatility and liquidity, efficiency and co-location are the topics that recur. In this thesis we will investigate:

“If there exist arbitrage opportunities in the FX market by using HFT”.

The main objective is to determine whether there exist high frequency (HF) arbitrage opportunities in the FX market in our dataset from 1997 until 2007. We will mainly focus on triangular arbitrage. However, we will likewise investigate four-angular arbitrage, five-angular arbitrage if our dataset allows it. Further, we “may” investigate limit-order arbitrage depending on the dataset.

Other objectives will be to find out if the number of arbitrage opportunities has decreased or increased from 1997 until 2007. One would expect that the number of arbitrage opportunities is decreasing over this time period, given the introduction of high frequency trading (HFT) in the foreign exchange market in the early 2000. Our final sub - objective will be to search our second dataset (2008-2009) which have a time slice period of only 250 milliseconds, for arbitrage opportunities, and compare the results with our first dataset, which has a time slice period of one second.

1.2 Expected result

Given the size, and liquidity of the FX market, we expect the market to be very close to efficient, which should imply that arbitrage opportunities will have an

extremely short time frame. Further, we expect that arbitrage opportunities will decrease as we approach the end of our dataset, given the massive increase in HFT in the early 2000s. Finally we expect that our second dataset, which have a smaller time slice period, and a deeper order book, will give us the opportunity to investigate more advanced arbitrage opportunities. Our overall expectation will be that there exist high frequency arbitrage opportunities in the FX market.

1.3 Motivation and contribution

We both believe that HFT will be included in most academic papers regarding trading in the years to come. As far as our knowledge goes there are no empirical papers that investigate high frequency arbitrage in the FX market. With this in mind it will be in great interest to us to investigate this topic further.

As mentioned, most previous studies of HFT effect are focused on the equity markets, and not the FX market. If we achieve our expected results we hope to form a basis for a discussion on high frequency arbitrage in the FX market, especially triangular arbitrage. Our motivation to write a master thesis on this topic is affected by our contribution in this research field. We hope to show that high frequency arbitrages do exist in the FX market. Further, we hope to add a result that shows that arbitrage opportunities decrease after the introduction of HFT.

2.0 Literature review

HFT is a rather young and recent phenomenon. Although the topic has got more and more attention lately, both among researchers and academic communities, there is just a small group of researcher addressing questions explicitly regarding HFT. Most previous studies of HFT effects are focused on the equity markets. Questions addressing market quality and efficiency, co-location, market penetration, volatility, HFT activity and profitability are widely common. Since HFT has received most attention recently, the research papers we present in this section will be rather new, and are partly working papers still waiting to be published.

2.1 Research papers investigating HFT effects in the equity markets

Cvitanic and Kirilenko (2010) constructed the first theoretical model to address how market conditions or market quality is affected by HFT. They illustrate an electronic model by adding a HFT, i.e. a computer or a machine, to an already existing market consisting of low frequency traders (LFT), i.e. humans. The only difference between the two investors in the model is the time horizons, i.e. the speed advantage of the machine. Cvitanic and Kirilenko (2010) find that when HFT is accounted for; transaction prices differ from the distribution of transaction prices. This means that transaction prices have lower volatility and are more concentrated around the mean. Further, they find that liquidity increase when humans increase their trading volume and intertrade duration.

Jonathan A. Brogaard (2011a) investigates the relationship between HFT and the volatility of stock returns. He argues that one of the main concerns regarding HFT is that this new type of trader may contribute to destabilize financial markets and exacerbates volatility. This is the reason why it is crucial to understand how volatility impacts HFT activity. Firstly, he shows a strong relationship between HFT and volatility in a Granger causality context. The relationship goes both ways – HFT activity causes volatility, and volatility causes HFT activity. Secondly, he shows that both macro and stock specific news has an impact on volatility periods. During stock specific news periods HFTs tend to increase their supply of liquidity and decrease their liquidity demand. The opposite effect is true for macro specific news.

Further, Jonathan A. Brogaard (2011b) examines the role or the activity of high frequency trading in the U.S equities market. He shows that since 2008 high frequency traders have been a large market participant, i.e. involved in almost 70 % of the dollar - volume traded. HFT activity tends to focus on large and liquid stocks where intraday HFT activity is driven by returns, past liquidity and other HFT activity. Gross annual trading profit generate by HFTs is estimated to be between \$ 2.8 - \$ 4.1 billion in the equity market.

While Brogaard's two first papers describe the dynamics of HFT trading and the link between HFT and volatility, they do not evaluate to what extent HFTs are contributing to market quality, i.e. does the quality increase or decrease?

The last paper from Jonathan A. Brogaard (2011c) investigates the liquidity and price discovery role of high frequency traders in the U.S equity market, i.e. the link between HFT and market quality. Since the ability of market participants to receive, analyze and react to data in milliseconds, the question of speed and quality have risen. Brogaard shows that HFTs are adding to the market quality of U.S equity market. They both provide a sizeable amount of liquidity depth and to the permanent price process. However, the role it plays varies periodically with systematic and idiosyncratic volatility.

Menkveld (2011) shows that if you launch a new trading platform like the Chi-X, you will benefit from having HFT market makers. The reason for this is because they will decrease the spreads which implies an increase in the volume. When Chi-X were launched in the Dutch stock market they initially only generated 1-2% of all trades. After one month, a modern HFT market maker started using their platform, and suddenly they generated double-digit shares of all trades in the Dutch stock market.

Henderschott et al. (2011) finds results that Algorithmic Trading (AT) decreases the amount of price discovery correlated with trading, and lowers adverse selection. They further suggest that AT reduces trading costs and increases the informativeness of quotes. Further, they find temporary evidence that AT trading increases revenues to liquidity suppliers. However, their sample includes a period

of mostly rising stock prices, which can imply that the results would be different in a more volatile market.

Cui, Brabazon and O'Neill (2010) discuss how to trade a security most effectively without moving the price. They built an Artificial Stock Market (ASM) to test out different trading algorithms, to find the most efficient order execution strategy. Their result finds evidence that Generic Algorithms (GA) gives satisfactory results in order execution compared to the popular benchmark Volume Weighted Average Price (VWAP) strategy. They conclude that testing execution strategies on an ASM could be an alternative to regular back testing on historical data.

2.2 Research papers investigating HFT effects in the FX markets

The Bank for International Settlements (2011) compares similarities between HFT effects in the FX and the equity market. They found that there are a wide range of similarities regarding the impacts on the two markets. For instance; more frequent trades, tighter spreads, smaller quote size/life and shorter holding time period. Further, they show that HFT tend to focus on the most liquid exchange rates, similar to the focus on the most liquid stock in the equity market. Lastly, they refer to empirical literature and conclude that algorithmic and high frequency trading is neutral to beneficial for market quality, in that volatility has declined and the spreads has become tighter.

Chaboud et al. (2009) is the only major contribution that investigates AT in FX markets. Their empirical results conclude that algorithmic trades are more correlated and less diverse than trades made by humans. Most have argued that this will increase volatility. However, Chaboud et al (2009) does not find empirical evidence that an increase in algorithmic trading do increase the volatility. Further, they show evidence that algorithmic traders reduce their activity before important news releases when the volatility usually is very high, but they increase their activity again in the hours after the release, which shows that algorithmic trading provides liquidity during volatile market periods.

Further, Chaboud et al. (2009) finds evidence that the informed traders are driving price discovery in the exchange rate EUR/USD, while in USD/YEN it is the non-algorithmic traders. In the last exchange rate EUR/YEN they concludes that since

a large proportion of algorithmic trades are searching for triangular arbitrage, both the non-algorithmic and algorithmic traders are equally informed. Lastly, they show evidence that when algorithmic traders place their limit orders, they impact the price less than human traders. Controversy, they concludes by stating that given this research and data, the growth of algorithmic trading does not reduce the quality of the market like many of the headlines in the international press states.

2.3 Research papers investigating arbitrage in the FX markets

Kollias and Metaxas (2001) discuss the use of triangular arbitrage as a measure of efficiency in the FX market. They find evidence that arbitrage opportunities exist, but since they involve a degree of risk, they cannot be interpreted as an indication of market inefficiency. Further, they show that a great deal of the mispricing is also not possible to exploit because of the short duration. Lastly, they find evidence that when the magnitude of the mispricing is increasing, the timeframe to exploit it is decreasing.

Akram, Rime and Sarno (2005) working paper for the Norwegian Bank (Norges Bank) explores if arbitrage opportunities exist in the three major FX markets and capital markets over a period of 151 trading days in 2004. Their results shows that there exist temporary arbitrage periods in these markets, and that these periods are on average long enough for high frequency traders to take advantage of them.

Marshall, Treepongkaruna and Young (2008) examine triangular arbitrage opportunities on the EBS trading platform. They examine GBP, CHF and YEN against the USD and EUR. They find evidence of small fluctuating arbitrage opportunities through the entire trading day. When the volume is decreasing they find that arbitrage opportunities are increasing, which sounds reasonable given less competition. Further, they find that when the volume is low market makers tend to reduce their activity and let arbitrageurs help out keeping the currency rate in place, which is consistent with Grossman and Miller (1988) view that there is a cost to immediacy.

3.0 Data

The historical data used in this analysis is provided by EBS data mine. The time horizon of the data collected is from 1997 until 2007 with a time slice interval of one second. The data consist of three mine levels which includes both information on EBS Best prices and the dealt prices in the EBS Market. The EBS best prices include Best Bid (Disregarding credit, the highest bid price in the EBS market at the time) and Best offer (Disregarding credit, the lowest offer price in the EBS market at the time). The dealt prices include the highest buying deal price, i.e. the highest paid at the time, and the lowest selling deal price, i.e. the lowest given at the time.

The first level is Level 1.0, i.e. EBS Best Price. The second level is Level 1.5, i.e. EBS best Price with volume indicators. The volume indicators refer to a bid size and offer size indicator for prices, and a deal size indicator for both gives and paid. The third level is Level 2.0, i.e. EBS Best Price plus actual volume (un-masked). This implies that each level include all capabilities of the preceding level or levels.

Further, we will use a second dataset from (2008-2009) with a time slice interval of 250 milliseconds. This historical dataset consist of data mine level 5.0, i.e. Depth of Book – 10 levels of order book. Both dataset has a standard CSV format, i.e. comma separated values with no header or trailer records.

Further details and information on data will be provided in our final thesis. Illustrations will be included in the appendices.

4.0 Methodology

In this section we will outline how we will conduct and test our research question. In relation to the real world the speed of the algorithms is essential. This implies that location and how the algorithms are constructed are important factors.

However, since our data is ex post, i.e. after an event, we do not regard this as a problem.

(1) Triangular arbitrage

Triangular arbitrage is an arbitrage strategy where you search for price deviations between three currency pairs. If a price deviation between three currency pairs occurs it is possible to lock in a risk free profit. Arbitrage is per definition risk free, which implies that the transactions have to be done simultaneously since the foreign exchange rates fluctuate frequently.

In order to conduct our research question we will provide an example with these three currency pairs regarding triangular arbitrage:

EUR/USD, USD/YEN and EUR/YEN.

If you for instance start with EUR you have two possible round trips. First option is to convert your EUR into USD, then convert your USD into YEN, and finally convert your YEN into EUR. The second option is to convert your EUR into YEN, then convert your YEN into USD, and finally convert your USD into EUR. If the amount of EUR in the last transaction is larger than the amount of EUR you started with then an arbitrage opportunity exists.

As described above you will have two possible triangular arbitrage opportunities depending on which currency you start with, which imply that there will be six possible arbitrage opportunities when you have three currency pairs.

Suppose you observe these quotes on your trading platform:

	Bid	Ask
EUR/USD	1.304	1.3044
USD/YEN	87.88	87.92
EUR/YEN	114.548	114.562

Table 1

If you start with EUR you will have two possible round trips to search for arbitrage opportunities.

(1.1) Round trip number one:

$$y_1(t) = \frac{EUR}{USD_{bid}}(t) \times \frac{USD}{YEN_{bid}}(t) \times \frac{1}{\frac{EUR}{YEN_{ask}}(t)}$$

$$y_1(t) = 1.304 \times 87.88 \times \frac{1}{114.562}$$

$$y_1(t) = 1.0029$$

(1.2) Round trip number two:

$$y_2(t) = \frac{EUR}{YEN_{bid}}(t) \times \frac{1}{\frac{USD}{YEN_{ask}}(t)} \times \frac{1}{\frac{EUR}{USD_{ask}}(t)}$$

$$y_2(t) = 114.548 \times \frac{1}{87.92} \times \frac{1}{1.3044}$$

$$y_2(t) = 0.9988$$

If $y(t)$ is larger than one we have an arbitrage opportunity. As we can see from the example above there would be a small arbitrage opportunity by doing round trip number one, if we do not take transaction cost into account.

We will assess this formula as a starting point to search for triangular arbitrage opportunities in SAS, by SAS Institute Inc. Further explanations regarding the method in SAS will be provided in our final thesis.

(2) Four-angular arbitrage¹

Four-angular arbitrage is more or less the same as the triangular arbitrage strategy described above. The only difference is that we use four currencies instead of three.

In order to conduct our research question we will provide an example with these four currency pairs regarding four-angular arbitrage:

EUR/USD, USD/YEN, GBP/YEN and EUR/GBP

If you for example start with EUR you have two possible round trips. First option is to convert your EUR into USD, then convert your USD into YEN, then convert your YEN into GBP, and finally convert your GBP into EUR. The second option is to convert your EUR into GBP, then convert your GBP into YEN, then convert your YEN into USD, and finally convert your USD into EUR. If the amount of EUR in the last transaction is larger than the amount of EUR you started with then an arbitrage opportunity exists.

As described above you will have two possible four-angular arbitrage opportunities depending on which currency you start with, which imply that there will be eight possible arbitrage opportunities when you have these four currency pairs.

¹ Will depend on the currency pairs in the dataset

Suppose you observe these quotes on your trading platform:

	Bid	Ask
EUR/USD	1.30412	1.30422
USD/YEN	87.888	87.904
GBP/YEN	140.633	140.656
EUR/GBP	0.81169	0.81182

Table 2

If you start with EUR you will have two possible round trips to search for arbitrage opportunities.

(2.1) *Round trip number one:*

$$y_1(t) = \frac{EUR}{USD_{bid}}(t) \times \frac{USD}{YEN_{bid}}(t) \times \frac{1}{YEN_{ask}}(t) \times \frac{1}{GBP_{ask}}(t)$$

$$y_1(t) = 1.30412 \times 87.888 \times \frac{1}{140.656} \times \frac{1}{0.81182}$$

$$y_1(t) = 0.9996$$

(2.2) *Round trip number two:*

$$y_2(t) = \frac{EUR}{GBP_{bid}}(t) \times \frac{GBP}{YEN_{bid}}(t) \times \frac{1}{USD_{ask}}(t) \times \frac{1}{EUR_{ask}}(t)$$

$$y_2(t) = 0.81169 \times 140.633 \times \frac{1}{87.904} \times \frac{1}{1.30422}$$

$$y_2(t) = 0.9997$$

If $y(t)$ is larger than one then there is an arbitrage opportunity. As we can see from the example above this is not the case in this example.

We will use these formulas described above to search for four - angular arbitrage opportunities in our datasets. To perform the searches we will use the statistical program SAS. If our dataset allows us, we will also search for five-triangular arbitrage and limit-order arbitrage.

5.0 Thesis progression plan

Our main priority going forward is to get hold of the data. We will not spend any time to obtain the data since Geir Høidal Bjønnes has access to EBS Data mine. We expect to be provided with the data consecutively. Once we have received the data we will begin to process and analyze it. Further, in the start phase of this thesis it is crucial for us that we properly are aware of and understand the features of the statistical analysis system we shall use, SAS. Therefore, January and February will be used to understand SAS and work the data so it fit into the program.

Further, we will start our analysis in the beginning of March. Not later than mid-April will we analyze our results and comment the findings of our analysis. From mid – April and forth we will start producing a draft of the thesis and then work continuously until we have finished our thesis. By June 1th we will send our “almost” complete thesis to Geir Høidal Bjønnes in order to get a detailed review and feedback. Overall goal will be to hand in the thesis somewhere between July 1th and July 10th. We will try to follow this plan with exactness subjected to the fact that we may deviate from it

The plan for the thesis progression is illustrated below:

Time period	Specification
Jan 15 th	Hand in Preliminary Thesis
Jan 15 th – Feb 28 th	Process data and learn SAS
Mar 1 st – Apr 15 th	Analysis testing and interpretation of results
Apr 16 th – Jun 1st	Draft of the thesis
Jun 2 th – Jul 10 th	Complete and hand in final thesis

Reference list

Akram, Rime and Sarno. 2005. Arbitrage in the foreign exchange market: Turning on the microscope. Norges Bank Working Paper.

Bekaert, Geert and J. Hodrick, Robert. 2009. *International financial management*. Upper Saddle River, N.J.: Pearson Prentice Hall.

B.I.S. 2011. High-frequency trading in the foreign exchange market. Markets Committee chaired by Guy Debelle (The reserve bank of Australia).

B.I.S. 2010. Triennial Central Bank Survey Report on global foreign exchange market activity in 2010. Bank for International Settlements.

Brogaard, Jonathan A. 2010 (A). "High Frequency Trading and Volatility." (Working Paper Series)

Brogaard, Jonathan A. 2011 (C). "High Frequency Trading and Market Quality." (Working Paper Series)

Brogaard, Jonathan A. 2011 (B). "The Activity of High Frequency Traders." (Working Paper Series)

Chaboud, Alain, Hjalmarsson, Vega and Chiquoine. 2009. Rise of the Machines: Algorithmic Trading in the Foreign Exchange. *Federal Reserve International Finance Discussion Paper No. 980*

Cvitanic, Jaks, and Andrei A. Kirilenko. 2010. "High Frequency Traders and Asset Prices". (Working Paper Series).

Cui, Brabazon and O'Neill. 2010. Evolutionary Computation and Trade Execution. *Natural Computing in Computational Finances* Vol. 3

Grossman, Sanford, Miller.1988.Liquidity and Market Structure. *The Journal of Finance* **43** (3): 617–633

Grossman and Stiglitz. 1980. "On the Impossibility of Informationally Efficient Markets". *American Economic Review* 70 (3): 393-408

Grossman and Stiglitz. 1976. "Information and Competitive Price Systems". *American Economic Review* 66 (2): (246:253)

Hendershott, Jones and Menkveld. 2011. "Does Algorithmic Trading Improve Liquidity?". *Journal of Finance* 66: 1 - 33.

Kollias, Metaxas.2001. How efficient are FX markets? Empirical evidence of arbitrage opportunities using high-frequency data. *Applied Financial Economics* 11: 435-444

Marshall, Treepongkaruna and Young. 2008. "Exploitable Arbitrage Opportunities Exist in the Foreign Exchange Market". (Working paper series)

Menkveld, Albert J. 2011. "High Frequency Trading and The *New-Market* Makers." (Working paper series)

URL

The New York Times. 2012. "High-Frequency Trading". Accessed January 2, 2013.

http://topics.nytimes.com/topics/reference/timestopics/subjects/h/high_frequency_algorithmic_trading/index.html

DATA

EBS Data Mine – Record format. Levels 1.0, 1.5 and 2.0. March 2008. Accessed January 7, 2013.