Algorithmic trading, also known as automated computerized trading, has been widely used in financial markets in recent decades. The wide application of algorithm trading has brought significant benefits to transaction efficiency and market liquidity. A lot of developers have designed trading algorithms which can simulate their trading strategies, and some have claimed that these algorithms can keep making profits continuously as a substitute for human traders. However, performance of the ones tested, were usually not as satisfactory as human traders over time. Their performance was on a specific or finite period and generally followed by failure as time progressed.

Several factors, three chief among them, could lead to this failure in trading: (1) Programs cannot simulate all human behavior; (2) Most algorithms are over-sensitive; and (3) Failure predict or hedge Black Swan or SIGMA events (pg7), unpredictable episodes and market manipulated fluctuations. Attempting to solve these problems, therefore, evaluating the effectiveness and sensitivity of trading algorithms along with protective hedging implementation, is and continues to be a necessary part of research and development.

The contribution of this research includes a overview of different types of trading algorithms such as electronic or computerized algorithm, an opinion on high frequency trading (HFT), artificial intelligence algorithm trading and their algorithm experimental design, data analysis and the effect of their participation in the market. The study focuses on the conceptual mechanism of trading algorithms, which includes trading applications and algorithms deployment. References to existing research, writing and relevant existing work has been included and acknowledged for the purpose of comparison and to provide a broader perspective.

This paper describes how Foreign Exchange (Forex) algorithm trading systems are suitable for Forex price prediction through technical and statistical analysis. This paper also describes how Forex algorithm trading systems, when suitably implemented into a trading portfolio, demonstrates how Foreign Exchange trading to be necessary and valuable diversification strategy to a multi faceted trading portfolio.

The evidence shows that trading algorithm systems can capture the underlying “rules” of the Forex market trend by using time series, technical indicators and other factors. Conventional and Traditional standards for technical analysis are used to evaluate the accuracy of currency price fluctuation & changes when traders are using software for real trading.

The results indicate that practical forecasting can be completed where paper and real profits can be obtained by implementing the right trading algorithm systems. However, the collection of sensitive analysis is incompatible with efficiency testing. Most testing results were collected by chart review, real time trading data, forward testing, backward testing as far back as 1999 Forex data as well as hypothetical results for a period of 13 years and the test results show that the effectiveness and sensitivity of algorithm trading are both interrelated and contradictory. The more sensitive trading algorithms are tuned to more trading opportunities, the more results have shown to reduce performance and increase draw-downs size and overall portfolio risk.

Keywords — Forex Automatic Market Making, Automated trading algorithms, High Frequency Trading, Foreign Exchange Spot Computerized Trading, Network Latency, computer algorithm, high frequency algorithm, artificial intelligence trading algorithm.
1. INTRODUCTION

The electronic foreign exchange (Forex) market is a global financial market for trading currencies established in 1971. Since then, how one currency relates to another currency is expressed as foreign exchange, and it has naturally shifted from fixed to floating under the continuously trading environment. The foreign exchange market is known to be the largest financial market in the world, as measured by daily turnover. Trading in foreign exchange markets averaged $5.3 trillion per day in April 2013 as shown in table 1. This is up from $4.0 trillion in April 2010 and $3.3 trillion in April 2007. FX swaps were the most actively traded instruments in April 2013, at $2.2 trillion per day, followed by spot trading at $2.0 trillion. What may be less apparent is how quickly this market has grown over the past few years and why it is growing so quickly. By most estimates, the trading volumes in the foreign exchange market are continuing to grow rapidly. The Tower Group, for example, recently estimated that daily global trading volumes would likely reach US$5 trillion. Foreign exchange trading volumes will have more than tripled in two decades. Unlike other markets, the foreign exchange market has a large trading volume, since it covers all the currency exchange transactions in the world.

There is no physical trading location or a central market. In the past, only large investment funds could trade currencies. This trading process is called “interbank” trading, and is established by large banks and major financial dealers. Spreads are generated from Forex trading, and are presented by the gap between bids and ask. By the wide application of electronic Forex trading, more and more retail foreign exchange brokers are providing individual trading services for ordinary traders. According to a famous definition of foreign exchange, “Retail foreign exchange trading is a small segment of the large foreign exchange market.” Retail foreign exchange brokers earn money from spreads. Most of them are trust companies, small banks and other institutions. In the early 2000s, some software companies designed their own version of trading platforms. All this software includes trading interfaces and user terminals, and provides the functions to help traders design their own trading strategies.

In recent years, trading algorithms are widely used in Forex trading. Most of them are coded as programs, and they can automatically execute the trading by following trading signals. The greatest benefit of algorithm trading is the fast reaction to market sentiments. Usually, traders must waste time considering market sentiments and then make decisions. Trading algorithms can use pre-wired thinking and save time which can be used to handle many trading opportunities. Also, trading algorithms can avoid the psychological factors of human traders. There is no need to consider such factors as greed and fear influencing the trading results in algorithm trading.

The use of algorithmic trading systems (ATS), where computers monitor markets and manage the trading process at high frequency, has become common in major financial markets in recent years, beginning in the U.S. equity market in the 1990s. Since the introduction of algorithmic trading, there has been widespread interest in understanding the potential impact it may have on market dynamics, particularly recently following several trading disturbances in the equity market blamed on computer-driven trading. While some have highlighted the potential for more efficient price discovery, others have expressed concern that it may lead to higher adverse selection costs and excess volatility.

Table 1: Daily return on the global FX Market 1999-2013

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign exchange instruments</td>
<td>591</td>
<td>674</td>
<td>783</td>
<td>1,238</td>
<td>2,139</td>
<td>3,192</td>
</tr>
<tr>
<td>Spot transactions</td>
<td>592</td>
<td>674</td>
<td>783</td>
<td>1,234</td>
<td>2,134</td>
<td>3,192</td>
</tr>
<tr>
<td>Outright forwards</td>
<td>128</td>
<td>130</td>
<td>209</td>
<td>362</td>
<td>475</td>
<td>680</td>
</tr>
<tr>
<td>Foreign exchange swaps</td>
<td>734</td>
<td>656</td>
<td>954</td>
<td>1,714</td>
<td>1,759</td>
<td>2,228</td>
</tr>
<tr>
<td>Currency swaps</td>
<td>10</td>
<td>7</td>
<td>21</td>
<td>31</td>
<td>43</td>
<td>54</td>
</tr>
<tr>
<td>Options and other products</td>
<td>87</td>
<td>60</td>
<td>119</td>
<td>212</td>
<td>207</td>
<td>337</td>
</tr>
<tr>
<td>Turnover at April 2013</td>
<td>1,718</td>
<td>1,500</td>
<td>2,036</td>
<td>3,376</td>
<td>3,969</td>
<td>5,345</td>
</tr>
</tbody>
</table>

In this paper, we suggest the effect of the different algorithmic trades and non-algorithmic trades have on the informational efficiency of foreign exchange prices. The data represents a large share of spot interdealer transactions across the globe in these exchange rates. A crucial feature of the data is that, on a minute-by-minute frequency, the volume and direction of trades are allowing to measure the impacts of high frequency and rapid growth of algorithmic trading in an important market where it had not been previously allowed.
2. HISTORY AND BACKGROUND

Algorithmic trading started in the mid 1970s in financial markets, with symbols that the New York Stock Exchange (NYSE) adopted: Designated Order Turnaround (DOT) and the Opening Automated Reporting System (OARS). The DOT system directly built a relationship between traders and trading desks, and executed electronic transactions at the trading. The OARS assisted traders to make decisions on settling orders.

Algorithmic trading was adopted by The NYSE because The NYSE market owned a value of more than 100 million dollars, with over 15 trading portfolios of baskets of orders. With such a large volume, computers were necessary to handle trading instead of humans. In the 1980s, algorithmic trading was widely used in financial markets. Stock index arbitrage trading meant that traders bought (or sold) stocks such as S&P500 futures and simultaneously bought (or sold) a series of NYSE stocks, where the portfolio was highly relevant to the futures. The NYSE trading robot was enacted by a computer. When the direct spread was large enough to be profitable, the computer executed orders automatically.

In late 1980’s and 1990’s, the development of the telecom network made the financial market completely electronic. In the U.S. stock market, decimalization changes the minimum share price from 1/16 dollar to 0.01 dollars. This regulation changes market microstructure and reduces price spread, and thus reduces market liquidity. Papadamou and Stephanides (2005) consider that this probably promoted the development of algorithmic trading.

With more and more electronic trading, more algorithmic trading strategies have become possible. These strategies include arbitrage, statistical arbitrage, trend following and regression. Computers can effectively implement these trading strategies by monitoring different markets and analysing the historical data.

3. THE FOREIGN EXCHANGE MARKET

The increasing growth turnover in the Foreign Exchange Market over the last several of years, seen in Figure 1 and Table 1 seems to be led by two related factors. First of all, the presence of trends and higher volatility in Forex markets between 2001 and 2004, led to an increase of momentum trading, where investors took large positions in currencies that followed appreciating trends and short positions in decreasing currencies. These trends also induced an increase in hedging activity, which further supported trading volumes. Second, interest differentials encouraged so called carry trading, i.e. investments in high interest rate currencies financed by short positions in low interest rate currencies, if the target currencies, like the Australian dollar, tended to appreciate against the funding currencies, like the US dollar. Such strategies fed back into prices and supported the persistence of trends in exchange rates. In addition, in the context of a global search for yield, so called real money managers and leveraged investors became increasingly interested in foreign exchange as an asset class alternative to equity and fixed income. As one can see in Figure 1, the trend is also consistent from 2004 and forward, with more and more money put into the global Forex market. The number of participants and the share of the participants' portfolio towards Forex are continuously increasing, comparing to other asset classes.

![Figure 1: Daily return on the global FX market 1999-2013](image-url)
a. Market Structure

The Forex market is unlike the stock market and the Over The Counter (OTC) market. There is no single physical located place where trades between different players are settled, meaning that all participants do not have access to the same price. Instead the markets core is built up by a number of different banks. That is why it sometimes is called an inter-bank market. The market is opened 24 hours a day and moves according to activity in large exporting and importing countries as well as in countries with highly developed financial sectors. The participants of the Forex market can roughly be divided into the following five groups, characterized by different levels of access:

- Central Banks
- Commercial Banks
- Non-bank Financial Entities
- Commercial Companies
- Retail Traders

Central banks have a significant influence in Forex markets by virtue of their role in controlling their countries’ money supply, inflation, and/or interest rates. They may also have to satisfy official/unofficial target rates for their currencies. While they may have substantial foreign exchange reserves that they can sell in order to support their own currency, highly overt intervention, or the stated threat of it, has become less common in recent years. While such intervention can indeed have the desired effect, there have been several high profile instances where it has failed spectacularly, such as Sterling’s exit from the Exchange Rate Mechanism (ERM) in 1992.

Through their responsibility for money supply, central banks obviously have a considerable influence on both commercial and investment banks. An anti-inflationary regime that restricts credit or makes it expensive has an effect upon the nature and level of economic activity, e.g. export expansion that can feed through into changes in Forex market activity and behavior.

At the next level we have commercial banks. This level constitutes the inter-bank section of the Forex market and consists of participants such as Deutsche Bank, UBS AG, Citi Group and many others including Swedish banks such as Nordea, SEB, Swedbank and Handelsbanken.

Within the inter-bank market, spreads, which are the difference between the bid and ask prices, are sharp and usually close to non-existent. These counterparts act as market makers toward customers demanding the ability to trade currencies, meaning that they determine the market price.

As you descend the levels of access, from commercial banks to retail traders, the difference between the bid and ask prices widens, which is a consequence of volume. If a trader can guarantee large numbers of transactions for large amounts, they can demand a smaller difference between the bid and ask price, which is referred to as a better spread. This also implies that the spread is wider for currencies with less frequent transactions. The spread has an important role in the Forex market, more important than in the stock market, because it is equivalent to the transaction cost.

When speculating in the currency market you speculate in currency a pair, which describes the relative price of one currency relative to another. If you believe that currency A will strengthen against currency B you will go long in currency pair A/B. The largest currency is the global Forex market is US Dollar (USD), Euro (EUR) and Japanese Yen (JPY). USD stands for as much as 86 percent of all transactions, followed by EUR (37 percent) and JPY (17 percent).
b. Forex Elements

i. Expression of currency pairs

In Forex trading, products are described as currency pairs, and the trading process is exchanging one currency to another. For example, the exchange rate of the British pound and the U.S. dollar are formed as GBP/USD. Obviously the exchange rate is constantly fluctuating, and it is based on the stronger currency being addressed in the current currency pair.

Some currency pairs are traded by traders frequently, and are called major currency pairs, especially if one side of those currency pairs is the U.S dollar. There are seven major currency pairs that are traded every day in the world. Other currency pairs that are traded in the Forex market are called cross-currency pairs, when the currency pair does not include the U.S. dollar. For example, GBP/JPY is one of the cross-currency pairs.

ii. Trading Sessions

The foreign exchange market runs continuously within networks between banks for 24 hours. There is no physical trading location or central market. However, prices do not dramatically fluctuate whole day.

<table>
<thead>
<tr>
<th>Currency Pairs</th>
<th>Countries or regions of produce</th>
<th>Name of speech</th>
</tr>
</thead>
<tbody>
<tr>
<td>USD / JPY</td>
<td>America / Japan</td>
<td>Dollar yen</td>
</tr>
<tr>
<td>EUR / USD</td>
<td>Europe / America</td>
<td>Euro dollar</td>
</tr>
<tr>
<td>GBP / USD</td>
<td>U.K. / America</td>
<td>Pound dollar</td>
</tr>
<tr>
<td>USD / CHF</td>
<td>America / Switzerland</td>
<td>Dollar swissy</td>
</tr>
<tr>
<td>USD / CAD</td>
<td>America / Canada</td>
<td>Dollar loonie</td>
</tr>
<tr>
<td>AUD / USD</td>
<td>Australia / America</td>
<td>Aussie dollar</td>
</tr>
<tr>
<td>NZD / USD</td>
<td>New Zealand / America</td>
<td>Kiwi dollar</td>
</tr>
</tbody>
</table>

The Forex market trading sessions can be categorized into four major ones: the New York session, the London session, the Tokyo session and the Sydney session. The timetable of the four sessions is presented below.

<table>
<thead>
<tr>
<th>Time Zone</th>
<th>Auckland Time Zone</th>
<th>GMT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open of Sydney Session</td>
<td>10 AM</td>
<td>10 PM</td>
</tr>
<tr>
<td>Close of Sydney Session</td>
<td>7 PM</td>
<td>7 AM</td>
</tr>
<tr>
<td>Open of Tokyo Session</td>
<td>11 AM</td>
<td>11 PM</td>
</tr>
<tr>
<td>Close of Tokyo Session</td>
<td>8 PM</td>
<td>8 AM</td>
</tr>
<tr>
<td>Open of London Session</td>
<td>8 PM</td>
<td>8 AM</td>
</tr>
<tr>
<td>Close of London Session</td>
<td>5 AM</td>
<td>5 PM</td>
</tr>
<tr>
<td>Open of New York Session</td>
<td>12 AM</td>
<td>12 PM</td>
</tr>
<tr>
<td>Close of New York Session</td>
<td>9 AM</td>
<td>9 PM</td>
</tr>
</tbody>
</table>

It can be seen from Table 3 that overlaps cross every two sessions. Typically, in each overlap, the Forex trading activities are particularly busy, because transactions are being processed in two regions of the world. This creates greater volatility in the currencies’ prices, and thus makes more trading opportunities. In robot trading, session overlaps are usually designed in programs so that they can assist traders in maximizing profits. Archer (2008) believes that fluctuation in the Forex market is different every week, and that this factor should be considered in robot programming.

i. The calculation in foreign exchange market

The basic calculation rules are usually performed by trading robots in Forex market transactions, and human traders do not need to understand the principles. However, it is necessary to introduce these concepts in this research. Developers of robot programming must consider those factors since they will influence the effectiveness and sensitivity of the trading robot.

Unlike other financial markets, the foreign exchange market is traded with exchange rates. They are expressed as one currency relating to another, and are thus formed as currency pairs. Babypips states that transactions in Forex markets are quoted as pairs because traders buy one currency and sell another. For example, EUR/USD is
presented as the price of how many U.S dollars should be spent to buy a Euro. The table below is an example to show the calculation of trading GBP/USD.

### Table 4: Calculation for trading GBP / USD

<table>
<thead>
<tr>
<th>Action of traders</th>
<th>Amount of GBP</th>
<th>Amount of USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>At the price of 1.5472, trader bought 100,000 Euros.</td>
<td>+ 100,000</td>
<td>- 154,720</td>
</tr>
<tr>
<td>A month later, the exchange rate went from 1.5472 to 1.5572, so you sold your Euros and exchanged them to U.S. dollars.</td>
<td>- 100,000</td>
<td>+ 155,720</td>
</tr>
<tr>
<td>Trader’s account increase of $1,000</td>
<td>0</td>
<td>+1000</td>
</tr>
</tbody>
</table>

In Forex trading, the price of the exchange rates is presented as two prices. The bid price is used for the trader to purchase the base currency and sell the counter currency, and the definition of the ask price is the opposite. Therefore, spreads is the gap between the bid and ask prices. In the sensitivity evaluation, spread is the major factor that influences the performance of trading robots, and thus it can contribute to un accounted losses.

#### i. Leverage and fund management

Archer (2008) introduces the concept of leveraged transactions. It is an investment method that uses a small amount of money to make a trade at several times the amount. The purpose of using leverage is to obtain a greater amount of profit. In the past, the specific money that was used to carry out Forex trading was called *lots*. Due to the tiny daily movement of the Forex market, traders needed to trade large amounts of currency to take advantage of a Forex transaction. Archer (2008) argued that the nature of the Forex market drove up the entry requirement until the service of leverage emerged.

In human trading, the retail Forex broker requires traders to have basic funds, which are called “margin funds”. Once those initial funds have been deposited into a dealer’s account, the service of Forex trading can be opened. Usually, the trading position is calculated as lot size multiplied by the leverage, which can maximize the profit from the trading. However, any related loss would be carried out several times and decrease the traders account as well. An example is posted by Babypips (2011) and given below to show how leverage and *lots* work.

### Table 5: Leverage and Lot

<table>
<thead>
<tr>
<th>Steps</th>
<th>Action of traders</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Trader is buying USD / JPY at 92.59. Currently, the price is quoted as 92.56 / 92.59. Here, the spread is 3 pips. Due to the trader buying dollars, the trading price should be 92.59, which is called the ask price.</td>
</tr>
<tr>
<td>2</td>
<td>The trader sets a transaction by 1 standard lot, which is 100,000 units</td>
</tr>
<tr>
<td>3</td>
<td>Then the price moves up to 92.78 and the trader closes his transaction</td>
</tr>
<tr>
<td>4</td>
<td>At this moment, the new price of USD / JPY is quoted as 92.78 / 92.81. Once the trader closes the trade, the buy order would enter in the market. The trading price should be 92.78.</td>
</tr>
<tr>
<td>5</td>
<td>The trading platform which calculates the gap between 92.59 and 92.78 is 19 pips</td>
</tr>
<tr>
<td>6</td>
<td>The profit of this trade should be ( 0.01 / 92.78 ) * 100,000 * 19 = $204.79</td>
</tr>
</tbody>
</table>

From Table 5, profit and loss from the trading can be calculated by the following formula:

\[
Profit / Loss = (pip value / price) x lot size x number of pips of movement
\]

Gerald (2008) indicates that leveraged Forex trading increases the profit of transaction, but also expands the loss that is caused by analysis mistakes. Thus, fund management and risk control become more and more important. From the profit formula, resetting the capital of the lot size can reduce the risks that are taken by leverage. Babypips (2011) provides the formula of the relationship between leverage and lot size, as shown below.

\[
Lot size = leverage x actually amount of each transaction
\]

The above formula shows that regardless of how much leverage is regulated by retail brokers to control Forex trading risk, the best method is to control the capital of the lot size. Therefore, most of the Forex trading robots are programmed with fund management system, which has the ability to adjust the lot size.
v. Black Swan or SIGMA Events:
The term “Black Swan” comes from the common misconception that ‘All swans are white’ and has found general application in the financial markets, especially in light of the 1987 stock market crash, the 2008/09 credit market meltdown and the 2010 flash crash. The prevalent belief held among 17th century Northern Europeans that there was no such thing as a black swan, since no one had ever actually seen one. However, the discovery of the existence of black swans (Cygnus atratus) in Australia transformed the term to connote that a perceived impossibility had actually occurred. A Black Swan is a metaphor coined by Nassim Taleb to describe events that are apparently possible, but could not have been predicted based on past evidence. Taleb notes people are heuristic to disbelieve that which one cannot predict. Taleb(2007), states “although these unpredictable deviations are fairly rare, they cannot be dismissed as outliers because cumulatively, their impact is so dramatic." Taleb (2007) defines a black swan as an event with three attributes:

1) It is an outlier, lying outside the realm of regular expectations because nothing in the past can convincingly point to its occurrence;
2) It carries an extreme impact;
3) Despite being an outlier, plausible explanations for its occurrence can be found after the fact, thus giving it the appearance that it can be explainable and predictable. In short, then, a black swan has three characteristics: Rarity, Extreme Impact, and Retrospective Predictability.

Now consider Black Monday. Between inception on May 26/1896 and Oct.16/1987, the Dow had only twice in its whole history fallen by more than 10% in one day. This happened on back-to-back days in the midst of the crash of 1929; on Oct.28,1929 and Oct.29,1929 the Dow fell 12.8% and 11.7%. But nothing in the 90+ years of history of the Dow pointed out to the possibility of a fall of the magnitude observed on Oct.19,1987. And yet, the unexpected and inconceivable did happen. Black Monday was an extremely rare event; it did have a very significant impact on investors’ portfolios; and, as discussed by Haugen (1999) and others, many and varied stories were advanced to explain it ex-post. In short, Black Monday was a black swan. As discussed below, day swings in the markets do not have to be so dramatic to have a substantial impact on long term performance. For this reason, the focus of this article is on ‘large’ daily swings, as informally defined below. And although some attention is paid to daily returns more than three standard deviations away from the mean, as well as to the best and worst 10, 20, and 100 daily returns, no attempt is made here to formally define a black swan.

A Black Swan Event can be characterized by the disproportionate role of high-impact, hard to predict, and rare events that are beyond the realm of normal expectations. Examining this in the context of our unpredictable financial markets, these events can broadly be translated into the natural disasters and geo-political tensions that occasionally (although seemingly more frequently) rock the market. The horrific earthquake and subsequent tsunami in Japan is an obvious recent example.

The spike in short term volatility that is typical of a Black Swan, brings with it a sobering reminder of the potential losses that an unprepared corporate treasurer may face. On the face of it, such events should send a shiver down the spine of any trader, but for the more sophisticated, there are a number of tools available which enable them to successfully navigate the choppy markets, and actually use the increased volatility to their favour. Effective risk mitigating tools, such as market orders and a live rate watch service, prove to be extremely popular during times of duress, given the significant intra-day swings in exchange rates that often occur. Not only do they allow treasurers to take advantage of any unforeseen rate movements, but they also allow them to benefit from large overnight moves in the rates.

Using Japan as a recent example, many UK companies were affected by delayed (or even cancelled) contracts after the heavily industrialized North East region was crippled by the tsunami as a result we witnessed a greater demand for the flexibility that products such as Vanilla Options bring. In contrast to the spike in short term volatility, it is common to see longer term FX option volatility remaining largely unchanged, allowing companies to take advantage of the fact that long term optionality has been as cheap as it has been for many a year. Unlike a standard forward contract where there is an obligation to buy the currency on maturity, a Vanilla Option gives the buyer the choice as to whether they want to convert into the foreign currency or not. Therefore if the delivery of goods is cancelled by suppliers, a prepared treasury wouldn’t be obliged to take delivery of the unwanted currency and therefore avoid the associated currency risk.

Another notable consequence of the loss in Japanese output has been that some UK companies have looked to source replacement goods from elsewhere in the world. As a result we’ve witnessed increased demand for alternative currencies such as the Brazil Real. As the Real is a non-deliverable currency, the demand for NDFs (Non-deliverable forwards) has heightened. This is an added challenge for treasurers looking to manage
currency risk on deliverable goods. An NDF is a product that allows a company to hedge the risk of currency volatility even in a currency that can’t be physically delivered.

Black Swan Events can also be characterized by the deep impacts they carry through the interest rate and inflation markets. For example, as the markets slowly digested the economic implications of the earthquake, interest rate expectations across most major currencies tended to fall. These markets were predicting that such an event was likely to reduce global demand and therefore cause a slowdown in the economic recovery – thus making central banks less likely to hike rates in the future, even though inflation fears persisted.

With the expectation that rates may remain lower for a longer period priced into the swap curve – corporations with long-term borrowings were able to take advantage of this opportunity to fix their funding rates at the low levels suddenly achievable. Furthermore, for those corporations who already had hedges in place (many of which were done at higher rates), by proactively analysing their hedge profile, were able to restructure and extend their existing hedges to achieve an overall lower blended cost of funds.

vi. High Frequency Trading (HFT) Participants and trading venues in Forex

HFT participants in Forex are mostly specialized independent firms that currently tend to trade only on their own account. Market contacts suggest that several large and better capitalized players account for the bulk of Forex HFT volume. There are also a large number of small HFT firms with more limited capital. As noted above, some of these HFT players in Forex have evolved from high-frequency trading in equities. Others have been developed by existing Forex specialists that have decided to move into the HFT space. A few banks also conduct some HFT in proprietary trading, but they are not major players in this particular space and do not see HFT as an important trend for their business. Rather, they see this as a way to keep up with the technology, which may have positive externalities for their overall Forex business.

HFT participants in Forex tend to be concentrated in three cities: Chicago, New York and London. Outside these three centers, there are currently very few HFT firms, even in regional Forex centers such as Hong Kong, Singapore and Sydney. However, the actual physical location of the HFT firms’ offices is irrelevant: what matters is that they co-locate the servers on which they run their algorithms close to the matching engines of the trading venues, which are primarily located in London, New York and Chicago.

HFT firms conduct their Forex activities mainly on inter-dealer electronic broking platforms (EBS and Reuters, both London-based companies) and multi-bank electronic communication networks (ECNs, most notably Currenex, Hotspot Forex and Forex all, typically US-based). They are also active on the Chicago Mercantile Exchange (CME) for trades involving Forex futures. The two main inter-dealer electronic platforms were developed earlier (in the 1990s) than the multi-bank ECNs (which were developed in the 2000s).

All venues operate on differing technologies, although there may be more similarities among the newer ones. Participants must adapt to the different technologies, trading rules and trading parameters across venues. The variation in rules reflects, in part, differences in technologies and, in part, different views on market conduct. For example, some venues provide pricing updates at set intervals while others stream prices in real time; the older inter-dealer venues tend to restrict the number of quotes per second and demand certain fill ratios (i.e. the amount of trades completed relative to quotes submitted), whereas the newer multi-bank ECNs tend to allow freer access and appear able to manage higher volumes of data handling. Despite the subtle differences at the front end, much of the architecture is built on common connectivity protocols (APIs) and messaging standards (generally the FIX protocol), as well as straight through processing and Continuous Linked Settlement (CLS).

Market contacts suggest that the larger, more sophisticated HFT players tend to trade on EBS and Reuters, which are currently seen as the predominant source of interbank liquidity in the Forex market. However, these wholesale venues traditionally have much larger minimum trade size requirements[8] and tighter trading controls. Smaller players tend to prefer the multi-bank ECNs due to the lower minimum trade size, less tight trading controls and potentially full anonymity. The fact that some multi-bank ECNs have built-in algorithmic trading functionalities (e.g. Currenex) also helps to make them attractive venues for very small HFT firms that are just starting up. More developed firms, by contrast, usually use customized in-house models, which provide greater control than do the standard built-in algo functions on ECNs. Market contacts also report that some HFT firms have multiple licenses to trade on some platforms. Such multiple presences helps these firms achieve greater market coverage and circumvent certain platform constraints such as limits on the number of quotes that can be submitted per unit of time.
Very few, if any, Algorithm Trading Firms trade solely on single-bank platforms. This is mainly because HFT strategies require a diverse, information-rich (multi-bank, multi-price) environment from which to source trading opportunities. That said, Algorithm Trading Firms do utilize pricing from single-bank providers as one component of their suite of price streams. Since different venues offer somewhat different trading environments (e.g., due to different trading controls), HFT firms must adapt their trading strategies to the different conditions across venues in order to maintain efficiency (i.e., they tend to run a portfolio of strategies rather than relying only on one particular strategy).

However, given the greater anonymity in electronic trading (compared with voice, especially at the customer level), it can be difficult to identify what type of player or strategy lies behind a particular trade. Currently in the Forex marketplace, there are banks, corporate, funds, institutional investors and even retail users executing trades with some form of algorithm, and some with high frequency. Since HFT firms typically access the various electronic trading platforms through their prime brokers, participants on these platforms can usually see, at most, only the prime brokers’ names and not their clients’ names.

vii. High Frequency Trading effects on the market

Having come to prominence in equity markets, high-frequency trading (HFT) has increased its presence in the foreign exchange (Forex) market in recent years. This development is one aspect of a broader trend facilitated by the wider use of electronic trading in foreign exchange, not only in the broker-dealer market, but also at the customer level. HFT in Forex operates on high volume but small order sizes, low margins, low latency (with trade execution times measured in milliseconds) and short risk holding periods (typically well under five seconds). As such, it occurs mainly in the most liquid currencies. While, to date, HFT has been most prevalent among the major currency pairs, it has the potential to spread to other relatively actively traded currencies, including some emerging market currencies.

In equities, where HFT accounts for a significant share of turnover in some markets, one the rapid growth of HFT and the perception of predatory practices have generated heightened scrutiny and debate about the benefits and risks posed by this type of trading activity. A number of regulatory initiatives are being considered. A similar discussion is now emerging about the role of HFT in Forex.

The assessment of HFT is often hampered by difficulties in identifying this particular type of activity, which is, at times, hard to distinguish from other types of automated (but not high-frequency) trading. There is a lack of reliable data and analysis on the prevalence of HFT as distinct from other forms of automated electronic trading. It is therefore crucial to have a clearer understanding conceptually of what HFT is (and is not) and what it does (and does not do) before assessing the implications of HFT from a policymaker’s point of view. Furthermore, given the different nature, structure and size of the Forex market compared with equity markets, it is important to ensure that any conclusions about HFT in equities – as well as any regulatory responses – are not inappropriately generalized to HFT in Forex.

We present the results of a fact-finding exercise conducted by a Study Group consisting of Forex market experts from 14 Markets Committee member central banks. Study Group members surveyed existing materials on HFT and also interviewed market contacts (including Forex dealing banks, prime brokers, trading platforms and HFT firms) in different financial centers to collect information and views.

The growth of high-frequency trading (HFT) is one particular aspect of a broader trend in the foreign exchange (Forex) market, brought about by advances in information technology and the spread of electronic trading. Before the 1990s, the Forex market was predominantly a broker-dealer market. The bulk of transactions took place in the inter-dealer core of the market. Activity between dealers and their customers was in the second or outer tier of this market, where bid-offer spreads tended to be wider than those in the inter-dealer market. Requests for quotes and transactions were typically done over the telephone (“voice”).

The advent of electronic broking/trading in the 1990s revolutionized the inter-dealer market. But since this innovation was not yet available in the customer market, the boundary separating it from the inter-dealer market remained (Graph 1, top panel). This boundary blurred when electronic trading became more readily available to Forex customers in the early 2000s, when Forex dealing banks began to offer trading services to clients via electronic portals (single-bank or proprietary trading platforms) and as the use of credit sponsorship through prime brokerage arrangements grew. Now many types of clients can participate in the over-the-counter (OTC) Forex market on a more or less equal footing in terms of price (figure 8).
Automated trading, defined as electronic trading using algorithms at some stage in the trade process, has grown rapidly over the past decade and is still evolving. Commonly referred to as algorithmic trading or algo trading, it can be divided into two main strands:

- **Algorithmic execution**: a human trader decides to trade but uses an electronic trading software to execute the trade. This is often used for larger orders. For example, the software may use smart order routing to choose where to best trade, or it may use a time- or volume-weighted method to execute the dealer’s trade to achieve the best price. Bank traders may use this type of approach to trade via an aggregator; real money investors may use a time-weighted approach to drip-feed a large order to the market.

- **Algorithmic trade decision-making**: a firm builds a model to initiate a trade based on certain key input parameters such as order book imbalance, momentum, correlations (within or across markets), mean reversion, and systematic response to economic data or news headlines. Once a trade decision has been made, the algorithm also executes the trade. Banks’ automated risk management tools may also use this method to offset risk automatically. Hedge funds engaged in model-based strategies and specialized HFT funds operate in a similar fashion.

One can think of HFT firms as a subset of algorithmic decision-makers. Typically, HFT firms generate earnings from doing a large number of small-size, small-profit trades. The small trade sizes, in part a consequence of operating with low latency (see below), imply that HFT firms take little risk per trade compared with traditional market-makers. The risk holding period is also very short, usually well under five seconds and frequently less than one second. As such, HFT requires a liquid underlying market.

![Figure 8: Changing structure of the Forex market over time a): 1990s: electronic trading was confined to the inter-dealer market](image)

![Figure 8: Changing structure of the Forex market over time b): 2000s: electronic trading became available to clients new participants and venues emerged](image)

In the above figure the red lines denote electronic communication; the black lines denote voice communication.

HFT = high-frequency trading firm; SBP = single-bank platform; MBP = multi-bank platform; ECN = electronic communications network; Exchange = Chicago Mercantile Exchange, for trades involving Forex futures.

One of the defining characteristics that set HFT players apart from other algo decision-makers is the high speed with which they detect and act on profitable trading opportunities in the marketplace. Since speed is of the essence, there has been a trend to co-location, ie trading firms moving their servers as close as possible to the trading venue. At the time of writing, market contacts suggest that some HFT participants in Forex can operate with latency of less than one millisecond, compared with 10–30 milliseconds for most upper-tier non-HFT participants (for comparison, it is said to take around 150 milliseconds for a human being to blink). Market
experts believe that further declines in latency are likely to come at increasingly high costs and may have only minimal financial benefit.

As more and more HFT participants enter the market to exploit these opportunities, or as non-HFT market participants upgrade their systems and reduce their speed disadvantage, the scope to profit purely from the ability to trade with low latency is expected to diminish.

There are indications that this process is already occurring. As a result, some HFT firms are reportedly beginning to rely less only on small-size low-risk trades and to branch out to take on more traditional (directional) risk trades using their sophisticated algorithms.

**Negative Effect of HFT’s:**

- **Frontrunning**: needs no explanation
- **Subpennying**: providing a "better" bid or offer in a fraction of penny to force the underlying order to move up or down.
- **Quote Stuffing**: the HFT trader sends huge numbers of orders and cancels
- **Layering**: multiple, large orders are placed passively with the goal of “pushing” the book away
- **Order Book Fade**: lightning-fast reactions to news and order book pressure lead to disappearing liquidity
- **Momentum ignition**: an HFT trader detects a large order targeting a percentage of volume, and front-runs it.

Nanex (nanex.com) states that it’s not high frequency trading (HFT) that is the concerns’ it's high frequency quoting, and it should concern everyone. Quote spam has exploded with no signs of stopping, while trade frequency has stalled and is actually lower than it was years ago.

Further more Nanex states the chart below plots daily trade and quote counts from January 2006 through August 7, 2012. The red line shows the number of quotes each trading day for U.S. Stocks. The blue line snaking across the bottom of the chart shows the number of trade executions. Note the scale is in billions. During the end of the Internet bull market in 2000 (not shown), the number of quotes in a day was about 5 million, less than the height of 1 pixel on our chart.
After Reg NMS, a form of High Frequency Trading (HFT) appeared that took advantage of time latency arbitrage caused by differential system loads (an imbalance of quotes on one network versus another). It wasn't long before one of these HFT figured out how to induce latency arbitrage and the divergence between quote and trade traffic began.

There are three peaks labeled A, B, and C that brought out the worst in HFT:

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>Quotes millions</th>
<th>Trades millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>Internet Bull Market</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>A 10-Oct-2008</td>
<td>Financial Crisis</td>
<td>1,018</td>
<td>83</td>
</tr>
<tr>
<td>B 06-May-2010</td>
<td>Flash Crash</td>
<td>1,112</td>
<td>65</td>
</tr>
<tr>
<td>C 08-Aug-2011</td>
<td>U.S. Downgrade</td>
<td>2,297</td>
<td>74</td>
</tr>
</tbody>
</table>

After the system-overloading quote volumes during August 2011, Nanex, Themis Trading, and others who were concerned about the long term health of our markets, became vocal about the enormous costs being heaped on those who do not benefit from HFT, yet have to pay for the infrastructure they require. In fact, during peak times, quote spreads are often wide and unstable.

Whenever a new peak in message traffic occurs, those who process market data must upgrade systems to be able to handle the new capacity plus additional overhead for higher traffic on high volume days. In other words, peak message rates set new, permanent capacity requirements. You can't just flip a switch and get additional capacity when you need it, then turn it off to reduce costs when you don't.

Graph 2: Trades and Quotes per day

viii. Strategies and business models of HFT in Forex

A number of different strategies are pursued by HFT firms in the Forex market. The unifying characteristic is the method of implementing the trading strategies using sophisticated quantitative models and high speed. The various strategies can be classified as follows:

- **Classic arbitrage** exploits the differences between market prices and prices implied by “no arbitrage” conditions. If the price gaps are large enough to cover transaction costs, trades can be executed to lock in a risk-free profit. In spot Forex, the arbitrage would be done with a set of currency pairs and the relevant cross rate, eg EUR/USD, USD/JPY and EUR/JPY. This is akin to manual dealers arbitraging USD/JPY, USD/DEM and DEM/JPY in the 1990s on an EBS keypad – but at much higher speed. Arbitrage could also be done across the spot and futures prices of the same currency pair.

- **Latency arbitrage** exploits the small time lag between when market-moving trades take place and when market-makers update the prices they quote. By directly detecting potential price moves, the HFT player can profit from what it has learned ahead of other participants that rely on market-makers’ quotes.

- **Liquidity-providing (or liquidity-redistributing)** strategies aim to detect order book imbalances for a particular currency pair and pricing discrepancies across trading platforms. The HFT participant earns a spread by arbitraging these differences.
Complex event processing includes a number of different strategies. They aim at detecting profit opportunities by exploiting various properties of currency prices such as momentum, mean-reversion, correlation (with other currency pairs or with other assets) and response to economic data releases.

An individual HFT firm may execute a number of these strategies simultaneously. The quantitative models used may be similar within a particular strategy but can vary significantly across strategies within the one firm. The majority of HFT strategies are designed to benefit from high liquidity and low volatility. Hence there is a tendency for HFT participants to reduce risk when volatility rises. But market contacts suggest that some HFT firms have also developed trading models that are designed to work under more volatile conditions.

Shortly after its emergence in equity markets, HFT appeared in the Forex market in the early 2000s. Some equity hedge funds began to apply some of their algorithmic models developed for trading equities to Forex, taking advantage of the Forex market’s very deep liquidity, broad participation, ease of access and arbitrage opportunities. Other firms started out by running pure “latency models”, exploiting the different time lags in price updates across different trading venues. Both types had begun to pursue HFT liquidity-providing (or -redistributing) strategies by 2007.

There is a growing trend for HFT firms to contribute prices to trading platforms (market-making, liquidity-providing) rather than just executing on existing prices (liquidity-taking), although opinion is divided as to how much of this behavior in Forex can be considered “true” market-making. Given their “high-volume, low-margin” business models, HFT firms typically are highly sensitive to the impact of even small errors and exercise tight risk controls.

Market contacts note that as HFT firms become better capitalized, they may extend their risk appetite – for instance, by scaling up already successfully running trading models to gain more volume and increase profits, or by taking on more traditional trade risks. Market contacts also report that some HFT firms are moving to access client flow more directly, either by feeding their price interest directly to banks or to the retail platforms, or even by directly streaming pricing to other market participants.

4. THEORY OF ALGORITHM TRADING

A. ARTIFICIAL INTELLIGENCE TRADING

Artificial intelligence trading is also called genetic algorithm (GA) trading. GA is a search technique used to find exact or approximate solutions to optimization and search problems. GA uses techniques inspired by evolutionary biology such as inheritance, mutation, selection, and crossover.

We can now see a growing trend to solve problems in the financial field by mathematical methods, in the sub-field of active decision-making for stock markets, foreign exchange, and investment credit and of course the foreign exchange (Forex) market as the largest financial market in the world. At its core are exchange rates and market timing. It is very complicated to predict exchange rates based on fundamental analysis alone, which studies all relevant economic and financial indicators. Therefore, technical analysis is a sound alternative to forecast short term Forex market movements. Its advocates do not concern themselves with fundamental values such as account balance or economic conditions, but instead base their ideas on the hypothesis that any factor that truly influences the market will immediately show up in the Forex rate. Therefore, some GA techniques only study indexes and the charts that describe their movements.

To avoid the difficult problem of forecasting the precise exchange rate, some GA developers proposed a way to optimize Forex trading on the timing to make an investment. In their research, they aim to raise the profit of an investment by buying and selling the foreign exchange in very short periods, assuming that we start off with a certain amount of Japanese Yen. Their GA system searches for the optimal combination of Technical Indexes which will allow us to accurately judge the timing when the exchange rates rise or fall. Furthermore, by actually introducing the concept of leverage in accordance with the settings employed by Forex companies in Japan, they also consider the profit generated through application of their method. Their continued goal is to develop and implement an evolutionary system which is able to learn the nuances of trading rules in Forex markets, and to adapt to its changing conditions.

Though some method’s claim is to search the preferable trading strategies from the past time series data of Forex rate (Data for Learning), simply searching all the patterns requires a great amount of time. Application of
GA may achieve a great reduction in the computing time. In addition, the evolutionary operators of GA allow successful rules for past problems to adapt to changes in the market conditions.

Technical indexes are tools to expect and analyze the change of the price in the future, using the change of pricing generated in the past. Here, three typical technical indexes used to forecast and to analyze the stock or Forex prices are described.

Jamie (2008) indicates that there are three methods of Forex trading analysis: fundamental analysis, sentiment analysis and technical analysis.

B. FUNDAMENTAL ANALYSIS - (A NECESSARY CONSIDERATION FOR COMPUTERIZED TRADING)

Jamie (2008) considered that fundamental analysis is an efficient method to evaluate the economic, social and political factors, which focuses on money supply and demand. It is necessary to study economics factors, because only supply and demand can determine the currency price. In addition, Babypips (2011) states that fundamental analysis focuses on the reaction to economic events. In particular, it guides traders to predict the future movements of the Forex market. However, fundamental analysis is formed by many indicators. Jamie (2008) provides an example, an economic report of U.S. employment data, which could have changed the monetary policy of the Fed in America. However, John (2009) points out that many economic events are not released as specific reports, but they could influence the reactions of traders, which can decide the future movement of the Forex market. In all, Jamie (2008) considers there are several indicators that can be analyzed by traders: interest rates, inflation, monetary policy and economic growth.

Jamie (2008) indicates that the interest rate is the most important factor to help traders determine the Forex market direction. Thus, it is necessary for traders to understand the monetary policy of central banks, such as new interest rate decisions. Furthermore, John (2009) states that inflation decides the stability of central bank monetary policies. Inflation can make investment in products and services, but too much inflation can damage the economy. Thus, as Babypips (2011) indicates, central banks always watch the indicators that are related to inflation, such as CPI and PCE. Usually, moderate inflation is accepted by central banks, because suppressing it could take the growth out of the economy. In order to keep inflation at a stable level, Babypips (2011) points out that central banks will change interest rates that lead to lower economic growth and inflation. But in the Forex market, Jamie (2008) believes that higher interest rates can cause a stronger currency price. He defines a new concept of interest rate expectation, which can directly influence the movement of the Forex market. Jamie (2008) considers that the Forex market is moved by the different expectations of traders. So, as interest rates are not changed very often, most of traders do not focus on current interest rates, because they have already been issued by central banks. More important is the movement of the interest rates, which is defined as interest expectation by Babypips (2011). This web tutorial indicates that interest rate expectation can determine the future movement of the Forex market. To calculate the current interest rate, a formula is presented.

Real interest rate = nominal interest rate – expected inflation

Jamie (2008) also states that most used by traders use rate differentials, which can decide the future movement of a specific currency pair. The formula is presents as follows.

Rate differentials = base currency interest rate – counter currency interest rate

As well as interest rates, the monetary policy of central banks can influence future movements of the Forex market. Jamie (2008) states that monetary policy is divided into contractionary and restrictive policies. They are used to increase or reduce the capital of the money supply, and can also make interest rates rise. Babypips (2011) believes that restrictive policy is also increasing interest rates and reducing economy growth. Also, the difficulty of getting bank loans will reduce the spending and investment of businesses. On the other hand, with contractionary policy, which is opposite to restrictive policy, it is easier to borrow money or expand the supply of funds, and they believe that this will increase spending and investment and increase economic growth.

Babypips (2011) states that enterprises will spend money with large amounts of funds, and thus the tax will be increased for the government. This action can cause the whole society to spend, and will tend to be a temporary positive influence on the economy. Meanwhile, Jamie (2008) indicates that the balance of capital flow can cause movement in the Forex market as well. He provides an example of the positive aspects of capital flow to a country: in the situation of more investment from overseas, the government has to sell foreign currency to buy local currency. This action can lead to the value of local currency increasing. The related trade flow formula was posted by Babypips (2011) can be seen below.
Exports > Imports = Trade Surplus = Positive (+) Trade Balance
Imports > Exports = Trade Deficit = Negative (-) Trade Balance

In trading robot design, programmers usually select five economic indicators as parameters in their trading robot. However, depending on the trading environment, the selection of parameters will be different. For example, inflation can often be represented as CPI and PCE. The values of parameters are not expressed by economic data; instead a simple number can be better to predict the future market trend. The following diagram shows the economic indicator selection in trading robots.

SENTIMENT ANALYSIS

In theory, price should reflect all the information of the Forex market. However, it is not simple a simple matter for Forex traders. The Forex market does not reflect all the information, since it also includes the behavior of traders. Babypips (2011) states that traders have their own opinions on future market movements. The market is a combination of traders’ reactions to economic news. Jamie (2008) considers that no matter how strong the personal feelings of a single trader, the Forex market will be influenced by most of the traders’ actions. Therefore, the market sentiment analysis contains some factors from both fundamental analysis and technical analysis, which focuses on the traders’ psychological state.

As an interest rate expectation, market sentiment depends on the psychological state of most of the traders. Jamie (2008) believes that sentiment indicators are not unique, since they represent traders’ psychological states. Usually, economic data makes traders take action. Thus, the role of sentiment indicators is to measure the importance of the economic data. In Forex robot trading, these indicators are usually used to presents the weight of specific economic indices. The Figure 3 also shows the application of sentiment analysis in robot trading.

C. COMMON TECHNICAL ANALYSIS

Archer (2008) considers that technical analysis is the framework that traders use to determine Forex market movement. He believes that historical data can determine current market conditions and potential movement. In theory, the present price can reflect all the information of the Forex market, and thus trading can be made by that information Gerald (2008) indicates that technical analysis is basically following the support or resistance level in the past chart. Traders keep watching it and determine the trading around that price level. But Jamie (2008) believes there are many patterns which are all important for trading that should be analysed.

1) Japanese candlestick as price chart measure

Generally one of three basic charts are used to present historical movements in the Forex market: line chart, bar chart and Japanese candlestick. The basic concept of the Japanese candlestick chart. Like the bar chart, the Japanese candlestick indicates the market direction in the period segment. “Open” presents the start price in the current period, “Close” presents the end of the price, and “Low” and “High” present the highest and lowest price at this moment. The Japanese candlestick is different from the bar chart. The reason is that it introduces the concept of “Body”, which presents current market direction.

2) Moving average

Moving average (MA) is based on the Dow Jones “average cost concept”. Similar to the “moving average” principle in the statistics, it aligns with the average financial market price in each of the time segments to display historical price volatility, and thus reflect the potential trends. In fact, we calculate the average price value of a specific period when we use this indicator. As with changes of price, the moving average can increase or decrease. There are four types of moving average: simple moving average, exponential moving average, smoothed moving average and linear weighted moving average. Each of them has their own algorithm, but usually the formula of the moving average is presented as follows, because the most common application is simple moving average.

\[ SMAn = \frac{(C1 + C2 + C3 + \ldots + Cn)}{N} \]

(C expresses the close price in the current period. N is present as the number of total periods.)

3) MACD

Moving Average Convergence / Divergence (MACD) is a dynamic index that is following the market trend. It is represented as a relationship between two moving averages. MACD indicator has three parameters. The first parameter presents the time period of the faster moving average, and the second presents the slower moving average’s period number. The third parameter is calculating the moving average of the gap between the previous two MAs.
4) **RSI (Relative Strength Index)**

The Relative Strength Index Technical Indicator (RSI) is a price-following oscillator that ranges between 0 and 100. RSI is widely useful in Forex trading. It does not only assist traders to determine the potential trend, but it also can help users distinguish the situation of oversold and overbought.

\[
\text{RSI} = \frac{\sum_{i=1}^{n} |U_i|}{\sum_{i=1}^{n} |D_i|} \times 100
\]

- \( |U_i| \): Sum of the absolute value of rising width in the past \( n \) days
- \( |D_i| \): Sum of the absolute value of falling width in the past \( n \) days

RSI is one of the typical index which is called “contrary” type, and aims to buy when the currency is sold too much (the price is low), and to sell when it is bought too much (the price is high). It is general to use 9 or 14 as \( n \). As a general guideline, an RSI value below 30 indicates that the currency has been sold too much, while an RSI higher than 70 indicates that the currency has been bought too much.

5) **Moving Average; MA**

The moving average is a technique for smoothing the short-term variation of price (longitudinal data), and it can be obtained by calculating the mean value of the past \( n \) days’ prices. The moving average is used to understand the present trend, and as such it is called a "Trend Following" type of index, opposite to the contrary type. There are several types of Moving Averages, depending on past prices are weighted. First, the Simple Moving Average (SMA) indicates a simple mean value with identical weights to past prices. Second, the Weighted Moving Average (WMA) is a kind of index which puts higher weights on more recent dates’ prices. An example of weight assignment would be to give weight \( n \) to the price at the current time (time \( t \)), weight \( n-1 \) to the price at time \( t-1 \), \( n-2 \) to \( t-2 \) and so on.

Finally, we refer to Exponentially Weighted Moving Average (EWMA) which is applied in the proposed method. Contrary to the linear weight putting in WMA, EWMA assigns weights exponentially. One example of weight assignment is shown in the below equation, \( \alpha \) is an arbitrary coefficient which takes range of \( 0<\alpha<1 \).[7]

\[
EWMAM = \frac{P_M + \alpha P_{M-1} + \alpha^2 P_{M-2} + \cdots}{1 + \alpha + \alpha^2 + \cdots}
\]

6) **Percent Difference from Moving Average**

\[
\text{Difference} = \frac{(\text{Current price}) - (\text{Moving average})}{(\text{Moving average})} \times 100
\]

This index indicates how much the current rate differs from the moving average described in 2). As well as RSI, Percent Difference is one of the “contrary” type indexes. And it is general to use either of the 5 days/25 days/13 weeks/26 weeks as the period \( n \). The experts say that it is sold too much when this is lower than -10%, while it is bought too much when this is higher than +10%.

7) **Fibonacci**

Fibonacci (1170–1240), an Italian merchant, became famous in Europe because he was also a brilliant mathematician. One of his greatest achievements was to introduce Arabic numerals as a substitute for Roman numerals. He developed the Fibonacci Summation Series, which runs as follows:

1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, …

This sequence moves toward a constant, irrational ratio. To put it another way, Fibonacci represents a number with an unending and unpredictable sequence of decimal numbers, which cannot be expressed with any degree of precision. But to keep things simple, we will use the number 1,618. In algebra, it is commonly indicated by the Greek letter Phi (\( \Phi = 1,618 \)).

This is a remarkable phenomenon—and a useful one when designing trading tools. Because the original ratio PHI is irrational, the reciprocal value PHI’ to the ratio PHI necessarily is also an irrational figure, which means that again there is a slight margin of error when calculating 0.618 in an approximated, shortened way.

We have discovered a series of plain numbers that can be applied to science by Fibonacci. Before we try to use the Fibonacci summation series to develop trading tools, it is helpful to consider its relevance in nature. It is then only a small step to reach conclusions about the relevance of the Fibonacci summation in international market movements, whether in currencies or commodities, stocks, or derivatives. Humans subconsciously seek the
divine proportion, which is nothing but a constant and timeless striving to create a comfortable standard of living.

The sneezewort, a Eurasian herb, is an ideal example of the Fibonacci summation series in nature, for every new branch springs from the axil and more branches grow from a new branch. Adding the old and the new branches together reveals a number of the Fibonacci summation series in each horizontal plane. Figure 9 illustrates the count. According to the same algebraic principle, we can easily identify Fibonacci summation series in plant life (so-called golden numbers) by counting the petals of certain common flowers. Taking the iris at 3 petals, the primrose at 5 petals, the ragwort at 13 petals, the daisy at 34 petals, and the michalmas daisy at 55 (and 89) petals, one must question whether this pattern is accidental or a particular natural law.

Figure 9: Fibonacci numbers found in the flowers of the sneezewort. Source: The New Fibonacci Trader Workbook, by Robert Fischer (New York: Wiley, 2001), p. 4.

In general, for corrections with Fibonacci-related trading tools, an impulse wave that defines a major market trend upward or downward will have a corrective wave before the next impulse wave reaches new territory. This occurs in both bull market and bear market conditions. Analysis would be easy if we could detect a single general pattern of corrections. The problem is that there can be many more price patterns than impulse waves in the commodities, futures, stock index futures, stocks, or currency markets. Markets move sideways for a longer period than an impulse wave appears.

We can never predict which of the next waves will be an impulse wave instead of another false move in continuation of a sideways market. Therefore, every serious trading approach using corrections has to be designed to survive even the longest sideways market correction phase. No market pattern can assure a profitable trade. At any time, we can be in a correction of an impulse wave or at the beginning of a new impulse wave.

Trading with corrections is a trend-following strategy. It is based on the assumption that after a correction of an impulse wave up or down, the next impulse wave will follow in the direction of the first impulse wave after the correction is finished. Thus, we generally expect a minimum of a three-swing price move, and in many cases, this assumption is correct. Therefore, working with corrections is a valid investment strategy, and it is discussed in detail later in this book. Corrections work equally well long or short, to the upside or downside of the markets. The worst thing that can happen in trending markets is that the market may run away without correcting enough and without leaving a valid signal. Markets moving sideways involve the risk of the trader getting stopped out in a streak of losing trades if the strategy’s parameters are too restrictive.

Trading with corrections is a short-term strategy. The goal is to have many trades, of which a large number are profitable. Likewise, there should be a low number of losing trades, and these should be small losses. Corrections are closely related to the Fibonacci ratios through the swing size and the volatility of a product. Which ratio to choose depends on the product and the time intervals selected. Weekly data might need different ratios from daily or intraday data. The safest way to find the best ratio for products and time spans is to test them on historical data with a computer.

The most common approach to working with corrections in research and practical trading is to relate the size of a correction to a percentage of a prior impulse wave.

For Fibonacci’s PHI, the following prominent percentages of possible market corrections can be derived directly from the ratios 0.618, 1.000, and 1.618 of the PHI series. 38.2 percent is the result of the division $0.618 ÷ 1.618$. 50.0 percent is the transformed ratio 1.000. 61.8 percent is the result of the immediate ratio $1.000 ÷ 1.618$. 
Figure 10 shows the different risk profiles when trading alternative percentages of corrections with stop-loss protection.

Forecasting the exact size of a correction is an empirical problem. Investing after a correction of just 38.2 percent might be too early, whereas waiting for a correction of 61.8 percent might result in completely missing a strong trend. But no matter what corrections are considered, traders should focus on the PHI-related sizes.

The Fibonacci studies are popular trading tools, and understanding how they are used and how much you can trust them is important if you want to benefit from the ancient mathematicians scientific legacy. Some traders unquestionably rely on Fibonacci tools to make major trading decisions, others view the Fibonacci studies as exotic scientific methodologies employed by so many traders that they can even influence the way market behaves. But, let’s examine how the Fibonacci studies may influence the market by its appeal to Forex traders.

i. **How to use Fibonacci**

Popular opinion has it that when correctly applied, Fibonacci can successfully predict market behavior 70% of the time, especially when a specific price is predicted. However, other traders maintain that the calculations for multiple retracements are too time-intensive and difficult to use accurately. Perhaps the greatest disadvantage of the Fibonacci method is the complexity of the results. This means that new traders especially should not rely on the Fibonacci method as compulsory support and resistance levels. The Fibonacci levels are sort of a frame through which traders look at their charts this frame doesn’t predict or contribute anything, but it does influence a large number of traders decisions.

The Fibonacci studies were created to dispel uncertainty with varying levels of success. Therefore, they should not serve as the only basis for one’s trading decisions. Fibonacci studies most often work when no real market-driving forces are present in the market. Obviously, the levels of psychological comfort and the frame which they create and through which the majority of traders look at their charts, are not the only determining factors in those situations, when other, more significant reasons for the increases or decreases in a currency’s prices.

ii. **Identify Support and Resistance**

A charting technique of three diagonal lines uses Fibonacci ratios to help identify key levels of support and resistance as shown below.
Many Forex traders view the Fibonacci retracement levels as support resistance levels. As there are so many traders who watch these levels and buy and sell on the basis of them, the support and resistance levels themselves become self-fulfilling.

iii. Fibonacci Extension Levels
0, 0.382, 0.618, 1.000, 1.382, 1.618
Fibonacci extension levels on the other hand are used by traders as profit-taking levels. With so many traders watching these levels and placing buy and sell orders to take profits, this tool also usually becomes self-fulfilling. Most charting software includes Fibonacci retracement levels and extension level tools. But in order to use these Fibonacci levels on your charts, you will need to be able to identify Swing High and Swing Low points. A Swing High is a candlestick with at least two lower highs on both the left and right of itself. A Swing Low is a candlestick with at least two higher lows on both the left and right of itself. The market is a complex system and realizing that the Fibonacci studies are often a self-fulfilling prophecy will assist you in using the tools more efficiently by helping you avoid dangerous over-reliance on them.

8) Golden Ratio
The famous Greek mathematician Euclid of Megara (450–370 B.C.) was the first scientist to write about the golden section and to focus the analysis of a straight line. The more complex structure of the geometry of a golden rectangle is shown in Figure 12. The ratio of the long side of the rectangle divided by the short side of the rectangle has the proportion of the Fibonacci ratio 1.618.

The proportions of the Parthenon temple in Athens bear witness to the influence of the golden rectangle as well as the golden section on Greek architecture. The proportions of the Parthenon temple fit exactly into a golden rectangle; its total width is exactly 1.618 times its height (Figure 13). Other geometric curves that are important

![Figure 12: Geometry of the golden rectangle](image)

![Figure 13: The Vitruvian man](image)
to humankind are plentiful in nature. The most significant to civilization include the horizon of the ocean, the meteor track, the parabola of a waterfall, the arc that the sun travels in the sky, the crescent moon, and the flight of a bird. Many of these natural curves can be geometrically modeled using ellipses.

This ellipse is also called PHI-Ellipse. The PHI-ellipse is an almost unknown trading tool that is closely related to the Fibonacci ratios. This tool surrounds price moves and makes investors’ behavior visible for analysis on any kind of data. Because swing formations are easy to identify and integrate into computerized trading environments, traders or managers investing in smaller accounts often use peak-and-valley formations. Many profitable trades are possible, as long as there are regular wave patterns and each impulse wave defines new highs or new lows by a wide margin. Working with PHI-ellipses can be difficult. The basic structure is simple, but because price patterns may change over time, the final shape of a PHI-ellipse also may vary. What makes PHI-ellipses so interesting is that they can identify underlying structures of price moves and can circumvent price patterns.

When a price pattern changes, the shape of the PHI-ellipse is circumventing the respective market price pattern changes, too. We find long and short PHI-ellipses, fat and thin PHI-ellipses, and even PHI-ellipses that are flat or have a steep angle. There are very few market price moves that do not follow the pattern of the PHI-ellipse. PHI-ellipses are related to the Fibonacci ratio. Generally speaking, the ratio of major axis A to minor axis B defines the shape of an ellipse. Ellipses are turned into PHI-ellipses whenever the ratio of major axis to minor axis is a member number of the PHI series. To make PHI-ellipses work as devices for chart analysis, we have applied a (proprietary) transformation to the mathematical formula that describes the shape of the ellipse. We still consider the ratio of the major axis A to the minor axis B of the ellipse, but in a Fischer-transformed way.

PHI-ellipses are instruments for investments that represent a countertrend to market actions. Thus, we observe whether a price move stays within a PHI-ellipse and invest accordingly if a price move breaks out of a PHI-ellipse at the very end. To draw a PHI-ellipse correctly, three points are necessary—the starting point and two side points. It is possible to draw the PHI-ellipse if the second impulse wave is at least as long as the first impulse wave. This principle is shown in Figure 14. After identifying the points A, B, and C in the typical 3-wave swing, we can position the PHI-ellipse around these points. Wave 1, from A to B, is an impulse wave. Wave 2, from B to C, is the corrective wave to the impulse wave.

![Figure 14: PHI-ellipse circumventing a 3-wave price pattern.](image)

For wave 3, we expect a second impulse wave in the direction of the first impulse wave. This general pattern follows Elliott’s Wave Principle and can be seen in every traded product, be it commodities, futures, stocks, or cash currencies. The fundamental structure of the PHI-ellipse provides another way to analyze price moves. What makes it unique is that it is dynamic over time and follows price patterns as they develop. That is why it is necessary to be patient and wait—from the very beginning to the very end—until a price move stays within the PHI-ellipse. Traders can take action as soon as the market price moves out of the PHI-ellipse, but only if a price pattern runs completely inside until reaching the final point.

There are several ways to invest against the market trend at the end of the PHI-ellipse:
- Enter a position when the market price breaks the outside line of the PHI-ellipse.
- Enter a position based on a chart price pattern that forms at the end of the PHI-ellipse.
- Enter a position when the market price moves out of the outside line, which is parallel to the median line of the PHI-ellipse.

The sequence is proven to exist by way of fractals in everything from human (figure 13 above) and plant DNA to the world's financial markets. There's no question that Fibonacci numbers are all around us.
New research by the award-winning Socionomics Institute suggests that Fibonacci might affect the way people think, the way individuals act in a crowd and even the way investors make financial decisions -- all are tied to the Fibonacci sequence. Several terms spawn from Fibonacci and what others call the Golden Ratio, including Spiral, Fractal, Herding, Golden Section, Golden Mean, Golden Number, Divine Ratio, Phi and more.

However, for this paper, we do not account for the validity of the sequences or whether the correlation is founded on universal laws or simply on the "self fulfilling prophecy" effect on the collective actions of traders due to their recognition of these sequence patterns.

Rather we use the sequence as spastically re-occurring patterns that have continued to manifest over decades of recorded data.

**D. ALGORITHM TRADING**

Since the era of floating exchange rates began in the early 1970s, technical trading has become widespread in the stock market as well as the Forex markets. The trend in the financial markets industry in general is the increased automation of the trading, so called algorithmic trading (AT), at electronic exchanges. Trading financial instruments has historically required face-to-face contact between the market participants. The Nasdaq OTC market was one of the first to switch from physical interaction to technological solutions, and today many other market places have also replaced the old systems.

Some markets, like the New York Stock Exchange (NYSE), still uses physical trading but has at the same time opened up some functions to electronic trading. It is of course innovations in computing and communications that has made this shift possible, with global electronic order routing, broad dissemination of quote and trade information, and new types of trading systems. New technology also reduces the costs of building new trading systems, hence lowering the entry barriers for new entrants. Finally, electronic markets also enables for a faster order routing and data transmission to a much larger group of investors than before. The growth in electronic trade execution has been explosive on an international basis, and new stock markets are almost exclusively electronic.

The Forex market differs somewhat from stock markets. These have traditionally been dealer markets that operate over the telephone, and physical locations where trading takes place has been non-existing. In such a
market, trade transparency is low. But for the last years, more and more of the Forex markets has moved over to electronic trading. Reuters and Electronic Broking Service (EBS) developed two major electronic systems for providing quotes, which later on turned into full trading platforms, allowing also for trade execution. In 1998, electronic trading accounted for 50 percent of all Forex trading, and it has continued rising ever since. Most of the inter-dealer trading nowadays takes place on electronic markets, while trading between large corporations and dealers still remain mostly telephone based. Electronic trading platforms for companies have however been developed, like Nordea e-Markets, allowing companies to place and execute trades without interaction from a dealer.

During the last years, the trend towards electronic markets and automated trading has been significant. As a part of this, many financial firms has inherited trading via so called algorithms, to standardize and automate their trading strategies in some sense. In this section different views of AT is given, to present a definition of the term. In general AT can be described as trading, with some elements being executed by an algorithm. The participation of algorithms enables automated employment of predefined trading strategies. Trading strategies are automated by defining a sequence of instructions executed by a computer, with little or no human intervention. AT is the common denominator for different trends in the area of electronic trading that result in increased automation in:

- Identifying investment opportunities (what to trade).
- Executing orders for a variety of asset classes (when, how and where to trade).

This includes a broad variety of solutions employed by traders in different markets, trading different assets. The common denominator for the most of these solutions is the process from using data series for pre-trade analysis to final trade execution. The execution can be made by the computer itself or via a human trader. In figure 5 one can see a schematic figure over this process. This figure is not limited to traders using ATS’s; rather it is a general description of some of the main elements of trading. The four steps presented in figure 5 define the main elements of trading. How many of these steps that are performed by a computer is different between different traders and is a measure of how automated the process is. The first step includes analysis of market data as well as adequate external news. The analysis is often supported by computer tools such as spreadsheets or charts. The analysis is a very important step, which will end up in a trading signal and a trading decision in line with the overlaying trading strategy. The last step of the process is the real execution of the trading decision. This can be made automatically by a computer or by a human trader. The trade execution contains an order, sent to the foreign exchange market and the response as a confirmation from the same exchange.

This simplified description might not hold for any specific trader taking into account the many different kinds of players that exists on a financial market. However, it shows that the trading process can be divided into different steps that follow sequentially. If one are now to suggest how trading is automated, there is little difficulty in discuss the different steps being separately programmed into algorithms and executed by a computer. Of course
this is not a trivial task, especially as the complex considerations previously made by humans have to be translated into algorithms executed by machines. One other obstacle that must be dealt with in order to achieve totally automated trading is how to connect the different steps into a functional process and how to interface this with the external environment, in other words the exchange and the market data feed. In the next section different levels of AT will be presented. The levels are characterized by the number of stages, presented in figure 5, that are replaced by algorithms, performed by a machine.

1. Types of Algorithm or Electronics Trading:

Electronic trading can be divided into two main types:
- **Manual**, where instructions are executed by humans on an electronic trading platform; and
- **Automated**, where instructions are executed by computer algorithms, with little or no human intervention (though still subject to human monitoring).

Throughout the years many different trading strategies have been developed to capture return from the Forex market. As one finds in any asset class, the foreign exchange world contains a broad variety of distinct styles and trading strategies. For other asset classes it is easy to find consistent benchmarks, such as indices like Standard and Poor’s 500 (S&P 500) for equity, Lehman’s Global Aggregate Index (LGAI) for bonds and Goldman Sachs Commodity Index (GSCI) for commodities. It is harder to find a comparable index for currencies.

When viewed as a set of trading rules, the accepted benchmarks of other asset classes indicate a level of subjectivity that would not otherwise be apparent. In fact, they really reflect a set of transparent trading rules of a given market. By being widely followed, they become benchmarks. By looking at benchmarks from this perspective there is no reason why there should not exist an applicable benchmark for currencies.

The basic criteria for establishing a currency benchmark is to find approaches that are widely known and followed to capture currency return on the global Forex market. In March 2007 Deutsche Bank unveiled their new currency benchmark, The Deutsche Bank Currency Return (DBCR) Index. Their index contains a mixture of three strategies, namely Carry, Momentum and Valuation. These are commonly accepted indices that also other large banks around the world make use of. Carry is a strategy in which an investor sells a certain currency with a relatively low interest rate and uses the funds to purchase a different currency yielding a higher interest rate. A trader using this strategy attempts to capture the difference between the rates, which can often be substantial, depending on the amount of leverage the investor chooses to use.

To explain this strategy in more detail an example of a “JPY carry trade” is here presented. Let’s say a trader borrows 1,000,000 JPY from a Japanese bank, converts the funds into USD and buys a bond for the equivalent amount. Let’s also assume that the bond pays 5.0 percent and the Japanese interest rate is set to 1.5 percent. The trader stands to make a profit of 3.5 percent (5.0 - 1.5 percent), as long as the exchange rate between the countries does not change. Many professional traders use this trade because the gains can become very large when leverage is taken into consideration. If the trader in the example uses a common leverage factor of 10:1, then he can stand to make a profit of 35 percent.

The big risk in a carry trade is the uncertainty of exchange rates. Using the example above, if the USD was to fall in value relative to the JPY, then the trader would run the risk of losing money. Also, these transactions are generally done with a lot of leverage, so a small movement in exchange rates can result in big losses unless hedged appropriately. Therefore it is important also to consider the expected movements in the currency as well as the interest rate for the selected currencies.

Another commonly used trading strategy is Momentum, which is based on the appearance of trends in the currency markets. Currencies appear to trend over time, which suggests that using past prices may be informative to investing in currencies. This is due to the existence of irrational traders, the possibility that prices provide information about non-fundamental currency determinants or that prices may adjust slowly to new information. To see if a currency has a positive or negative trend one would have to calculate a moving average for a specific historical time frame. If the currency has a higher return during the most recent moving average it is said to have a positive trend and vice versa.

The last trading strategy, described by Deutsche Bank, is Valuation. This strategy is purely based on the fundamental price of the currency, calculated using Purchasing Power Parity (PPP). A purchasing power parity exchange rate equalizes the purchasing power of different currencies in their home countries for a given basket
of goods. If for example a basket of goods costs 125 USD in US and a corresponding basket in Europe cost 100 EUR, the fair value of the exchange rate would be 1.25 EURUSD meaning that people in US and Europe have the same purchasing power. This is why it is believed that the currencies in the long run tend to revert towards their fair value based on PPP. But in short- to medium-run they might deviate somewhat from this equilibrium due to trade, information and other costs. These movements allows for profiting by buying undervalued currencies and selling overvalued.

2. Different Levels of Automation
A broad variety of definitions of ATS’s is used, dependent on who is asked. The differences are often linked to the level of technological skill that the questioned individual possesses. Based on which steps that are automated and the implied level of human intervention in the trading process, different categories can be distinguished. It is important to notice that the differences do not only consist of the number of steps automated. There can also be differences between sophistication and performance within the steps. This will not be taken in consideration here though, focusing on the level of automation. Four different ways of defining ATSs’ are to be described. The first category, here named AT1 presupposes that the first two steps are fully automated. They somewhat goes hand in hand because the pre-trade analysis of ten leads to a trading signal in one way or another. This means that the human intervention is limited to the two last tasks, namely the trading decision and the execution of the trade.

The second category, AT2 is characterized by an automation of the last step in the trading process, namely the execution. The aim of execution algorithms is often to divide large trading volumes into smaller orders and thereby minimizing the adverse price impact a large order otherwise might suffer. It should be mentioned that different types of execution algorithms are often supplied by third party software, and also as a service to the buy-side investor of a brokerage. Using execution algorithms leaves the first three steps, analysis, trading signal and trading decision to the human trader.

If one combines the first two categories a third variant of AT is developed, namely AT3. AT3 is just leaving the trading decision to the human trader, i.e. letting algorithms taking care of step 1, 2 and 4.

Finally, fully automated AT, AT4, often referred to as black-box-trading, and is obtained if all four steps are replaced by machines performing according to algorithmically set decisions. This means that the human intervention is only control and supervision, programming and parameterizations. To be able to use systems, such as AT3 and AT4, great skills are required, both when it comes to IT solutions and algorithmic development. Independent on what level of automation that is intended, one important issue is to be considered, especially if regarding high-frequency trading, namely the markets microstructure. The microstructure contains the markets characteristics when dealing with price, information, transaction costs, market design and other necessary features.

a. Market Microstructure
Market microstructure is the branch of financial economics that investigates trading and the organization of markets. It is of great importance when trading is carried out on a daily basis or on an even higher frequency, where micro-based models, in contrary to macro-based, can account for a large part of variations in daily prices on financial assets and this is why the theory on market microstructure is also essential when understanding AT, taking advantage of for example swift changes in the market. Market microstructure mainly deals with four issues, which will be gone through in the following sections.

b. Price formation and price discovery
This factor focuses on the process by which the price for an asset is determined, and it is based on the demand and supply conditions for a given asset. Investors all have different views on the future prices of the asset, which makes them trade it at different prices, and price discovery is simply when these prices match and a trade takes place. Different ways of carrying out this match is through auctioning or negotiation. Quote-driven markets, as opposed to order-driven markets where price discovery takes place as just described, is where investors trade on the quoted prices set by the markets makers, making the price discovery happen quicker and thus the market more price efficient.

c. Transaction cost and timing cost
When an investor trades in the market, he or she faces two different kinds of costs: implicit and explicit. The latter are those easily identified, e.g. brokerage fees and/or taxes. Implicit however are described as hard to identify and measure. Market impact costs relates to the price change due to large trades in a short time and timing costs to the price change that can occur between decision and execution. Since the competition between
brokers has led to significant reduction of the explicit costs, enhancing the returns is mainly a question of reducing the implicit. Trading in liquid markets and ensuring fast executions are ways of coping with this.

d. Market structure and design
This factor focuses on the relationship between price determination and trading rules. These two factors have a large impact on price discovery, liquidity and trading costs, and refers to attributes of a market defined in terms of trading rules, which amongst others include degree of continuity, transparency, price discovery, automation, protocols and off-markets trading.

e. Information and disclosure
This factor focuses on the market information and the impact of the information on the behavior of the market participants. A well-informed trader is more likely to avoid the risks related to the trading, than one less informed. Although the theory of market efficiency states that the market is anonymous and that all participants are equally informed, this is seldom the case which gives some traders an advantage. When talking about market information, we here refer to information that has a direct impact on the market value of an asset.

3. Development of Algorithmic Trading
As the share of ATS’s increases in a specific market, it provides positive feedback for further participants to automate their trading. Since algorithmic solutions benefits from faster and more detailed data, the operators in the market have started to offer these services on request from algorithmic traders. This new area of business makes the existing traders better off if they can deal with the increasing load of information. The result is that the non-automated competition will lose out on the algorithms even more than before. For this reason it is not bold to predict that as the profitability shifts in favor of AT, more trading will also shift in that direction. With a higher number of algorithmic traders in the market, there will be an increasing competition amongst them. This will most certainly lead to decreasing margins, technical optimization and business development. Business development contains, amongst other things, innovation as firms using AT search for new strategies, conceptually different from existing ones. Active firms on the financial market put a great deal of effort into product development with the aim to find algorithms, capturing excess return by unveiling the present trends in the Forex market.

4. Analysis of trading systems
Before we describe how the process of synthesis works, let us first take a look at the traditional analysis methodology, which is outlined in Figure 6. When a trading system is available, it is coded using a computer language, usually a high-level language. Back testing the trading system involves determination of exact market entry and exit signals followed by a calculation of a set of performance statistics, such as the success rate or profitability, the profit factor, the number of winning and losing trades, the maximum intraday drawdown, etc. The results are then analyzed using various statistical measures in order to determine whether the trading system is acceptable. The trading system code may be modified for the purpose of improving performance and the process of analysis is repeated. This is a trial-and-error method for trading system development and it is based on an advanced description of the system and on historical back testing.

5. Synthesis of trading systems
We now turn our attention to an alternative method of trading systems development we call “synthesis” as outlined in Figure 7. This method involves a model identification algorithm. The algorithm requires as input the general description of the trading systems that are considered during the synthesis. The other input to the algorithm is the historical data and its output is the code (model) of each candidate trading system to back test. The back testing involves calculation of a set of performance statistics of each candidate trading system. An
analysis of the performance statistics determines whether the criteria specified in advance by the user are satisfied. This is all done automatically. If the performance matches or exceeds expectations, then the code of the trading system is saved in a database, otherwise it is rejected and the process continues with the next identified trading system and terminates when there are no more trading systems to back test and analyze.

Figure 7: Development of trading systems using Synthesis

6. Hedging

Asymmetrical Passive Cross Hedging and Non Correlated Pairs Trading

Some currency trading exposure is beneficial, insofar as it introduces diversification to the portfolio. Hence, a 100% hedge ratio generally produces sub-optimal results.

Currency trading exposure affects a portfolio’s risk in two ways:
- it introduces volatility, and
- it introduces diversification.

The net effect of these two influences determines the optimal fraction of currency trade exposure to hedge in order to minimize a portfolio’s risk.

These two forms algorithm trading Hedging have shown to be the most effective approaches to address the risk and draw-downs resulting from unexpected, unanticipated, unknown and uncalculated events often referred to as;
1. Black Swan Events as previously described;
2. Draw downs (consequence of high volatility or unexpected variance in currency valuation)

5. RESULTS

The following results are non compounding. They demonstrate the optimized profitability of a real-time algorithm trading system with parameters recommended below accounting and optimized for the following targets:
1. 14 Years & 10 months: From Jan 1st 1998 thru 2012 Oct
2. Lowest draw-down possible
3. Highest profitable trade numbers
4. Non compounding
5. Lowest margin to maintain single account without hedging requirements
6. Highest Profit Factor
6. PROPOSED ALGORITHM ARCHITECTURE METHODOLOGY GUIDELINES

- Architecture is based on multiple secondary multiple technical and statistical analysis acting as foundation support to a main supportive predictive technique.

- Each of these technical analysis is more sophisticated than pairs trading. Even if performance divergence between correlated markets is the core of the strategies, as it is for pairs trading. The mathematical structure would more likely be one that simultaneously analyses two markets at a time.

- Methodology incorporate global markets, not just the US

- Methodology incorporate equally related instruments, Forex pairs, options and multi-portfolio hedging strategy.

- Soft and hard protective hedge though correlated pairs and instruments

- In order to balance the portfolio so that it is relatively unaffected by the trend of the general market, position sizes are probably adjusted to account for factors such as the varying volatility of different pairs and the correlations among them in the positions.

- The portfolio is balanced not only to remove the influence of price moves in the broad market, but also to mitigate the influence of currency price swings and interest rates

- Entry and exit strategies are employed to minimize transaction costs and capitalize on low spreads.
• All of these strategies and models are monitored simultaneously in real time. A change in any single element can impact any or all of the other elements. As but one example, a signal by one predictive technique to buy a specific Forex pair and sell another requires the entire portfolio to be taking in consideration and rebalanced.

• The trading model is dynamic – that is, it changes over time minute-by-minute to adjust for changing market conditions, which dictate dropping or revising some predictive techniques with organic adjustments.

7. CONCLUSIONS

In this paper, we propose algorithm trading is gaining momentum and will remain an intricate part of the market trading execution. In order to have an all encompassing participation in the market, substantial portfolios will need to consider some level of participation and algorithm implementation in their overall trading strategies.

Proposed paper studies the impact of algorithmic trading on the process in the global foreign exchange market using a long times series of high-frequency trading data in three major exchange rates.

The algorithmic methodology proposed in this paper are a natural organic evolution of bringing simple rules in rapidly evolving technological field that requires constant monitoring and continued research and development in order to help keep a profitable Forex trading participation.

The growth in algorithmic and particularly high frequency trading in foreign exchange is likely to have significant implications for both the structure and the functioning of the global Forex market. After the study of different types of algorithm methods we can say that high frequency trading gives very fast and accurate information to the policy maker and other economic bodies.

Policymakers will need to keep abreast of changes in this space. In some cases, this is happening through the involvement of policymakers in the Foreign Exchange Committees in various jurisdictions. Beyond that, policymakers should develop appropriate contacts and maintain a dialogue with (i) the various foreign exchange trading platforms, (ii) the prime brokerage service providers, and (iii) the algorithmic and high-frequency trading community in Forex in order to track developments and to identify key policy issues in a timely fashion.

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