Econometric Model for Intraday Trading on the Spot Foreign Exchange Market, Considering Heavy Tails and Volatility Clustering

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Abstract

Spot foreign exchange (forex) market is the most liquid and volatile of all the financial markets. It involves and effects any country in the world, reflects governments' monetary policies and provides hedging opportunities for trading corporations. Modeling of foreign exchange rates and volatility is not yet as developed as modeling of other markets' behavior. Moreover, intraday trading on forex is governed by other rules and implies other approaches than a long term exchange rate forecasts. The present research thoroughly analyzes every aspect of the spot intraday trading on the forex market - mechanisms, efficiency, liquidity, volatility - as well as the existing models based on macro fundamentals or describing market microstructure. Among other results, it has been concluded that the spot forex market is efficient in a weak form only, it is extremely liquid and is not effected by regional equity trading sessions or news announcements, but its volatility increases in the first and the last thirty minutes of corresponding regional trading sessions. Finally, a hybrid model based on microstructure approach, including additional macro variables and data on two different time frames was constructed. GARCH approach is used to reflect the volatility clustering, and alpha-stable distributions describe the heavy tails behavior. Tests showed that this new model outperforms the previously analyzed models for the case of intraday trading.

Introduction

Financial markets play multiple role in the economic and financial life of all countries of the world. They reflect monetary policy of governments, provide funds for business and make capital gains (and losses) to private and institutional investors. To take advantage of financial markets, one needs to know their mechanisms, understand past performance and forecast future development.

Intraday trading is defined as short term trading, but it does not necessarily imply opening and closing position within the same day. Intraday trading is used by an important number of private traders and asset managers who speculate of the quotes changing over short period of time. In spite of the seemingly minor changes in quotes (actually the fifth digit after comma is already significant), leveraged investors can get important return on investment.

The research departs from financial markets in general, using the totality of the available knowledge, and then narrows its analysis to foreign exchange market, and in particular the spot foreign exchange market. Foreign exchange (forex) market is today the most important by its turnover, the most liquid and probably the most volatile market of the world. Naturally, important is the need to model and forecast it. The main question is if the models already developed for the equity market, are applicable to forex. Can these models be applied "as is" or at least be adapted? What specific factors need to be considered?

The paper is split into four parts. The first part introduces the basics of financial markets in general and the foreign exchange market in particular: market participants, trading mechanisms and trade instructions. The second part goes into mode details analyzing various market characteristics, such as efficiency, liquidity, volatility and trading costs. The third part of the research overviews the practically used approaches of the technical and fundamental analysis. Finally, the part IV analyzes and tests academically developed models and proposes an improved model for forex intraday trading.

Financial markets are first of all their participants: people and institution

active on it. Financial markets are a tool for Central Banks for implementing their monetary policy. They provide a way of hedging risks for big multinational companies. They are an investment place for private and institutional investors. Providing access to financial markets is the core business for brokerage companies.

As any domain of life, financial markets have its rules and mechanisms. The knowledge and respect of these rules is a *sine qua non* condition for any activity on the market. Mechanisms include legal limitations and regulations such as government licences and brokerage agreements. Technical context puts its own boundaries on what is possible and what is impossible to perform.

To make any operation on the market, technical details are needed. Trading instructions specify the volume, the type and the price of a transaction. With computer and networking progress, a big part of trades are executed in more or less automated way, but human mediation is still used, especially in the case of technical issues.

Medieval markets were completely non transparent, as one often did not know the prices on the other side of a mountain. With today's technologies, news announces in United States are incorporated in London and Hong Kong market quotes within less than ten seconds. What does a market participant or an external observer knows about the price formation, identity of traders or the market stability? This question is answered by the analysis of the market performance.

Once anybody buys an asset, one of the most important questions is weather he will be able to resell it later. For most of financial assets, especially those quoted on main Exchanges, the liquidity is not an issue. Virtually any asset can be bought or sold within seconds during the trading sessions. Foreign Exchange market with its 24 hours trading, is considered to be the most liquid of all financial markets. Liquidity influences the attractiveness of an investment and the market efficiency.

The volatility of financial markets is a headache for corporate managers and the source of gain for speculators. Volatility of different markets, different sectors and in different geographical regions cannot be the same. Is it constant? What are the interdependencies? Can volatility be modeled and forecast?

As any other service, trading is associated with costs. The traditionally known costs are the bid-ask spread, commissions and negative interest rates applied to margin account. Indirect costs are numerous and case specific. In spite of apparent low absolute value, when incorrectly taken into account, trading costs can make loss out of a profitable operation.

Since more than one hundred years, two traditional approaches to market

analysis are the technical and the fundamental analysis. Fundamental analysis is studying macroeconomic factors ("fundamentals") that may influence the asset price. To forecast the market, traders using fundamental analysis follow the latest news announcements to derive their expectations about the market.

Technical analysis, on its turn, supposes that all the publicly available information is already incorporated in the market price. The technical analysis is limited to analyzing the price charts, finding particular behavior patterns in it and using this information, forecast the future development of the price pattern. Technical analysis techniques are numerous, individual, sometimes contradictory and delivering opposite results on the same market situation. In spite of that, some of technical analysis conclusions look amazing by their correctness and precision. It is important to tell that practical models often lack of consistent foundation proper to academic approaches. They still constitute a part of the present research: to make the analysis of the market complete - as for an obvious reason we cannot neglect the everyday relatively successful practice of millions of traders.

Forex is a specific separate market, and specific models are developed to describes its behavior. By definition, there are no insiders or particularly informed traders on forex. The only exception are Central Banks or other institutions capable of influencing the whole market segment on their own. What are the specific foreign exchange models and what are they based on? How far these models go and what is their modeling quality?

Financial markets are not casinos. Their volatility reflects multitude of known and unknown factors. Appropriate models partially reflect the market behavior and help making decisions, but a correct deterministic model will probably never be found because it does not exist. For this reason, while making any financial operation, one should always keep in mind that these operations are risky, that the past performance will no way guarantee future profits and that one should never risk funds he cannot allow himself to lose. Any useful model should be forward looking instead of simply fit the coefficients to the past data.

To achieve optimal results in funds management, traders need to apply all the available knowledge. It is usually beneficial to follow several simple steps:

1. **Define goals** of the operations on the market, such as capital gain or risk hedge.

2. **Identify the target market** and its sector, for example, industrial US stocks, Latin American mutual funds, majors foreign exchange.

3. **Gather information** known about the target market: regulations, trading conditions, characteristics of the market such as performance, transparency and volatility.

4. **Define its own position** relative to the market: informed or uninformed trader, speculator, long term investor.

5. **Select an appropriate model** and estimate its parameters, using the available data samples.

6. **Forecast the market development** using the estimated model and act accordingly.

If the appropriate model chosen after the four first steps is that for the intraday forex trading, the present research is an attempt to develop a good one which can be used in practice. It describes the forex market in all its variety of aspects, carefully analyzing every assumption of each building block. Often the paper speaks about models developed for equity markets, usually with the purpose of study its relevance for the currency exchanges.

It is important to mention, that the study is limited to the intraday spot foreign exchange market for currencies under floating exchange rate regimes. Controlled currencies like Chinese Renminbi or Ukrainian Hryvnia are not studied unless necessary for comparison or example. Forex options, futures and other derivatives are not studied. Models built are intended for everyday trading under regular or moderately hectic market conditions. Models for extreme events, major crashes, important and short Central Bank interventions are not developed. It is also assumed that basic econometric tools do not need to be described, and can be found in references and general econometric literature.

Every chapter, every analysis and every test made in the research constitutes a building block for the new model for the intraday spot trading on the foreign exchange market. The apogee of the paper is the chapter 14, which puts these blocks together towards a new model.

A great value of the present research lies in the absolutely unique data set analyzed, which was not addressed by any known to us prior study. The data is exceptional in terms that it uses:

- High frequency data, up to tick by tick data,
- Over a long period of time of several years of intensive trading,
- On a large number of currency pairs, involving currencies from all regions of the world,

- Extensive list of auxiliary data, such as chronological signed and unsigned orders flow, analyzed by required time frame, by execution price, by response time, by frequency of transactions, by local business time of the concerned countries and even by type of traders initiating the operation.

Because the research aims exploring the properties of the foreign exchange market in quickly changing conditions of intraday trading, such an extensive data set was selected in order to permit studying different aspects of the market in total as well as its particular segments.

Last but not least, this research is inspired and enriched not only by academic studies, but also by the practical experience of the author as a technical specialist for e-trading on the foreign exchange market over several years. Facing the everyday routine of forex, its practices, successes and difficulties, the author was determined to make her possible best contribution to resolve the arising questions.

Most of published books about the financial markets are either too scientific and technical at the point of being unapplicable to practice, or superficial and reflect only personal experience of a small group of traders. The purpose of the present research is to bring the academically developed models to the practitioners of financial markets: institutions, asset managers and private traders, by developing a tool interesting from both academic and practical standpoint. All the calculations made here can be easily replicated in R software, the tools of which were for this purpose recently completed to make it possible.

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Contents

Part I

Introduction to Financial Markets

Chapter 1

Market Participants

Foreign exchange (forex) is the market where one currency is traded for another. Exchange rate forex futures were first introduced in 1972 at the Chicago Marcantile exchange. Today forex includes spot market, forward contracts and swaps. This is an "over the counter" (OTC) market, meaning that the trades are negotiated within a network of traders and dealers, and there is no central exchange and no clearing house. Traders on the forex market take positions by buying or selling one currency against another.

1.1 Introduction to the FOREX Market

The foreign exchange market is typically characterized by a large trading volume, extreme liquidity, geographical dispersion, 24 hours trade and the variety of factors that influence market conditions. By its daily volume, the forex market is the largest financial market in the world. Today, the average volume of daily forex trades exceed two trillion US dollars(**?**). According to The Wall Street Journal Europe (issue 2nd September 2006, p. 20), 73% of the volume is made by only 10 most active market participants.

There is almost no "insider's information" on forex. The fluctuations on the market are caused by expectations of change in monetary flows, GBP growth, inflation, interest rates, budget deficit and other macroeconomic conditions. Currency prices are also a result of the demand and supply relationship, as well as political and psychological factors.

The currency pairs composed of main currencies, like EUR, CHF, GBP, JPY versus USD are called "majors", the other currency pairs are called "crosses", e.g. NZDJPY. While the crosses are still traded independently, they are strongly pricewise dependent of the exchange rates of the respective currencies vs. the USD.

The geographical dispersion of the forex market stays more or less stable for the last 6 years (**?**). The main activity centers are in London, New York, Tokyo and Singapore. 31% of trades take place in the United Kingdom, 19% in the United States. Japan, Singapore and Germany provide respectively 8%, 5% and 5% of the forex market activity. Switzerland, the traditional financial center, processes only 3% of the foreign exchange trades.

There are two levels of the foreign exchange market. The first levels is the interbank market. The trades are made directly between dealers, without intermediaries. This part of the market is not transparent, because a small part of transactions is disclosed and reported. Informed dealers who trade on this market pay higher spread. This market level also "processes" macroeconomic information and to incorporate it in the market price.

The second level consists of the customer-dealer trades: operations do not influence the market prices directly. Trading statistics remains the commercial secret of the brokerage company: only the transaction itself is disclosed, but not the identity of the dealer. This part of the market indirectly influences the price formation through the coverage that brokers perform for their net position. As a consequence, brokers with a big number of clients are supposed to have more information, which provides them a competitive advantage (8).

There is usually no single exchange rate on the forex market. Offered prices change for different traders depending on the local regulatory environment and his individual trading conditions offered by the intermediary he is trading through. It is important to distinguish different market participants, because their identity influences directly the pursued goals, trading strategy, resources available, decision making, risk aversion and the influence on the global market. Central Banks have the greatest impact. Their interventions are seldom, but their importance in terms of volume and impact is high. The identity, roles, objectives and trading approaches of market participants will be presented and discussed.

Market participants may trade directly between them or via brokers. Dealers having access to private information or performing important transactions usually choose direct trades, even if the cost of such operations is usually higher.

1.2 Identity of Market Participants

The range of forex market participants is broad. The most important are large banks, Central Banks, institutional investors, hedge funds, multinational corporations, governments and other financial and market institutions.

The relative importance of different market participants change over time, due to shifts in the market structure and individual changes of the market participants themselves. Electronic trading, for example, generally facilitates access to the market for small traders. On the other hand, bank mergers and increasing concentration in the banking industry lead to the reduction of forex desks. The turnover increases and decreases do not always happen with the same magnitude, and sometimes one change compensates another. For example, as the volume of trades between reported traders rose in 2001-2004, their relative part dropped (**?**).

According to the European Central Bank survey (12), the part of the interbank trading is decreasing while retail traders gain higher share of trades. The reason of such changes reside in the consolidation of the bank system and the development of the electronic brokerage.

According to Carpenter and Wang (8), market participants can be classified as Central Banks, Non Bank Financial Institutions and Non Financial Corporations. We also add to this list the Commercial Banks, Private Traders and Asset Managers as well as Passive Investors. Some market participants belong to several groups in the same time, for example, commercial banks that trade for themselves seeking for speculative profit, manage clients' funds and provide brokerage services in the same time.

1.2.1 Central Banks

Central banks are major participants of the foreign exchange market. They are monopolistic suppliers of the national currencies and the performers of the national monetary policy. Considering the state of the domestic economy, they are usually pursuing three goals:

- exchange rate stability,
- efficient financial markets and
- liquidity.

Only two out of these three goals can be achieved simultaneously (4). In other words, this so called "impossible trinity" means that a country cannot maintain a fixed exchange rate, a free flow of capital and maintain its monetary independence in the same time. The type of the country policy depends on which objectives are preferred by the local authorities. Japan is the one that intervenes the most on the foreign exchange market (16). India officially has a flexible exchange rate, but in reality the rupee closely follows the movements of the USD due to the Central Bank interventions (9).

The activity activity of Central Banks on the foreign exchange market can be identified through five indicators (17):

- The daily deviation from the long term trend of the spot exchange rate,
- The conditional volatility of daily changes in the spot rate,
- Differentials between the US (or other countries with important economies) and the domestic overnight interest rates,
- A measure of the conditional profitability of past interventions, and
- The foreign currency reserve inventory considerations.

An official intervention generally aims either the change of the exchange rates level or the exchange rates volatility. On days when Central Banks intervene, their daily trading volume is usually considerable relative to the market size. On the other hand, there are many days of inactivity. Such behavior can be modeled by Probit and Friction Model. While the Central Banks may believe their actions are effective, economists have three different opinions about it (13):

- intervention policy is ineffective in altering the level of the exchange rate and is counter productive, because it increases volatility,
- official operations can influence the level of the exchange rate and can reduce the volatility,
- interventions do not effect either the level or the volatility of the exchange rates (10)

In reality, the effectiveness of an intervention seem to depend on its type. First, operations coordinated between several Central Banks tend to be more efficient than unilateral interventions. Second, the actual volatility of the market before the intervention influences the volatility after the operations are performed (11). Third, the outcome of the intervention seem to depend on whether is was officially announced or secret. Active and frequent interventions are considered to be the most efficient if unannounced. Recent trends indicate that the number of secret interventions is increasing, but the coordinated operations still stay publicly known in most cases (6). Most of time, interventions have an effect over a relatively short term (14).

The most important Central Banks are Federal Reserve (FED) in USA for the USD, European Central Bank (ECB) in the European Union for EUR, Bank of England (BoE) in the United Kingdom for the GBP and Bank of Japan (BoJ) in Japan for the JPY.

1.2.2 Commercial and Investments Banks

Banks usually manage their clients' funds, perform investment and holding operations, provide brokerage services to clients. While managing their own or borrowed funds, banks' main purpose on the forex market is getting positive profit.

Generally, greater is trading volume generated by a market participant, more considerable is the volatility his actions induce on the forex market (7). This is apparently due to the fact that important transactions cannot stay unperceived by other participants, and thus influence their offer or demand of the corresponding currencies significantly. Also, banks are often seen as better informed traders. As a consequence, an important part of forex activity is centered around important commercial banks like Citibank, Deutsche Bank and JP Morgan Chase.

Investment banks, usually very active on the equity market, are relatively neglecting towards forex. Banks like Goldman Sachs or Merill Lynch are definitely present on the foreign exchange, but their part in forex trades is marginal and forex activity is secondary for their everyday operations.

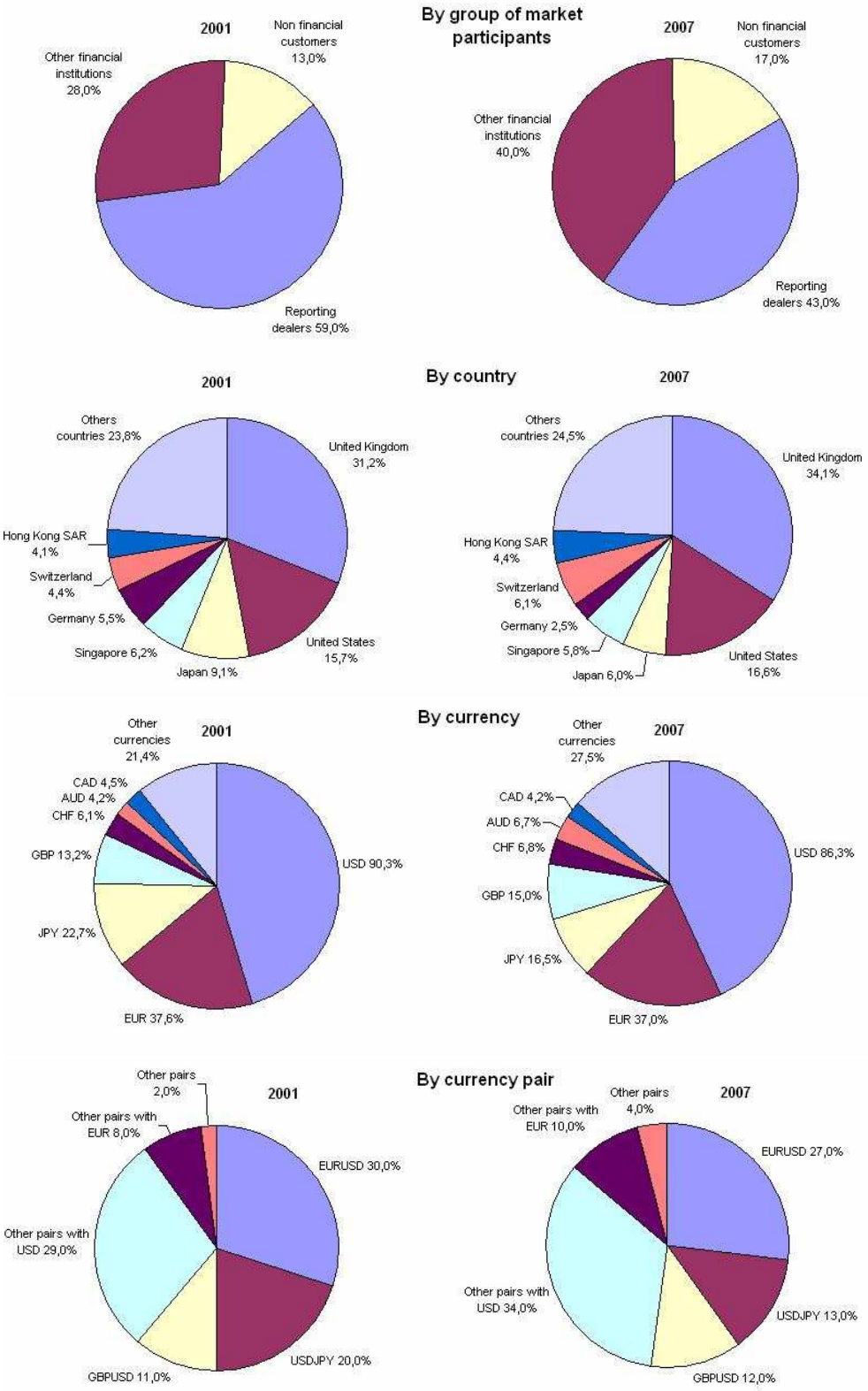
1.2.3 Non Bank Financial Institutions

This group of market participants includes asset managing non-banking institutions: hedge funds, mutual funds, insurance companies, brokers. Their activity on the foreign exchange market is usually motivated by profit seeking speculation or hedging risks of their other investments. Institutional investors treat currencies as an investment asset.

1.2.4 Non Financial Corporations

This group of traders usually does not aim a short term speculative forex profit. In contrast, corporations cover the exchange rate risk related to their trade operations in goods and services, production, contracts in different countries and currencies, foreign investments and repatriation of profits. Multinational companies pay salaries to their employees in different countries and in different currencies. In order to hedge the risk related to the exchange rate, they buy the necessary amount of the corresponding currency upfront or buy forward contracts. Exporting companies are often billed or charge in US dollars or another currency, different from their domestic currency - another risk to be hedged using forex market operations. Companies tend to be risk averse and concentrate on their core business. Their share of forex trades reaches 11% of all spot transactions (8). Forex operations of major

Encadré 1: Statistics of the forex market: by geographical location, by currency pair and by type of trader (shares in the global turnover)



Source: Bank for International Settlements, "Triennal Central Bank Survey. Foreign exchange and derivatives market activity in 2007", December 2007.

exporters are susceptible to influence the expectations of other participants about the market (20).

The number of international company mergers and acquisitions is important and is increasing. For example, the Winterthur Insurance Company was acquired French Insurance Company AXA from the Suisse Bank Credit Suisse in summer 2006. Such acquisitions are often accompanied by important forex transactions, and the announcement of such an agreement itself, can already provoke important movements on the exchange market.

The foreign exchange operations of the non financial institutions is often mimicking that the Central Banks, according to one recent research (18). Institutional investors on the other hand, usually perform opposite transactions.

1.2.5 Financial Intermediaries

Financial intermediaries provide their professional services on the foreign exchange market to different groups of participants. They generally concentrate on providing access to the market, because not all institutional and retail traders cannot access the market directly. Intermediaries can be licensed brokers or banks, and their customers include central and commercial banks, insurance companies, managed funds, non financial corporations and individuals. They do not act on behalf of their own, but rather limit themselves to providing access to the market or managing somebody else's investments.

1.2.6 Individual Traders

The number of individual traders - people and companies - is extremely high on forex. Almost all of them trade via brokers. Most of their transactions are immediately executed inside the brokerage company. In the case of a market maker, i.e. a company that acts as a counter-party for his clients' transactions, these positions are not hedged individually. The reason is that many clients of the same company will be trading the same currency, and many of their long and short positions will compensate each other.

Many individual traders are professionals or semi-professionals that trade private funds seeking for their primary or secondary income. They occasionally manage somebody else's funds, agreeing privately with their customers. Foreign exchange is being perceived as a casino by some irresponsible traders, who deliberately use the verb "play" to describe their activity, instead "trade", "invest" or "manage money".

In terms of trading conditions, there are leveraged and unleveraged market participants. The leverage is sometimes regarded as a loan of the broker

to the customer for the period when a trading position opened. Small individual traders often get up to 100:1 or even 200:1 leverage from their brokerage company. As traded funds increase, the available leverage generally shrinks. It is partially explained by the fact that small investments can rarely generate any significant profit without a considerable leverage. On the other hand, the leverage tremendously increases the risk by amplifying both potential profits and losses, add dynamics into trades of small traders. Brokers and market makers usually charge fees for their services in the form of spread and commission.

1.2.7 Passive Investors

The last group of investors are those who do not perform any forex operation themselves, but influence the market through their investments. Their funds are managed by one of the previously describes market participants: commercial banks, hedge funds, asset managers.

Encadré 2: George Soros

Private trader is not a synonym of "small" or "retail". A well known example is George Soros.

George Soros is Chairman of Soros Fund Management, LLC and the founder of The Open Society Institute. He was born in Budapest in 1930. He accumulated a large fortune in the United States through the investment advisory firm he founded and managed. Soros has been active as a philanthropist since 1979.

On the Black Wednesday (September 16, 1992), Soros became immediately famous when he sold short more than 10 billion US dollars worth of pounds. The Bank of England was forced to devalue the pound sterling, and Soros earned an estimated 1.1 billion USD. He was called "the man who broke the Bank of England."
In 1997, during the Asian financial crisis, Soros speculated in Malaysia and Thailand. For his financial operations, he successfully analyzes political situation in the region, and his operations may impact the whole economy of a country.

1.3 Roles of Market participants

1.3.1 Policy Makers

Traders whose operations are susceptible to move the market price, are considered as policy makers. Central Banks usually expect that the state of the market will not be the same before and after their operation. More often than not, they cannot conduct their whole transaction at the same price, and thus split it in slices. A comparable behavior may be expected from some important commercial banks, hedge funds or even private investors, even if the purpose of their operations is other than moving the market price.

1.3.2 Price Takers

Most of market participants are however the price takers. That means that they are not able to influence the market sensibly by their operations, and have to accept the current market price or to consider another moment to perform their transaction.

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Chapter 2

Trading mechanisms

Institutions of the forex market and their functioning define the way the operations are performed. Market structure, trading rules and trading systems constitute important elements to be considered for both real life trading and econometric modeling.

2.1 Institutional Context

2.1.1 Fixed and Floating Exchange Rates

Depending on country's monetary regime, the exchange rates can be fixed or floating.

Pure fixed exchange rates regimes are relatively uncommon today, but still exist in China, in Ukraine and several other countries. Under such regime, the government defines exchange rates towards major international currencies to be kept, and any foreign exchange operations with the local currency should be done at these rates. Allowed deviations are usually very low, not exceeding 1%. These conditions generally apply until the government announces new exchange rates. Overall, the rates are kept a certain level by both actual Central Bank interventions and legal restrictions. This second element of the control leads to market imperfections, when the announced value of the currency does not correspond to its intrinsic value. As a consequence, a black currency market emerges. A vivid example of this is the former Soviet Union's monetary situation, when the exchange of the Ruble against the US dollar was was at 0.65 for dozens of years, and individuals were not even allowed to purchase foreign currency without special permission. The black market made the foreign exchange possible at about ten times the official price.

Encadré 1: History: Bretton-Woods agreements
The Bretton Woods agreements were the first international system for a coordinated managing the currencies of the world's major states. The agreements were signed in July 1944 in Bretton Woods, New Hampshire at the United Nations Monetary and Financial Conference. The system obliged each for the participating countries to adopt a monetary policy that maintained the exchange rate of the local currency versus US dollar within one percent distance from a fixed rate. The US dollar, on its turn, had a fixed exchange rate to gold. Until early 1970s, the system was efficient enough to achieve its goals. It collapsed in 1971, when the United States suspended the convertibility of the US dollar to gold.

Floating exchange rates regimes can differ significantly. They can be assorted by different limitations, sometimes leading to an equivalent of controlled exchange rates. Thus, in Venezuela in 2003, the currency control was in reality equivalent to multiple exchange arrangements. In any case, even if only a partial control is applied, the market exchange rate will be more accurate than the official rate.

2.1.2 Government Regulations

Foreign exchange operations are often regulated, generally by the country's government or the highest financial authority. Forex trades are highly international. A typical situation may involve for example a Russian trader purchasing Great British Pound against US dollar through a Swiss broker. In such cases, most restrictive regulations are applied to the brokerage company, by the laws of the country where the broker is incorporated. Only occasionally some legal limitations may apply to the trader, by the tax authorities or capital movements control, or the traded currency, e.g. through exchange rates regulations.

Developed industrialized countries with strong currencies occasionally show themselves excessively restrictive vis-á-vis foreign exchange brokerage. As of 2008, Swiss government require forex brokers to have banking license. European regulation puts limits on the activity of asset managers: hedging is limited and short positions are forbidden in Sweden, Germany and France. As of 2009, US government limits the available leverage to 20:1 and prohibits hedge positions.

Tax regulation equally contributes to the limits already in place. Profits realized on the forex market are sometimes declared by the broker, sometimes

Encadré 2: Financial regulating authorities

The banking and the brokerage activity is usually subject to special licences aiming the customers protection. Fundamental requirements are similar in each country: anti-money laundering control, qualification of the company's personnel, data protection, etc. Specific requirements can however differ significantly from one country to another. There are usually one or few authorities in each country, who responsible for licensing and control of financial intermediaries. Note that regulating organizations are not necessarily public.

United States. In the United States the Federal Reserve Bank (http://www.federalreserve.gov) monitors the banking system, and the Commodity Futures Trading Commission (CFTC, http://www.cftc.gov) has the jurisdiction over all the Futures and Forex activity.

United Kingdom. Financial Services Authority (FSA, http://www.fsa.gov.uk) is an independent non-governmental body, empowered by the Financial Services and Markets Act 2000 to exercise control over trading activity in the country. The FSA is accountable to Treasury Ministers, and through them to the Parliament. It is operationally independent from the Government and is funded entirely by the companies it regulates.

Switzerland. Swiss Federal Department of Finance (FDF, http://www.efd.admin.ch) is the main licensing authority of the country. As of 1st April 2008, all Swiss Forex Brokers need to have banking license. Before 2008, forex brokerage activity was controlled by private associations, who supervised financial intermediaries on behalf of FDF (e.g. http://www.arif.ch).

Some other general financial authorities are:

- United States: Securities and Exchange Commission (SEC),
- Germany: Federal Financial Supervisory Authority (BaFin - Bundesanstalt für Finanzdienstleistungsaufsicht),
- Russia: The Federal Financial Markets Service (FFMS),
- China: China Securities Regulatory Commission (CSRC),
- Hong Kong: Securities and Futures Commission (SFC),
- Japan: Securities and Exchange Surveillance Commission (SESC).

Some countries do not have special licences for forex brokerage activity, but nevertheless require brokerage companies to be licensed. In 2006, some Russian forex brokers operated with casino licences.

by the beneficiary. Losses may or may not be deductible. In some cases, like for example in Switzerland, the capital gains are completely exonerated from Swiss taxes. While such details may seem irrelevant for evaluating the market movements, they have a non negligible impact on trading strategies and international capital movement.

2.1.3 Geography of the Foreign Exchange Market

Currency pairs traded on the forex market are usually split into two groups:

- Majors: main currencies like EUR, GBP, CHF vs. USD.
- Crosses: other currency pairs.

Sometimes less traded currency pairs, e.g. those involving Turkish Lira, Mexican Peso, Eastern European currencies, are called exotic.

Trading mechanisms and the market structure are not globally equal, but change from one country to another. The emerging markets are characterized by their concentration on the exchange of the local currency to USD, occasionally versus other majors, commonly at the bank-customer level. Some developing countries of the Central and Eastern Europe may prefer the exchange against EUR, as their economies are closer related to the economies of the countries of the Euro-zone, than to the economy of the United States. The forward forex market is underdeveloped and even prohibited in some countries. Monetary regulations of many transitional and developing economies often put important limits on the foreign exchange transactions. Forex market is not transparent, but is surprisingly very active both in terms of the number and volume of transactions.

Currencies of emerging economies became recently available for trades on the international market. Chicago mercantile exchange and Reuter's systems allow trades on the Russian Ruble, Brazilian Real, Mexican Peso and South African Rand. On the retail foreign exchange market, these currencies are only occasionally offered by brokers for trading, probably due to the lack of transparency about the related macro fundamentals and thus lower interest in trading these currencies.

Local foreign exchanges in emerging economies are still underdeveloped. Central Banks are unable to make reliable estimations of the market, and thus intervene occasionally. Retail trading is often strictly regulated. Fixed exchange rate regime may apply to the local currency.

2.2 Trading Rules

2.2.1 Main Currencies

US dollar is the most traded currency: in 2004, 89% of operations of the forex market involved US dollar. Euro is the second most important currency and took place in 37% of all operations. Japanese yen, Great British Pound and Swiss Frank were respectively involved in 20%, 15% and 5% of all the forex trades. By far the most traded currency pair is EURUSD - 28% of foreign exchange transactions. It is followed by GBPUSD and GBPEUR (1).

2.2.2 Prime Brokerage

The Prime Brokerage is an arrangement where forex deals are executed through a single bank, "hub", usually a big bank, with third-party bank, "spoke".

Standard services of the Prime Brokerage include global custody, securities lending, financing, customized technology and operational support. Some value added services, like capital introduction or risk management advisory services can be additionally offered by the prime broker.

This kind of brokerage is accessible to leveraged funds and important banks, but not to big corporations or small banks. The Prime Brokerage is more used in Europe than it is in the United States.

2.2.3 Live Trading

A series of factors can make a huge difference between the theoretical and the real world trading.

The bid-ask spread is often published as fixed, but deviations from it are possible on a hectic market. Requotes, i.e. proposing another price than that requested by trader, often accompany quick price changes.

The electronic brokers fight against such phenomena as pip hunting and rollover abuse. The pip hunting, also called scalping, is a way of trading when traders makes many successive trades, each time taking only a small profit corresponding to several basic points. In this case the market maker is unable to appropriately cover these positions, and all the profit acquired this way is made against the market maker itself rather than the market.

The rollover abuse is another kind of illegal speculation. Every night, a fee in the form of rollover charge is applied to the opened positions. Positive or negative rollovers rates depend on the difference between interest rates of the currency pair on which the position is taken. For religious reasons,

Figure 2.1: The change of the EURUSD exchange rate on 05.10.2007, the first Friday of the month, at around 14:30.

some brokers offer rollover free (islamic) accounts, on which no rollovers are charged. The rollover abuse consists in creating an arbitrage situation: two opposite positions are taken, one with positive rollovers on a regular account, another with negative rollovers - on the islamic account. The trader thus has no market risk and gets a certain positive profit.

As far as news are quickly incorporated in the exchange rates, news announcement attract particular attention of many market participants. An example of such trading periods can be observed each first Friday of the month at 14:30 CET, when the Non Farm Payrolls are announced for the US economy. Within several seconds, the market can move up to one hundred basis points, while in normal conditions such change would usually occur within at lest twenty-four hours.

2.3 Trading Systems

2.3.1 Trading Software

The great advantage of the trading platforms is that it makes traders from different locations meet in the same time on the same basis. According to ECB, 85% to 90% of the interbank trading go through the electronic systems EBS and Reuters. The interdealer trading can be direct and indirect. The

direct trading is performed by the Reuters Dealing 3000 system. The indirect trading is provided by brokers through various online platforms. In both cases, telephone trading is possible.

In the 1990s most of the trading software was single-trader, thus binding the trader to one provider or one broker. In early 2000, first multi-trader platforms, like Currenex, appeared.

Today, a big number of trading platforms are present on the market. Important brokers often develop their own trading software which then constitutes a part of their corporate identity. The disadvantage for the trader is the necessity to study a new trading tool if the trading service provider is changed.

The externally developed platforms, like Meta Trader, Ninja Trader, Avalon and others, are developed by professional programming companies and are easily customized for each particular broker. Functionally, they are often more advanced than the internally developed applications, due to the specialization of the developers. From the traders' standpoint, these platforms allow for more flexibility in the choice of the financial services provider without changing the favorite technical tool.

Functionally, the palette of available functions and tools is extremely wide. Starting from the simplest open/close operations, till sophisticated technical analysis, email and sms alerts, real time news feed, mobile trading and managing several accounts with a single click - the trading technology is quite advanced today. Many interesting functions are also implemented on the broker's side: modern software allows for intelligent automated orders processing, fine server customization, analysis and reports.

Electronic platforms facilitate access of retail traders to the forex market. As a consequence, the part of the traditional floor brokers has dramatically fallen. But electronic systems are still unable to replace the human intermediation completely. Also, contrary to what is expected, systems do not necessarily decrease transaction costs (6). Instead of the cost of human time, new systems induce costs of the development, maintenance, system errors and specialists training costs.

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Chapter 3

Trade Specifications

Individual operations are building blocks of any trading strategy. Trade instructions given by a trader to his agent have to specify all the parameters of the transaction to be performed. A trade specification usually includes:

- what to trade;
- buy or sell;
- how much;
- when and how; and
- under what conditions.

For the case of retail forex trading via brokers and market makers, aspects of trade instructions is discussed below.

3.1 Orders Specification

3.1.1 Currency Pairs

Each forex trading order should specify the currency pair, also called instrument, which a trader wants to trade. All the currency pairs are usually split into two groups: majors and crosses.

The currency pairs involving main currencies, i.e. GBP, CHF, EUR, JPY, CAD, AUD, versus the USD are called majors. All the other currency pairs are called crosses. Sometimes currency pairs that include currencies of the developing countries, i.e. TRY, RUR, CNY, etc., are called exotic.

As mentioned previously, even if the major currency pairs are not numerous, more than a 50% of all the forex trades in the world are done on these instruments.

3.1.2 Volume

Each order specifies the amount of the currency it wants to buy or sell. The amount is usually standardized for each currency pair, and called standard lot. It is expressed in the first currency of the currency pair, for example 100 000 EUR for EURUSD, 100 000 GBP for GBPUSD, 100 000 USD for USDJPY, etc. When a trader gives a trading instruction, it specifies the number of lots he wants to buy: 1, 3, 10, 100 or 0.1, 0.5 of standard lots.

The number of lots that can be traded at each transactions, including mini lots (0.1 of the standard lot) and micro lots (0.01 of the standard lot), depends on the trading conditions of a particular broker. For cost saving reasons, brokers may limit the minimum number to be traded. The maximum number of lots for each operation is depending on the currency pair and is fixed between 20 and 200 standard lots for streamline trades. For more important transactions, conditions may apply.

3.1.3 Type of Transaction: Buy and Sell

Each trading order specifies if the trader buys or sells a specified amount of the currency pair, i.e. buys or sells the first currency against the second one in the currency pair. For example, the purchase of one lot EURUSD means that the trader buys 100 000 EUR against a respective amount of US dollars.

3.1.4 Market Orders and Pending Orders

Alternative to immediate execution orders, also called market orders, one can place pending orders. These orders can be of four types:

- Buy Stop (buy if the price goes up to a pre-specified price),
- Sell Stop (sell if the price goes down to a pre-specified price),
- Buy Limit (buy if the price goes down to a pre-specified price),
- Sell Limit (sell if the price goes up to a pre-specified price).

Pending orders may be set for a limited period of time or without expiration. As soon as the market price reaches the pre-specified price, the order is being activated, i.e. the effective buy or sell operation is placed instead.

A particular kind of pending orders widely used in risk management are called Stop Loss, Trailing Stop Loss and Take Profit. A trader has the possibility to specify the Stop Loss - the price at which his active order has to be closed, if the market reaches this level. Thus the investor is guaranteed

against losses that he is not able to support. Trailing Stop Loss adjusts the Slop Loss level depending to the price evolution. Finally, the Take profit option closes a position that reaches a certain profit level.

3.1.5 Trading Schedule

The Forex trading schedule is not in line with equity trades. It has no regional sessions and is usually performed 24 hours from Sunday evening to Friday evening. However, regional equity trading has in any case its impact on the movements of the corresponding currencies. For example, exchange rate of the Japanese Yen fluctuate more when trading on the Tokyo Stock Exchange is active.

The end of the trading day on foreign exchange is not necessarily midnight, but it may be 11:00 pm, 1:00 am or any other time chosen individually by the brokerage company for its operations. The market itself operates nonstop.

3.1.6 Trading Terms and Conditions

Points and Ticks. Exchanges rates are generally specified two or four digits after comma. The last digit is called *Point* or *Pip*. One speaks about the *Pip Value* as a money equivalent of what a trader gains or loses on a one lot position as the price moves of one point up or down. It is expresses in the second currency of the currency pair. For example, for the EURUSD currency pair, it corresponds to 10 USD, for USDCHF - 10 CHF, for USDJPY - 1000 JPY.

Each change in the last digit, or equivalently, each new price becoming available on the market is called a *Price Tick*. During news announcements, the prices between two consecutive ticks can be any point away. If it happens, one speaks about a *Market Gap*.

Leverage. Smaller is the amount a trades manages, higher is the leverage available to him. In extreme cases, one can have the leverage up to 500:1, but common values are about 50:1, 100:1 and 200:1. The leverage of 100:1 means that a trader needs only 1/100th of the amount he actually buy buys or sells on the market. For example, to buy one lot of EURUSD, a trader leveraged at 100:1 will need to have an equivalent of 1000 EUR on his trading account instead of 100 000 EUR. The rest of the amount is a virtual credit given to the trader by the broker for the period when the position is opened. Respectively, is the leverage is 200:1, one need to have 500 EUR on the account, and with the leverage 50:1 - 2000 EUR.

MARGINS

The margin or leverage a client can have depends on the client's account equity. The table below shows MIG's margin requirements for the different equity levels:

Account Equity (US Dollars)	Initial Margin	Maintenance Margin end of each weekday (before 23:00 CET)	Maintenance Margin on Friday at 23:00 CET & before holidays
Less than 25,000	0.5%	No minimum required. Accounts are only stopped out at the stop out level.	0.5%
25,000 to 1,000,000	1%	No minimum required. Accounts are only stopped out at the stop out level.	1%
1,000,000 to 5,000,000	2%	2%	2%
5,000,000 to 10,000,000	3%	3%	3%
Above 10,000,000	5%	5%	5%

For accounts with equity below $1,000,000 there is no maintenance margin during the week; however, the margin level must be respected by Friday at 23:00 CET and before holidays. For accounts with amounts above $1,000,000, the required margin levels must be respected by the end of each weekday. Accounts that fail to meet the required margin levels at the above mentioned hours, must close all or part of their open positions, open a hedge position or deposit more money.

Figure 3.1: Example of leverage conditions on the forex market. Source: MIG Investments SA, 18th January 2008.

Even if a high leverage is viewed positively by traders, i.e. less money needed for the same market operations, one should keep in mind that higher leverage means significantly higher risks. The whole amount of the profit or loss is applied to the account balance. Say, an account with equity of 1000 EUR allows for opening 1 lot, whatever buy or sell, of EURUSD with the leverage 100:1, and 2 lots if the leverage is 200:1. As the price changes and the market goes against the trader, the trader looses an equivalent of 10 USD per lot at each point against him. In the case of 1 lot, the market should move a bit more than 100 points against the trader to bankrupt the account. In the case of opening 2 lots, a half of this movement, i.e. slightly more than 50 points, will be enough to do the same.

The illustration 3.1 shows standard leverage conditions on the forex market.

Generally, the leverage on the foreign exchange market is much higher than the leverage on on the other financial markets. The figure 3.2 shows examples of leverage conditions on the bond, equity and money markets.

Margin and Margin Level. A *Margin*, or *Required Margin*, is the amount needed for opening a trading position:

U.S. SECURITIES (NYSE, NASDAQ, AMEX)

Category of Security	Margin Requirement	Concentration Guidelines
Option eligible securities ($5.00+)	30%	$1,000,000 (U.S.) Loan Value
Listed securities ($3.00+)	50%	$500,000 (U.S.) Loan Value
Listed securities under $3.00	100%	Not Applicable
OTC Bulletin Board	100%	Not Applicable

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BONDS

Please note that margin is not extended for any bond with a Credit Rating below Investment Grade.

Category of Security	Margin Requirement	Concentration Guidelines
Government of Canada	4%	$1,000,000 Loan Value
Provincial Bonds	5%	$1,000,000 Loan Value
Municipal Bonds	10%	$1,000,000 Loan Value
U.S. Treasury Bonds	4%	$1,000,000 Loan Value
Corporate Bonds	15%	$750,000 Loan Value
Convertible Bonds*	See below	
Trading ABOVE par, use rates above plus:		
For: securities eligible for **reduced** margin	30% excess Market Value over par with a minimum of 10% of par	$500,000 Loan Value

MONEY MARKET

Category of Security	Margin Requirement	Concentration Guidelines
Canada Savings Bonds	100%	Not Applicable
Provincial Savings Bonds	1%	$1,000,000 Loan Value
T-Bills	1%	$1,000,000 Loan Value
GICs	15%	$1,000,000 Loan Value
Term Deposits	4%	$1,000,000 Loan Value
Banker's Acceptance	4%	$750,000 Loan Value
Commercial Paper	15%	$750,000 Loan Value

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Figure 3.2: Examples of leverage conditions on the bond, equity and money markets. Source: TD Waterhouse, 18th January 2008.

$$\text{Margin} = \frac{\text{lot size}}{\text{leverage}} \tag{3.1}$$

This amount is blocked on the account once the respective position is opened. For pending orders, the margin is not blocked until the order is activated, i.e. when the market price reaches the pre-defined level.

The *Balance* of an account equals to

$$\text{Balance} = \text{Deposits} - \text{Withrawals} + \sum \text{Realized profits and losses.} \tag{3.2}$$

The *Equity* is

$$\text{Equity} = \text{Balance} + \sum \text{Unrealized profits and losses.} \tag{3.3}$$

The *Margin Level* is defined as

$$\text{Margin level} = \frac{\text{Required Margin}}{\text{Equity}}. \tag{3.4}$$

Hedging. Long and Short positions opposite, but not necessarily cancel each other when opened on the same account. When short and long positions are opened simultaneously, it is called *Hedging*. In this case, no margin is blocked for the compensating part of opposite positions. Hedging possibility is possible in most of trading softwares and is allowed by most of brokers. The margin is not required for the compensating positions.

Margin Call and Stop Out. The Margin Level is of crucial importance for the risk management. The *Margin Call* is a warning given by a broker to his client and requiring to bring up the margin level either by closing positions, hedging positions or depositions additional funds. If the request is not honored by the client before a fixed deadline, the broker has the right to take action himself, usually by closing or hedging positions.

The margin call is often fixed at the level of 100% and is required to be respected either by the end of the day, either by the end of each week. The reason of this requirement is primarily the protection of the investor: the price may abruptly change after the weekend break in trades and bring the account to the stop out level.

The *Stop Out* is closing of the most loosing position or all the positions of an account that reached the *Stop Out Level*. The Stop Out Level is a broker defined Margin Level at which an immediate action should be taken in order to immediately increase the Margin Level. The trader is usually not consulted in such cases, and the action is taken automatically. The purpose

of the Stop Out is to protect the trader and the broker again an eventual negative balance on the trading account. The Stop Out level is usually fixed somewhere between 2% and 100%.

Swaps and Rollovers. In the context of the spot foreign exchange market the term Swap, or Rollover, is not related to derivative instruments, but defined as a positive or negative interest applied to forex positions opened overnight. It is defined by the difference of the interest rates between the two currencies of the currency pair, and is meant to compensate for the amount that one would get if borrowed in one currency and invested in another. The amount is calculated as per the formula 3.5.

$$\begin{aligned} \text{swap rate (short \% or long \%)} \quad & \times \quad \text{pip value} \\ & \times \quad \text{number of lots} \\ & \times \quad \text{number of days} \end{aligned} \tag{3.5}$$

Due to 2-days delay in bank transactions, swaps calculated for the night from Wednesday to Thursday are triple, and the swaps of Friday to Monday are single. Some brokers, instead of calculating positive or negative swaps, close positions just before the en do the day and reopen positions first thing in the beginning of the next day, generally at the same price. No swaps are applied, the respective spread is charged[1]

The figure 3.3 shows trading conditions of the forex broker MIG Investments, valid on 17th January 2008.

3.2 Transmitting Instructions

3.2.1 Floor Trading

The traditional way of processing orders, floor trading, was used for dozens of years on all the markets. Traders or their representatives are physically present in the trading hall. Orders are attributed and recorded by a person.

3.2.2 Electronic Trading

The last years, the electronic trading largely replaced the floor trading. There is no physical location of the market, and traders can perform operations distantly from any place in the world. Trades are managed by a trading server of the brokerage company. Clients communicate their orders to the

[1]See chapter 7 for other trading costs.

Item Name	Symbol	Spread	Lot size (*1)	Limit & Stop Orders (*2)	Max Per Trade (Online) (*3)	Swaps Short (*4)	Swaps Long (*4)
Euro vs US Dollar	EURUSD	2	100,000 Euro	5	200 lots	+0.09	-0.14
US Dollar vs Japanese Yen	USDJPY	2	100,000 USD	5	100 lots	-1.34	+1.05
British Pound vs US Dollar	GBPUSD	3	100,000 GBP	5	50lots	-0.87	+0.53
US Dollar vs Swiss Franc	USDCHF	3	100,000 USD	5	50 lots	-0.90	+0.63
Australian Dollar vs US Dollar	AUDUSD	2	100,000 AUD	5	50 lots	-0.64	+0.34

Figure 3.3: Example of trading conditions on the forex market. Source: MIG Investments SA, www.migfx.ch, 17th January 2008.

trading server through special software called trading platform. Technology provides good quality trading services at lower costs, higher speed, better information quality and anonymity. Albuquerque (1) claims the advantages of the e-trading are not much valued, and thus traditional brokers will keep loosing their part of the financial services market.

3.2.3 Telephone Trading

The telephone trading is particular case of both floor trading and electronic trading. The traders communicate orders to their intermediary, who executed them either in the trading hall or on the electronic trading system. With the development of the electronic trading, the importance of the telephone trading decreases, while it does not disappear completely, especially for significant transactions.

3.2.4 Automated Trading

An advanced variant of the electronic trading is the automated trading. The trades in this case are performed through the same trading platform, but instead of a dealer, orders are given by a program, based on an automated analysis of the market situation.

This kind of trading is appropriate for experienced traders whose trading strategy can be expressed by some formulas and programmed based on the current market situation. In most cases, such strategies automate technical analysis of the market. The advantage automation is saving trader's time

and removing emotions from the market. On the other hand, the machine will blindly follow the predefined strategy whatever the market conditions are.

Strategies are usually programmed either on a standard programming language like C++, or on a special simplified tool. The market of ready-to-use and customized strategies appeared in the traders' community. The interest to fully or partially automated trading is steadily growing over the last several years.

3.3 Orders Processing

3.3.1 Market Makers vs. Brokers

Strictly speaking, a Broker is a financial intermediary on the market who is providing services to clients by finding a counter-party for client's transactions, either internally, among his other clients, or externally, anywhere on the market.

Many of the modern brokerage companies act as *Market Makers*, which means they become themselves the counter-party for all the market transactions of their clients.

3.3.2 Manual and Automated Orders Processing

In the electronic trading, all the clients' opened and completed transactions are kept and managed by a trading server. There are still two ways of processing orders: automatically or with a manual confirmation.

A manual order confirmation allows for additional checks for price correctness, special conditions for particular customers, eventual modifications needed. This approach implies the 24 hours of human presence in the dealing desk on the trading days. The automated orders processing is generally faster than the manual one, but may be less accurate. As a trade-off, the modern brokerage companies apply automated processing to small transactions and process big orders manually.

3.3.3 Data Providers

Any broker providing services on the retail forex market, processes only a minor part of the global number of transactions. That means that the market price formation is out of his control and he needs external source of information about the price on the market. Important brokers, big banks and

specialized information companies, like Currenex or TenFore, provide such services. They establish a permanent connection with the broker's server and provide real time quotes. Market prices from different sources stay usually within few points from each other.

Several data providers, like Dow Jones, broadcast real time news feeders, sending the most important market news directly to the trading platform within minutes after an important event happened.

3.3.4 Requotes

Electronic trading provides fast, but not an immediate execution. In the time between the orders is being sent and the position is already placed, the exchange rate of the currency pair may change. In this case, the broker proposes the client a new price. This is called a *Requote*. The trader can accept or refuse the proposed price. The requotes are the most frequent during the news announcements, when the price changes quickly.

3.3.5 Coverage

Market Makers bare the risk of loss against their clients. In order to hedge this risk, the *Coverage* of the clients' total net position is made via another, usually a more important, broker or on the interbank market.

For example, the Market Maker X has three clients, A, B and C:

- A buys 3 lots of EURUSD,
- B sells 1.5 lots of EURUSD, and
- C sells 2.3 lots of EURUSD.

The total net position of all the clients is 0.8 BUY EURUSD, and this will be the position that the Market Maker X will place on his account with another broker, Y. If the EURUSD goes up, the clients' profits that is not compensated from the other clients' losses, will be paid from the profit of X's 0.8 lot position with Y. If EURUSD goes down, the loss from the 0.8 lot position with Y will be compensated by the amount the clients lose against the Market Marker X.

The total net clients' position change at every moment, and the coverage is never possible at 100%. But market makers are usually happy enough with an approximation which is being periodically adjusted.

A Market Maker has no obligation to hedge the risk completely. If he believes the EUR will become more expensive against the USD, it can buy

for example 1 lot instead of 0.8 lot. If he believe the opposite, the Market Maker may not take any coverage position at all or take a smaller than 100% coverage. Such approach may give the Market Makers X some additional profit if his forecast is right: he will get additional profit from the market for the 0.2 additional lots, or additional profit from the clients' losses for 0.8 lots.

3.4 Spot and Term Market

It is not absolutely correct to speak of *the* forex market, as there several parts of it. The primary market is the spot foreign exchange market where currencies exchange take immediate effect. This is usually the market that also provides the field for Central Banks interventions. Term forex market includes options, futures and other derivative. It provides speculation possibilities, as well as valuable tools for hedging exchange rate risks of the importing and exporting companies.

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Part II

Market Characteristics

Chapter 4

Market Efficiency

Market efficiency is defined by how fast and how accurately all the relevant information is absorbed by the market, in particular in the price and the traded volume. The concept was first introduced by Eugene Fama in 1960s, and was widely accepted until 1990s, when the market psychology was studied in more details. According to Fama's Efficient Market Hypothesis (EMH), financial markets incorporate immediately all the known information. In 1970, Fama (5) introduced the concept of three forms of the market efficiency: weak, semi-strong and strong.

Different particular macroeconomic variables can change their relative importance for the exchange rates, but the set of these variables is always of interest.

4.1 Public Sources of Information

Market operations are generally effected by both public and private information. Public information usually refer to the publicly known information about macroeconomic fundamentals. Private information concerns operations inside a company, its realized and expected profit, assets and liabilities, opportunities and threats. Private information is often crucial for determining price quotes of the company's shares, and this is why company insiders are watched closely for their market operations.

On the foreign exchange markets in particular, by the nature of these markets, there are no possible insiders. Market prices reflect a relative state of two economies - those, whose currencies are being exchanged. The "insider's" type of information is that about the state of a particular economy, rather than an individual company, and is supposed to be publicly known. The primary source of this public information are official announcements of

concerned government institutions through mass media.

An interesting question to ask is whether official and relayed communications are accurate and reliable to serve as a solid basis for financial decision making. If one considers multiple political interests behind economic activity of any country, especially in less democratic countries where official data can be easily manipulated, official sources appear less reliable for use in the market modeling and forecasting.

For example, if there is an announced Central Bank intervention, the public gets information about it from press reports. It was found (6) that these reports were relatively inaccurate, especially when concerned one Central Bank's actions only, rather than a joint coordinated intervention of several central banks. This particular research took advantage of the change in the Bank of Japan's information policy, when the bank decided to switch from summary press reports to publishing informative data set about its interventions on the foreign exchange market.

4.2 Alternative Sources of Information. Asymmetric information

In spite of the absence of insiders properly speaking, there are still some participants of the forex market who are better informed than the others. Immediate examples are Central Banks who know about their own interventions before anyone else, or market makers who observe and analyze traders' order flow before incorporating it into price.

If participants have different information about the market conditions, many market imperfections manifest themselves. This issue was first addressed by Akerlof (1) by analyzing car market. In his analysis, he assumes that there are only four types of cars: new or old, each of which can be good or bad, i.e. a "lemon". The probability that a new car is good is q, the probability it is a lemon is $1 - q$. At this moment, all market participants have the same knowledge about these cars. The situation is different for the used cars, when the seller knows what kind of car it is, while the buyer can only guess. As the buyer does not have a way to know what kind of car it is, he is ready to only pay the price based on his average estimation of the proportion of good and bad used cars on the market. On his turn, the sellers of good used cars, being able to get only the price which is lower than the real price of their cars, will withdraw from the market. Thus good cars will not be traded at all.

This situation is readily found on other markets. Health insurance com-

panies have the same situation having less information about actual state of the health of their clients then the clients themselves. The raise of the price to cover the potential risk will merely create an incentive to buy an insurance only by those who are certain about having to use it. Same process happens on the credit market. Same analogy is made with the currency market, in which case bad money drive out the good money out of the market. If the information of market participants is not equal, the market break down is likely to happen, in sense that no trades will take place.

4.3 Uncovered and Covered Interest Rate Parity

Interest rate parity refers to the relationship between interest rates of two currencies and a corresponding forward exchange rate. Say, the currency of the country A is X_A, and the currency of the country B is X_B. The respective interest rates for each currency are i_A and i_B. The present exchange rate is $r_{p,AB}$. Thus, the amount one can get in one period of time by investing n units in X_A is $n(1+i_A)$. If the same amount is converted into X_B, the result of the investment is $n(1+r_{p,AB})i_B$ units of X_B. If the forward exchange rate is $r_{f,AB}$, then the relationship

$$1 + i_A = \frac{r_{p,AB}(1 + i_B)}{r_{f,AB}} \tag{4.1}$$

has to hold if the market is *efficient*. If it does not, there is an arbitrage. Ideally and in a simplified way, this arbitrage situation will be recognized by market participants tending to take advantage out of it, which will generate excessive demand of the corresponding currency, and thus bring the exchange rate to equilibrium. This relationship is also called *covered interest rate parity*, as market participants have a possibility to cover their position today by concluding forward contracts at prices and conditions defined today.

Uncovered interest rate parity is defined for a situation when the forward exchange rate is not available for some reasons. If all investors are risk neutral, the relationship

$$1 + i_A = \frac{r_{p,AB}(1 + i_B)}{E(r_{f,AB})}, \tag{4.2}$$

where $E(r_{f,AB})$ is the expectation of the exchange rate in a future moment, holds. In this situation, traders cannot cover their positions, and have

the risk that the actual exchange rate will be different from the interest rate expected.

The market efficiency however has been put in a serious doubt, also in the aspects concerning the interest rates parity. Taking into account the trading costs (discussed in the chapter 7) and risk premia, the forward exchange rate stops being an accurate predictor of the future spot rate. In some cases, the relationship between the interest rate differential and exchange rates even showed to be the inverse of what was theoretically expected ((9)).

4.4 Carry Trades

Another arbitrage attempt are *carry trades* which consist in borrowing currency generating low interest rate and investing in high yielding currency, assuming the exchange rate does not change over time or at least change less than necessary to turn a potential profit into a realized loss.

With the modern trading technology on the foreign exchange market such operations became easy to realize. By placing their regular positions leveraged traders actually borrow one currency and invest it into another. To take into account the interest rates difference, brokers and market makers charge swap rates for positions held overnight. An example of such trading conditions is shown on the Figure 4.1.

The columns 6 and 7 on the figure above show interest rates charged for overnight positions on the respective currency pair. These interest rates are simply meant to reflect the difference between interest rates for each of two exchanged currencies, and thus are meant to be symmetric. In practice, negative rates have higher absolute value which constitutes another part of trading costs.

In attempt to find an evidence if carry trades are susceptible to generate significant positive income, we run hypothetic carry trades for one month on 23 currency pairs, for each month over two year from January 2007 till December 2008. We assume each time a position of 1 lot was placed the first day of the month and closed the first day of the next month. Each time the carry position is taken in the direction that generates positive overnight rate. All pip values are converted in USD at the average rate, and thus the generated profit is also expressed in US dollars. The monthly generated income is calculated as

Dealing Rates (Simple) (22)

Curre...	Sell	Buy	High	Low	Intr S	Intr B	Pip Cost	MMR	Time
EUR/USD	1,3332	1,3335	1,3349	1,3253	0,43	-0,48	0,75	50,00	19:28:15
USD/JPY	117,94	117,97	118,44	117,62	-1,01	0,99	0,64	50,00	19:28:26
GBP/USD	1,9695	1,9699	1,9725	1,9581	-0,05	0,03	0,75	50,00	19:28:33
USD/CHF	1,2147	1,2151	1,2230	1,2116	-0,68	0,64	0,62	50,00	19:28:15
EUR/CHF	1,6197	1,6201	1,6220	1,6169	-0,47	0,45	0,62	50,00	19:28:00
AUD/USD	0,8101	0,8104	0,8109	0,8027	0,17	0,13	0,75	50,00	19:24:52
USD/CAD	1,1620	1,1625	1,1640	1,1592	-0,23	0,21	0,65	50,00	19:28:12
NZD/USD	0,7168	0,7172	0,7184	0,7088	-0,35	0,34	0,75	50,00	19:28:43
EUR/GBP	0,6769	0,6772	0,6778	0,6753	0,40	-0,52	1,48	50,00	19:28:01
EUR/JPY	157,26	157,30	157,41	156,28	-0,87	0,84	0,64	50,00	19:28:46
GBP/JPY	232,31	232,40	232,84	230,83	-1,98	1,87	0,64	50,00	19:28:33
CHF/JPY	97,08	97,12	97,18	96,53	-0,27	0,24	0,64	50,00	19:28:45
GBP/CHF	2,3926	2,3932	2,4011	2,3882	-1,37	1,22	0,62	50,00	19:28:33
EUR/AUD	1,6453	1,6462	1,6525	1,6425	0,68	-0,73	0,61	50,00	19:28:21
EUR/CAD	1,5493	1,5501	1,5516	1,5390	0,14	-0,18	0,65	50,00	19:28:12
AUD/CAD	0,9414	0,9421	0,9430	0,9332	-0,35	0,29	0,65	50,00	19:26:40
AUD/JPY	95,55	95,61	95,73	94,68	-0,95	0,90	0,64	50,00	19:28:37
CAD/JPY	101,47	101,54	101,99	101,28	-0,68	0,64	0,64	50,00	19:27:17
NZD/JPY	84,56	84,62	84,85	83,49	-1,08	1,00	0,64	50,00	19:28:43
GBP/AUD	2,4305	2,4317	2,4418	2,4283	0,33	-0,41	0,61	50,00	19:27:15
AUD/NZD	1,1298	1,1302	1,1377	1,1270	0,23	-0,25	0,54	50,00	19:28:43
EUR/NZD	1,8593	1,8605	1,8765	1,8540	1,05	-1,16	0,54	50,00	19:28:43

Figure 4.1: Overnight rates charged by FXCM broker. Source: www.forexfactory.com, 17th June 2009.

$$\begin{aligned} Income &= \text{Swap income} + \text{Exchange income} = \\ &= 30 \text{ days} * \text{Swap rate} * \text{Pip value} \\ &\quad + \text{Price change in pips} * \text{Pip value} \end{aligned} \tag{4.3}$$

The results of calculations are shown in the table 4.1. The profit is rounded to the closest dollar.

In equilibrium the result of carry trades should be close to zero, i.e. investing in one currency should not produce more income than investing in another. Taking into account trading costs, the result might be expected to be below zero, approximately equal to the encountered trading costs. However, the empirical result vary from several thousands a month of profit to several thousands lost, i.e. several percent per month of profit or loss, as one lot equals 100 000 units of base currency. The average monthly profit is positive for 7 out of 23 currency pairs, and the average of all the trades gives a significant loss. With this quick test, we confirm that we do not find any evidence of profitability or at least stability of carry trades.

4.5 Effect of News Announcements on Foreign Exchange Trades

If we assume that official and unofficial news about macro fundamentals are immediately incorporated in market prices, their effect on the behavior of market participants can last for substantial period, up to several days. The reaction of different groups of market participants - corporations, unleveraged investors, active traders - may also differ, as their trading objectives and thus the sensitivity to short term and long term fluctuations is different.

Official announcements about macro-fundamentals are usually scheduled in advance. Evans and Lyons (4) address daily data and are paying particular attention at moments of news announcements over a period of six years. Authors point out that is is difficult to distinguish rational trades following the news announcement, and those that are non rational and have to be rather studied using market psychology.

4.6 Behavior of the Market in Proximity of Central Bank Interventions

The Central Bank interventions on the foreign exchange market are special cases of market conditions in which

1. It is known in advance that there will be a shift in market conditions.
2. Timing of the shift is known in advance.
3. Importance if shift can be estimated in advance.
4. Information about the change can be known in advance or learnt by other participants ex post.

In case of publicly announced intervention, the information becoming public is likely to be incorporated in participants' expectations about the market, and thus in price, at the moment when it is announced, even if it happens before the actual intervention takes place.

In the case of non announced central bank interventions, which have shown to be more efficient (2), the market learns about the intervention as it occurs, and there is no time lag between the moment when the shift happens and the moment when its effects are incorporated in the market price. On the other side, whenever an unannounced intervention occurs, the situation of asymmetric information arises, when a major participant of the market, the central bank of a country or even central banks of different countries in case of joint intervention, have a thorough knowledge of future occurrences on the market, while a large number of corporate, financial and retail participants are not informed about it.

4.7 Testing the Market Efficiency

The question about the market efficiency and its form is interesting only for traders aiming for profit on the forex market, but also for governments. In an inefficient market, Central Banks have more potential influence on the exchange rates, market liquidity and volatility. On the other hand, if the market is efficient, it needs minimal government intervention to stay in equilibrium.

Contrary to strong form of market efficiency, semi-strong and weak forms of this hypothesis are less restrictive. Semi-strong form claims that all *public* information is incorporated in prices, which exclude any privately known

information. In other words, investors can consistently get abnormal returns only by having access to private information that influences prices. In a market is proved to be efficient in semi-strong form, neither fundamental nor technical analysis can consistently produce abnormal returns.

The weak form of market efficiency states that all past prices are reflected in the today's price on the market. This basically means that is it not possible to get any significant advantage on the market by analyzing pas prices only, as it is done in the case of technical analysis. However, fundamental analysis can be successfully applied.

The hypothesis of equity market efficiency has been challenged by numerous researches since 1990s. In a similar way, the efficiency of foreign exchange markets has not been so far proven. This holds for both major and exotic currencies. Some researches however find evidences for weak form of market efficiency. For instance the Wickremasinghe (13) tests the semi-strong and weak market efficiency hypothesis for Sri Lanka, and find evidences of a weak form of market efficiency.

Tools used to test market efficiency are dependent on the form of efficiency to be tested. Weak form may be detected using unit root tests. Semi-strong form is analyzed using cointegration, Granger causality and variance decomposition analysis.

Any market analysis and forecast have a specific time frame. This obviously holds for fundamental and technical analysis also. As information may take time to be incorporated in market prices, it is not impossible that the market shows to be efficient for one time frame and data frequency, but not for another. The question we address in the next section is whether the foreign exchange market is efficient in weak and semi-strong form for high frequency data with short term trading objective of intraday trading.

4.8 Efficiency of Foreign Exchange Market over Short Term.

To define whether the foreign exchange market is efficient in semi-strong form, we are going to test:

- If the spot exchange rate behaves as a random walk, and
- If there is cointegration among a set of spot rates.

If this analysis does not provide us with a positive answer, we will run a unit root test to check if the foreign exchange market is efficient in a weak form over short period of time.

Methodology. To test if there is cointegration among spot rates, we do a two step analysis:

1. We find the order of integration of the variables, i.e. the number of times is differentiated before becoming stationary. For this, we use the Augmented Dickey-Fuller (ADF) test, which we expect to be confirmed by Phillips-Perron (PP) test. The reason of this step is that the test for cointegration should be done only among variables with the same degree of integration.

2. We apply Engle and Granger method to define if variables are cointegrated. In this method, one variable is regressed on the other, and we test if the residuals are stationary. Again, the Augmented Dickey-Fuller and Phillips-Perron tests are used to test for stationarity.

Data. The analysis is first run on the minute-by-minute exchange rates on a set of currency pairs for the period from 1st March 2009 until 31st May 2009. Because of the extensive second step of the analysis, our attention is restricted to only the exchange rates of USD vs. major currencies: EUR, GBP, CHF, JPY, CAD, AUD, NZD.

Results. The results of the Augmented Dickey-Fuller and the Phillips-Perron tests are in the table 4.8. At this first step, if there is a unit root of a series, it is considered to be non stationarily, and it is differentiated once again. The procedure is repeated until the p-value of at least one of two unit root tests is below 5%. The table presents the tests statistics along with p-values, as well as the number of times the series was differentiated until became stationary.

As seen in the table 4.8, all the series became stationary after one differentiating. Thus, the Engel and Granger method can be run on the second step, and the table 4.8 presents, for each pair of exchange rates, the statistics and the p-value of the Augmented Dickey-Fuller and Phillips-Perron rests for residuals of regression of one series of exchange rates on another.

The results obtained in the table 4.8 are consistent with previous studies: the market is not efficient in a semi-strong form. This time the proof of it has been given for the foreign exchange market, on the minute-by-minute exchange rates of the major currency pairs.

We can finally check if the market is efficient in a weak form. To test for it, we run a unit root test. As it was seen above, for every series, the null hypothesis of unit root could not be rejected. All the series became stationary after being differenciated once. Thus it is concluded the forex market market displays weak form of efficiency over short term.

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Currency	Pip value (USD)	Monthly profits 2007											
		01/07	02/07	03/07	04/07	05/07	06/07	07/07	08/07	09/07	10/07	11/07	12/07
EURUSD	10	-1471	2079	1589	2839	-1761	1009	1519	-351	6569	2079	1839	-371
USDJPY	9.02	1972	-1842	-634	1963	2369	1476	-3898	-2212	-589	782	-3636	836
GBPUSD	10	509	-141	659	3049	-1931	2799	2169	-1251	2999	3339	-2531	-6821
USDCHF	8.76	2218	-2057	-287	-384	1719	-200	-1619	834	-3844	-138	-2258	361
EURCHF	8.76	1205	-626	1029	2238	232	574	-854	530	1283	1581	-1765	-57
AUDUSD	10	-1221	1129	2259	2039	-211	2269	69	-3361	7309	4359	-4851	-641
USDCAD	9.38	1213	-579	-1639	-3890	-3684	-588	472	-1067	-5832	-4472	5237	-607
NZDUSD	10	-1388	1162	1592	2642	-298	3662	-1138	-5828	6082	1372	-988	622
EURGBP	13.64	-1242	1624	887	600	-232	-546	123	396	3165	-82	2401	3206
EURJPY	9.02	507	-377	597	5411	976	2869	-3974	-3623	5718	3013	-3740	579
GBPJPY	9.02	4464	-3750	-657	7151	2534	6150	-5652	-5796	1822	5014	-10115	-5210
CHFJPY	9.02	-314	155	-278	1931	471	1426	-1928	-2550	2716	822	-1161	380
GBPCHF	8.76	5104	-4226	67	2493	1372	2581	-1020	382	-4734	3001	-7292	-6022
EURAUD	8.51	659	284	-2218	-422	-1316	-2507	1450	5339	-5238	-4422	9092	812
EURCAD	9.38	-251	1428	-645	-2428	-6958	68	1925	-1902	-1987	-4716	9101	-1405
AUDCAD	9.38	-359	870	1123	-1044	-3323	1751	485	-4158	2014	-134	363	-1175
AUDJPY	9.02	171	-171	1884	3760	3985	1370	-3210	-5383	7051	5193	-8259	45
CADJPY	9.02	606	-1107	840	5204	5736	1958	-4119	-1098	5601	6070	-9799	1444
NZDJPY	9.02	-126	0	1199	4193	1343	5211	-4391	-7826	5933	1984	-3787	1208
GBPAUD	8.51	4271	-3192	-5073	-1703	-1235	-2392	2075	7190	-14271	-5958	8117	-4996
AUDNZD	7.30	401	6	583	-825	262	-1671	1444	3523	218	2750	-3335	-1204
EURNZD	7.30	-	-	-	-	-354	-5453	3951	10910	-4789	-142	375	-1215
Currency	**Pip value (USD)**	**Monthly profits 2008**											**Av.mon. profit**
		01/08	**02/08**	**03/08**	**04/08**	**05/08**	**06/08**	**07/08**	**08/08**	**09/08**	**10/08**	**11/08**	
EURUSD	10	2719	3579	5809	389	-2081	1989	-1461	-16341	1759	-13521	989	-26
USDJPY	9.02	-4475	-2221	-3095	3523	2053	818	1864	-751	-372	-8234	-3140	-758
GBPUSD	10	179	39	-541	449	-1321	1909	-981	-17151	-2841	-17491	-6941	-1819
USDCHF	8.76	-4317	-3529	-3809	3725	711	-1619	2498	4619	2131	3410	5170	145
EURCHF	8.76	-3964	-2265	-898	4367	521	-1047	2387	-1529	-2799	-9185	5944	-135
AUDUSD	10	2009	3759	-1901	2999	1159	439	-1671	-8431	-6201	-12591	-1591	-560
USDCAD	9.38	950	-1498	3877	-1789	-992	2442	312	3680	162	13830	2648	356
NZDUSD	10	2042	1392	-1348	-278	232	-1998	-2768	-3228	-2828	-8458	-3868	-592
EURGBP	13.64	1869	2483	4380	-1105	518	423	-382	3643	-2592	300	4571	1061
EURJPY	9.02	-4227	-278	263	4645	1796	2968	1210	-7842	-8491	-21312	-3776	-1178
GBPJPY	9.02	-8781	-4534	-6563	8179	2174	3202	2733	-15408	-6004	-26921	-9953	-2866
CHFJPY	9.02	-124	1264	768	92	831	2445	-810	-3866	-3569	-8392	-5832	-675
GBPCHF	8.76	-8440	-6986	-8028	7723	364	-1642	4044	-7319	995	-11629	960	-1663
EURAUD	8.51	-490	-2303	8402	-5698	-2022	1339	1271	5237	5305	11381	3501	1193
EURCAD	9.38	3820	949	11249	-4201	-2165	5630	-1124	-3234	-5645	3932	2713	181
AUDCAD	9.38	2746	2089	1779	1216	110	2689	-1260	-4946	-6044	-3352	-68	-375
AUDJPY	9.02	-2029	1470	-4616	6329	2633	1118	144	-7628	-7519	-16274	-2984	-996
CADJPY	9.02	-5534	-783	-6832	5538	2571	-1621	1489	-2892	-1928	-16200	-3722	-808
NZDJPY	9.02	-1524	-469	-3760	2777	1479	-1307	-1289	-2678	-3994	-11802	-4797	-975
GBPAUD	8.51	-3992	-7345	3326	-5277	-3226	1097	2331	791	11138	13997	-4017	-363
AUDNZD	7.30	-125	1998	-88	3187	940	2881	1984	-4349	-2839	-3101	4019	290
EURNZD	7.30	-770	1091	8124	-405	-544	6110	4534	-1652	449	5643	11129	1755

Table 4.1: Monthly profits generated by carry trades.

Currency pair	Times diff.	ADF (p-value)	PP (p-value)
USDCHF	1	-45.7 (0.01)	-217 (0.01)
EURUSD	1	-45.3 (0.01)	-206 (0.01)
GBPUSD	1	-44.1 (0.01)	-192 (0.01)
USDJPY	1	-46.1 (0.01)	-214 (0.01)
USDCAD	1	-45.4 (0.01)	-209 (0.01)
AUDUSD	1	-44.4 (0.01)	-204 (0.01)
NZDUSD	1	-44.7 (0.01)	-224 (0.01)

Table 4.2: Statistics and p-values of the Augmented Dickey-Fuller and the Phillips-Perron unit root tests, minute data.

	EURUSD	GBPUSD	USDJPY	USDCAD	AUDUSD	NZDUSD
USDCHF	-2.27 (0.46) -2.35(0.43)	-2.85 (0.21) -2.96 (0.17)	-2.50 (0.34) -2.54 (0.35)	-2.85 (0.21) -3.06 (0.12)	-2.15 (0.51) -2.25 (0.47)	-2.12 (0.53) -2.20 (0.50)
EURUSD		-2.78 (0.25) -2.83 (0.23)	-2.61 (0.32) -2.57 (0.33)	-2.44 (0.39) -2.54 (0.35)	-1.62 (0.74) -1.75 (0.68)	-2.07 (0.55) -2.18 (0.50)
GBPUSD			-2.39 (0.41) -2.42 (0.40)	-3.41 (0.05) -3.72 (0.02)	-3.19 (0.09) -3.26 (0.08)	-2.80 (0.24) -2.89 (0.20)
USDJPY				-2.86 (0.21) -2.91 (0.19)	-2.64 (0.30) -2.55 (0.34)	-2.16 (0.51) -2.06 (0.55)
USDCAD					-2.34 (0.43) -2.56 (0.34)	-2.15 (0.51) -2.22 (0.49)
AUDUSD						-2.00 (0.58) -2.23 (0.48)

Table 4.3: Results of the Engel and Granger method applied to daily exchange rates: statistics and p-values of ADF and PP tests, for residuals of the regression of price series of one currency pair against another, minute data.

Chapter 5

Liquidity

Market liquidity characterizes how easy and fast the assets can be exchanged, moved, bought or sold, without effecting price and incurring significant costs. Cash money are usually considered the most liquid assets. As the spot foreign exchange market is a place where different currencies are exchanged, it is definitely the most liquid market in the world. It operates the daily volume of 3.2 trillion USD (state April 2007, (3)), 24 hours a day, actively five days a week and even with some transactions over the weekend.

The foreign exchange market has changed a lot over the last fifteen years. The spot forex market is now decentralized, i.e. over the counter, and is made by three main groups of participants - customers, dealers and brokers. In most cases it is active 24 hours a day 5 days a week. The volume of transactions is tremendous and exceeds as much as 200 billion USD per day on EURUSD exchange only (8). Approximately a half of transactions are done by dealers through brokers (2).

The liquidity characteristic of a market is important not only for the general knowledge, but it is crucial for price determination. Take a simple example of 1 000 000 USD on a bank account and a house worth the same amount of money. If the owner, as an investor or a speculator, needs money for operations, he may even be willing to sell the house for 900 000 USD, just to get the liquidity and assuming the loss of 100 000 USD. If he had the same amount of money in the bank he would not have incurred the loss which can be perceived as the cost if illiquidity of a real estate asset.

The knowledge of liquidity property of each particular market at any time is valuable for both policy makers like Central Banks for their interventions, as well as for investors and traders pursuing different purposes with their market transactions.

5.1 Historical Perspective

Liquidity question is not new concept that arises on the modern market. Liquidity solutions and crises have always been a part of the world economy questions. They definitely deliver important lessons.

Holy Roman Empire currencies, XVIIth century. Currencies, usually in the form of coins, have been broadly used for trades. While three basic currencies of the country, Reichs-Gulden, Marck and Reichsthaler, remained relatively stable in their exchange rate to each other, a real chaos reigned on the exchange market for various regional currencies. Local governments issued regional money uncontrollably and nobody could determine a real exchange rate, due to the lack of reliable information about the market - they were therefore less willingly exchanged. Thus, the three main currencies can be perceived as a prototype of modern majors, while exchange to regional currencies would have now been called crosses. The role of the information on the medieval foreign exchange market seemingly had the same importance as it has now, also for the market liquidity.

Tulip mania, the peak of which occurred in February 1637, is considered to be the first officially recorded speculative bubble. The price of tulip bubble on the market rose up to ridiculously high levels, only to collapse afterwards. While opinions diverge, many historians and researches agree that the tulip mania was a case of irrational behavior rather than some rational expectations relative to market fundamentals. The tulip market stayed relatively liquid at all times in term of the possibility to buy and sell tulip bulbs, the market could not however be considered as liquid in our definition: the costs were huge, mainly induced by being unable to get convert bulbs into a *predefined* amount of money - price was in constant change.

Great Crash of 1929 happened during several days when the Dow Jones Industrial Index value fell down and came into its pre-1929 level only in late 1959 (10). During the initial crisis, and well as the downturn that followed it for at least a month, and "uptick rule" was introduced: short selling was only allowed if the last quote was higher than the previous one. This was an attempt to prevent short selling that would drive prices down - another form of barriers for market liquidity, through regulatory barriers.

Bretton Woods monetary system imposed to allied independent Nations an fixed exchange rate (plus or minus 5%) to US dollar, which was on its turn tied to gold at the rate of 35 USD an ounce. In reality, the 35 USD an ounce of gold exchange rate was available to institutions only, but not to the public. Although the official rate was stable, the market was absolutely illiquid. In early postwar year, private holding of gold was illegal in many countries, so the gold market for gold simply closed. Unofficial market quotes

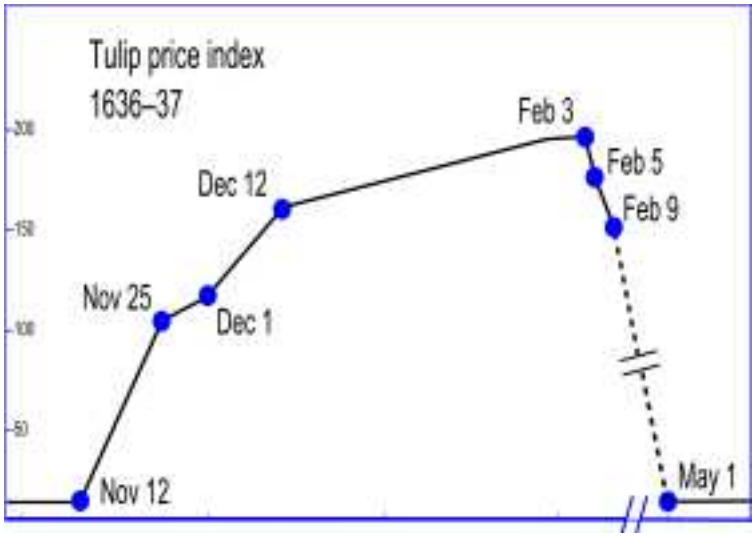


Figure 5.1: Tulip Price Index 1636-1637. Source: (14)

gold at 55 USD an ounce before 1954 ((5), p.223) - another illustration of lack of liquidity translated into costs.

Russian Crisis of 1998, partially caused by the Russia's default on domestic debt - ruble denominated bonds yielded 200% per annum - make the stock market totally illiquid: it was closed for 35 minutes on 13th August 1998, during which prices dropped by 65%.

Finally, the **Credit Crisis of 2008** happened and made the US government commit more than the cost of the World War I, World War II, Marshall plan, Korean War, the Moon Landing, Vietnam War and both Golf wars combined and adjusted for inflation over the years. Markets were less regulated this time, no restrictions like "uptick rule" were applied ((13), p.168). The illiquidity of the market, again, translated into costs. The USDCHF exchange rate remained between 1.15 and 1.32 for two two and a half years between January 2005 and September 2007, after what it dropped dramatically to 0.95 in only five months.

5.2 Measures of Liquidity

The most common measure of liquidity of a market is the frequency with which transactions take place. In other words, how often assets are bought and sold.

An alternative measure of liquidity is the probability that the next trans-

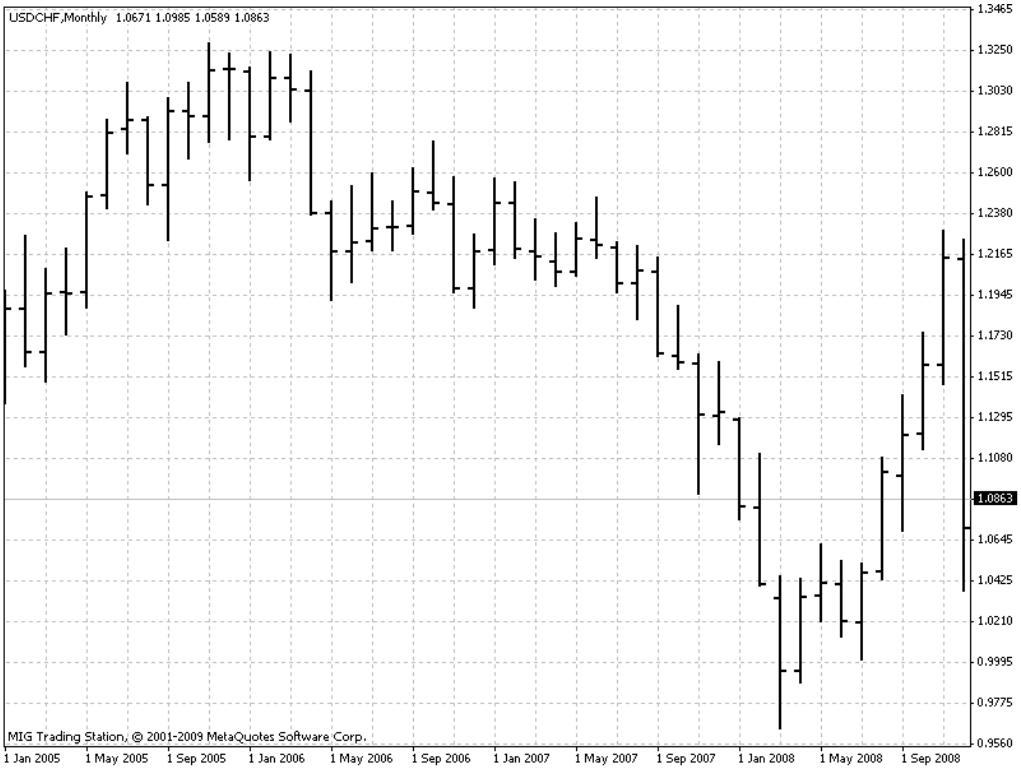


Figure 5.2: USDCHF monthly exchange rates 2005-2008. Source: MIG Investments SA, www.migfx.com.

action will be executed at the same price as the previous one. This simple measure incorporates both the frequency of transactions and the possibility to buy or sell at the current market price.

The third possible measure of liquidity is the measure of how much trades influence the price. On a less liquid market trades are more susceptible to move the market price. Evans, Lyons (7) investigate for example if trades have more influence on the price around the moments of news announcements, i.e. if the market becomes temporarily less liquid.

Relevant variables to be analyzed are

- Trading costs: spreads and eventual commissions
- Trading volume: number of transaction, volume of transactions, returns
- Volatility: change in price, change in signed order flow, change in volume of short and long trades

5.3 Costs Related to Liquidity

Illiquid assets are often less desirable for investors for the fact that they are not sure to be able to sell them at a desired price whenever they need to do so. Market makers contribute greatly in the liquidity of the market, by translating the illiquidity of an asset into cost, usually in the form of the spread. The table figure below shows an example of trading conditions of one of foreign exchange market makers, offering trades on seventy currency pairs. As it can be observed, majors have a tight spread of 2-3 points, while exotic currency pairs, involving such currencies as ZAR, MXN, HKD, DKK and others, are bought and sold sometimes with a spread higher than 100 points. Translating spread into money, it means if one buys and immediately sells one lot of EURUSD, i.e. 100 000 EUR, with no price change in the meanwhile, he loses 20 USD as trading costs, in the form of the spread. The same operation on USDZAR will cost him 1250 USD!

5.4 Time-Varying Liquidity

5.4.1 Central Banks Interventions

Central Banks interventions also affect the forex market liquidity. Pasquariello (9) finds evidence for Switzerland, when the lack of information about the Swiss National Bank interventions, impact the liquidity of the foreign exchange market and increase the transaction costs borne by traders.

Majors

Symbol	Spread	Limit & Stop Orders	Max Per Trade (Streamline)
EURUSD	2	5	200
USDJPY	2	5	100
AUDUSD	2	5	50
GBPUSD	3	5	50
USDCHF	3	5	100
USDCAD	3	5	50
NZDUSD	4	5	50

Crosses

Symbol	Spread	Limit & Stop Orders	Max Per Trade (Streamline)
EURGBP	2	5	100
EURCHF	2	5	100
EURJPY	3	5	50
CADJPY	4	5	50
CHFJPY	4	5	50
AUDJPY	5	5	50
GBPCHF	6	5	50
NZDJPY	6	5	20
EURAUD	8	5	50
EURCAD	6	5	20
AUDCHF	7	5	30
NZDCAD	7	5	20
EURDKK	7	5	50
AUDCAD	7	5	20
GBPCAD	8	5	20
GBPAUD	8	5	20
CADCHF	8	5	20
NZDCHF	8	5	20
GBPJPY	7	5	50
NOKSEK	10	5	50
EURNZD	7-20	5	20
AUDNZD	10-20	5	20
EURTRY	18-35	5	20
EURNOK	30	10	50
EURSEK	30	10	50

Exotics

Symbol	Spread	Limit & Stop Orders	Max Per Trade (Streamline)
CADSGD	7	5	10
SGDJPY	7	5	10
USDHKD	8	5	50
USDSGD	7	5	30
CHFSGD	10	5	10
EURSGD	10	5	20
NOKJPY	10	5	50
SEKJPY	13	5	50
NZDSGD	13	5	10
USDTRY	13-25	5	20
TRYJPY	13	5	20
GBPNZD	18	5	50
GBPSGD	15	5	10
USDDKK	15	5	20
EURHKD	30	10	50
USDNOK	30	10	20
NZDDKK	30	10	20
CHFNOK	30	10	30
CHFPLN	30	10	30
EURCZK	30	10	30
EURHUF	30	10	30
USDCZK	30	10	30
USDPLN	30	10	30
USDHUF	30	10	20
SGDHKD	30	10	30
EURPLN	30	10	50
USDSEK	30	10	20
USDMXN	55	15	30
HKDJPY	55	15	30
GBPPLN	55	15	20
GBPNOK	75	15	10
GBPSEK	75	15	10
NZDSEK	75	15	10
GBPTRY	28-45	10	50
GBPDKK	35	15	50
GBPHUF	45	15	10
EURZAR	125	20	10
USDZAR	125	20	10

Figure 5.3: Spreads on currency pairs of MIG Investments SA, www.migfx.com, 20th June 2009.

Scalia (11) distinguishes three states of the market:

1. Central Bank might perform secret intervention, dealers estimate low likelihood of a central bank intervention,

2. Central Bank might perform secret intervention, dealers estimate high likelihood of a central bank intervention,

3. Dealers indeed know that the intervention takes place.

Beine et al. (4) studied a twelve year intraday data, looking for realized moments of the day before the intervention, the day of the Central Bank intervention, and the day after the intervention, using ARFIMA model. The study confirmed an increased volatility after a coordinated central bank intervention.

In the case of controlled exchange rates, the government limits the volatility, along with the achievement of the goals of its monetary policy. Model with short-term pre-announced interventions can control exchange rate volatility, and the market may actually help the government to achieve its targets (1).

Traders are usually interested if it is possible to get above-average profits during Central Bank interventions. The concern of the Central Banks is whether this profit seeking is contradictory with the objectives of the foreign exchange market intervention.

5.4.2 News Announcements and Regional Sessions

The trading on the foreign exchange market is not uniform over time. Depending on currency pair, i.e. countries concerned, the market can be still and slow, or it can be quite hectic, even extremely volatile. If we schematically split the 24-hour period of trade into "Japanese", "European" and "American" sessions, corresponding to business hours in each respective part of the world, we can expect significant movements of currencies in periods of business hours of its home region. For example, the EURUSD currency pair would most move during the European and American session, but very little during Japanese business hours.

News announcements is another case that can be studied closely. For the same currency pair and the same trading session, the time elapsing between a request to the market maker and having a transaction completed, in most of cases, does not exceed 5-15 seconds. In the period just prior to major news announcements and up to 30 minutes after the announcement is made,

the market liquidity changes dramatically, and traders may have to wait up to several minutes until they are able to trade.

Scalia (12) brings micro analytical evidence from Czeck rep. Estimate a two equation system of exchange rate and order flow at hourly frequency within the framework of Evans-Lyons(7). Find significant impact of order flow on the exchange rate. The news of intervention increases the price impact of order flow. The order flow equation yield inconclusive results.

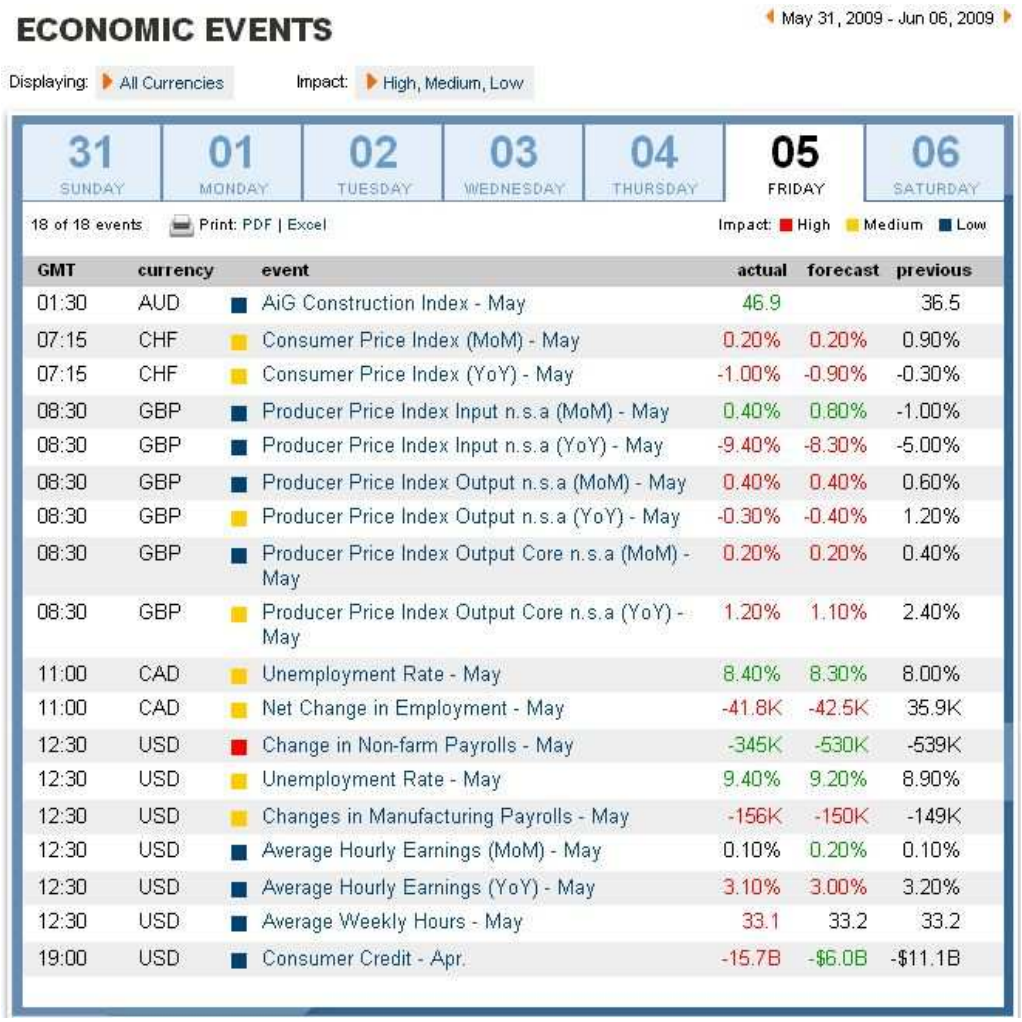
Unlike on the equity market when time and kind of news arrivals are not known in advance, foreign exchange has a relatively well established calendar of news announcements. This calendar describes the schedule and type of news announcements and is followed up to minutes. News announcements, by affecting the public information about macro economic fundamentals of a particular country, change at least the exchange rates of this currency relative to other currencies.

The figure 5.4 shows an example of forex news announcements calendar. The announcements of medium to high importance, like that of Non-Farm Payroll announcement of each first Friday of the month at 12.30 GMT time, are susceptible to temporarily affect market operations.

To test this hypothesis, we will compare the market liquidity between the time around a news announcement and all the other trading time. We analyze the announcements of medium and high importance as indicated and scheduled on publicly available calendars, e.g. www.fx360.com or www.dailyfx.com. Following statistics will be analyzed:

- Percentage of trades that were made at the same price as the previous trade, for evaluating regional sessions activity,
- Time between trader's request and the moment when the transaction is completed, for evaluating the impact of news announcements.

Percentage of trades executed at the same price. We analyze the order flow on 70 currency pairs over three months from 1st March 2009 till 31st May 2009. The following currency pairs were analyzed: AUDCAD, AUDCHF, AUDJPY, AUDNZD, AUDUSD, CADCHF, CADJPY, CADSGD, CHFJPY, CHFNOK, CHFPLN, CHFSGD, EURAUD, EURCAD, EURCHF, EURCZK, EURDKK, EURGBP, EURHKD, EURHUF, EURJPY, EURNOK, EURNZD, EURPLN, EURSEK, EURSGD, EURTRY, EURUSD, EURZAR, GBPAUD, GBPCAD, GBPCHF, GBPDKK, GBPHUF, GBPJPY, GBPNOK, GBPNZD, GBPPLN, GBPSEK, GBPSGD, GBPTRY, GBPUSD, HKDJPY, NOKJPY, NOKSEK, NZDCAD, NZDCHF, NZDDKK, NZDJPY, NZDSEK, NZDSGD, NZDUSD, SEKJPY, SGDHKD, SGDJPY, TRYJPY, USDCAD, USDCHF, USDCZK, USDDKK, USDHKD, USDHUF, USDJPY,



ECONOMIC EVENTS

May 31, 2009 - Jun 06, 2009

Displaying: All Currencies Impact: High, Medium, Low

31 SUNDAY | 01 MONDAY | 02 TUESDAY | 03 WEDNESDAY | 04 THURSDAY | 05 FRIDAY | 06 SATURDAY

18 of 18 events Print: PDF | Excel Impact: High Medium Low

GMT	currency	event	actual	forecast	previous
01:30	AUD	AiG Construction Index - May	46.9		36.5
07:15	CHF	Consumer Price Index (MoM) - May	0.20%	0.20%	0.90%
07:15	CHF	Consumer Price Index (YoY) - May	-1.00%	-0.90%	-0.30%
08:30	GBP	Producer Price Index Input n.s.a (MoM) - May	0.40%	0.80%	-1.00%
08:30	GBP	Producer Price Index Input n.s.a (YoY) - May	-9.40%	-8.30%	-5.00%
08:30	GBP	Producer Price Index Output n.s.a (MoM) - May	0.40%	0.40%	0.60%
08:30	GBP	Producer Price Index Output n.s.a (YoY) - May	-0.30%	-0.40%	1.20%
08:30	GBP	Producer Price Index Output Core n.s.a (MoM) - May	0.20%	0.20%	0.40%
08:30	GBP	Producer Price Index Output Core n.s.a (YoY) - May	1.20%	1.10%	2.40%
11:00	CAD	Unemployment Rate - May	8.40%	8.30%	8.00%
11:00	CAD	Net Change in Employment - May	-41.8K	-42.5K	35.9K
12:30	USD	Change in Non-farm Payrolls - May	-345K	-530K	-539K
12:30	USD	Unemployment Rate - May	9.40%	9.20%	8.90%
12:30	USD	Changes in Manufacturing Payrolls - May	-156K	-150K	-149K
12:30	USD	Average Hourly Earnings (MoM) - May	0.10%	0.20%	0.10%
12:30	USD	Average Hourly Earnings (YoY) - May	3.10%	3.00%	3.20%
12:30	USD	Average Weekly Hours - May	33.1	33.2	33.2
19:00	USD	Consumer Credit - Apr.	-15.7B	-$6.0B	-$11.1B

Figure 5.4: Calendar of news announcements affecting the foreign exchange market, www.fx360.com/calendar, 22nd June 2009.

USDMXN, USDNOK, USDPLN, USDSEK, USDSGD, USDTRY, USDZAR. Each order is decomposed into two transactions - opening and closing:

- Opening of a long position is considered as a BUY transaction;
- Closing of a long position is considered as a SELL transaction;
- Opening of a short position is considered as a SELL transaction;
- Closing of a short position is considered as a BUY transaction.

We additionally consider that the currency may be more volatile as the equity market trading session is opened and as news about the relative macro fundamentals are arriving. On the other hand, outside the trading session, as the number of transactions is usually lower, the price is more susceptible to change between transactions. Regional trading session is defined by the trading hours of the major regional equity exchange. We thus analyze the following situations:

- The regional session is active for any of two currencies of the currency pair,
- None of regional sessions corresponding to two exchanged currencies is active,

taking into account the regional sessions:

1. Japanese session (Tokyo Exchange): 9.00am till 3.00pm JST (GMT+9), for JPY, AUD, NZD, HKD, SGD;
2. European session (Frankfurt Exchange): 9.00am till 5.30pm CET (GMT + 1)/ CEST (GMT + 2), for EUR, CHF, GBP, DKK, NOK, SEK, PLN, HUF, CZK, TRY, ZAR;
3. American session (New York Stock Exchange): 9.00am till 4.00pm EST (GMT-5)/ EDT (GMT-4), for USD, CAD, MXN.

For each of seventy available currency pairs, we calculate the number of transactions for each quadrant as shown in the table 5.1.

After the analysis and in order to have meaningful comparison, only the those currency pairs were kept, for which there was in average at least one transaction per hour for the whole three months of analysis. This restriction was applied because if transactions are rare, it is not possible to know if the change is price is due to the liquidity of the market, i.e. new requests

	Regional session opened	Regional session closed
Execution at same price as previous trade		
Execution at different price from previous trade		

Table 5.1: Classification of counted transactions

modify demand and supply and thus move the price, or other reasons, e.g. macro information arriving in the meanwhile. The statistics is presented in the table 5.2.

Observing the results of calculations, we do not find any signs an increased percentage of trades executed at the same price as the previous one. The difference between the values calculated for periods when regional sessions are opened and when they are closed, differ very slightly. For some currency pairs, like AUDCAD, AUDNZD, EURJPY, USDCAD, the relationship even showed to be the inverse.

Analyzing time required to execute a trading transaction. The same transactions flow is analyzed under a magnifying glass, considering each transactions as a sequence of electronic information exchanges like

- Trader generated request for opening or closing a position,
- Initial analysis of this request by the server,
- Putting the request into the waiting line for processing,
- Dealer examining the request,
- Eventual requote (new proposed price) if the market price changed in the meanwhile,
- Eventual approval of the new price by the trader, depending on specification of the initial request,
- Order being processed - confirmed or deleted.

Only requests for immediate execution are considered. This means the analysis does not include changing parameters like Stop Loss, Take Profit,

Currency pair	Same price, session(s) opened, %	Same price, session(s) closed, %
AUDCAD	42.6%	46.9%
AUDJPY	39.6%	38.3%
AUDNZD	10.7%	21.4%
AUDUSD	37.5%	29.4%
CADCHF	69.9%	56.6%
CADJPY	37.5%	31.8%
CADSGD	69.2%	55.7%
CHFJPY	41.0%	42.0%
CHFSGD	62.5%	58.2%
EURAUD	15.6%	17.3%
EURCAD	75.7%	72.8%
EURCHF	44.3%	51.2%
EURGBP	57.6%	48.3%
EURJPY	31.5%	41.9%
EURNZD	33.3%	16.3%
EURTRY	10.6%	12.6%
EURUSD	40.6%	46.2%
GBPAUD	14.5%	12.7%
GBPCAD	61.0%	59.2%
GBPCHF	25.4%	38.1%
GBPJPY	22.2%	33.6%
GBPUSD	37.0%	35.9%
NZDCAD	1.0%	3.0%
NZDUSD	40.3%	25.9%
USDCAD	30.2%	33.6%
USDCHF	67.5%	51.5%
USDJPY	44.2%	51.8%
USDTRY	27.3%	23.7%

Table 5.2: Part of transactions executed at the same price as the previous trade depending if the regional sessions are opened for either of currencies

	Average time, s	Standard deviation
News time (major news)	3.24	4.76
News time (medium news)	3.21	4.65
Non news time	3.21	4.47

Table 5.3: Time required to complete a market transaction.

	Average time, s	Standard deviation
News time (major news)	4.62	8.35
News time (medium news)	4.60	8.10
Non news time	4.48	7.68

Table 5.4: Time required to complete a market transaction (manual order processing only).

placing and modifying pending orders. At every occurrence, we measure the total time elapsed between the moment the trader generates the initial request and the moment the position is placed on the market. We compare the average time required in two different periods of time:

- 3 minutes to prior and 10 minutes after major news announcements and announcements of medium importance, as classified and scheduled at www.dailyfx.com (state 28th June 2009).
- all the other trading time.

The results are shown in the Table 5.3.

It is a common practice that small orders are typically processed automatically, while important trades can be verified by a dealer before they are being approved. If we assume that trading system can automatically handle any volume the market generated at any conditions without changing the processing time, we narrow the analysis to positions processed after a dealer's approval. The results are presented in the Table 5.4.

The results above do not witness for any significant difference between the processing time. We attempt to make only the distinction between major

	Average time, s	Standard deviation
All transactions		
News time (major news)	3.23	4.69
Non news time	3.21	4.48
Manual processing only		
News time (major news)	4.71	8.32
Non news time	4.49	7.70

Table 5.5: Time required to complete a market transaction (important news only).

news and no news, as well as restrict the definition of news time to 1 minute prior and 5 minutes after the news announcement. The results are in the Table 5.5.

From the results above, we conclude that the orders processing time as a measure of forex market liquidity does not change in the period of news announcements.

5.4.3 Hot Potato Trading

Evans and Lyons (7) analyze the market liquidity using the orders flow. A particular attention is paid to the following aspects:

- News announcements about macro fundamentals, and
- "Hot potato" trading, when positions are passed many times between traders and dealers, for risk management purposes.

The term hot potato trading refers to the repeated transactions between dealers, depending on the volume of transactions they receive from their customers. Thus risk-averse dealers are attempting to pass their imbalances to other market participants.

Hot potato trading generates an increased number of transactions, i.e. a certain volume of demand and supply. On one side, the question is if these operations can bias the actual money demand. On the other hand however, repetitive transactions in both directions are susceptible to compensate themselves, thus having the resulting signed order flow to remain the same.

The model is described by two equations 5.1 and 5.2:

$$\triangle P_t = (\beta_1 + \beta_2 A_t)x_t - \beta_3 \triangle P_{t-1} + \eta_t^p, \tag{5.1}$$

$$\triangle x_t = \beta_4 x_{t-1} + \beta_5 \triangle P_{t-1} + \eta_t^x, \tag{5.2}$$

where

- $\triangle P_t$ is the price change in the moment t
- x_t is the order flow in the moment t
- $\eta_t^p = \beta_6 \triangle R_t$
- $\eta_t^x = (\beta_7 + \beta_8 A_t)x_t^{AGG}$
- $\beta_i > 0$, $i = 1...8$
- $\triangle R_t$ is the payoff increment in the moment t
- x_t^{AGG} is aggregated order flow in the moment t
- A_t indicates a proximity of news announcements

Thus, in the first equation the price innovation is dependent on the order flow due to news release (first term) and the previous price change (second term). The residual term captures macro information non encompassed by two first terms. The hot potato trading are captured by first two terms of the second equation - the current order flow is a function of the previous order flow and the previous price change. The residual term reflects non measured order flow impact.

The non parametric kernel regression is possible only on large samples of data. Evans and Lyons (7) found evidence of a clear impact of news announcements on market liquidity, as well as some evidence of potato trading using hourly data.

5.4.4 Evidence of Hot Potato Trading

To test for presence of hot potato trading activity, we are going to estimate the model 5.1 and 5.2 using minute by minute data on the major currency pairs. In a signed order flow, buyer and seller initialed transactions will compensate each other. To avoid this, instead of the signed order flow used in all other models, we use the unsigned order flow in this test. We introduce

Currency pair	β_2 (p-value)	R^2
EURUSD	0.0 (0.122)	13.53%
USDCHF	0.0 (0.002)	10.26%
GBPUSD	0.0 (0.137)	18.34%
USDJPY	0.0 (0.729)	11.02%
USDCAD	0.0 (0.358)	10.83%
AUDUSD	0.0 (0.201)	14.53%
NZDUSD	0.0 (0.546)	9.35%

Table 5.6: A_t, p-value and R^2 of the estimated hot potato trading model, minute data.

a dummy variable A_t which takes the value of 1 one minute prior and ten minute after major and medium news announcements, 0 otherwise. The β_2, its p-value and R^2 of the model are presented in the table 5.6.

All the coefficients differentiating between news announcements time, i.e. expected time of hot potato trading, and all the other time, are at zero. We thus find no evidence of hot potato trading on the foreign exchange market. This confirms the opinion that the forex market is extremely liquid, as impacts are stronger on less liquid markets and vice versa.

5.5 Influencing Market Liquidity

Market liquidity is generally perceived as a desirable market characteristic, as it decreases transaction costs and establishes market prices more accurately. One may ask if it is possible to improve it. The answer to this question is rather positive, to a certain extend. The simplest approaches to market liquidity enhancements are the following:

1. Regulatory: by canceling regulatory restrictions and providing favorable trading regulations, e.g. decreasing government imposed costs.

2. Commercially: by establishing brokerage and market making companies who are ready, against a remuneration, become a counter-party for traders' foreign exchange operations - usually any time, for any currency pairs and at any extend (6).

3. Technologically: with the development of new technologies, world foreign exchange market consolidates geographically and in time, transmits information to provide better price transparency and aggregates

the global transaction flow facilitating the search for counter-party for transactions.

However, each change is related to costs, which should not exceed the potential benefits of the chosen improvement measure.

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Chapter 6

Volatility, Risk and Risk Premia

Market volatility is a characteristic that describes how often and how much the market, in particular the price, changes. Market volatility is perceived differently by different market participants. Long term investors usually prefer low volatility markets and expect risk premium for accepting risky positions. Active speculative traders usually, in the opposite, favor highly volatile markets, as they get the bulk of their profits from short term variations in price, even if these variations are not supported by a long term trend.

Traders are generally assumed to be risk averse, and require risk premium for accepting to invest in risk assets. However, this theory applies to buy and hold investing, usually on the equity market. In practice, the answer about the risk premium varies heavily depending on the trading approach used. To determine the risk and the respective risk premia expected by investors, one should know how risky the intended trading strategy is. Additionally, Smith and Wickens and Smith (16) showed that the risk attitude is different for home investors, i.e. those for whom one of the currencies of the currency pair is their national currency, and the foreign investors, representing the rest of the world.

6.1 Measures of Volatility and Risk

Volatility is traditionally measured using basic statistical tools, like variance and standard deviation, which do not need to be commented. According to Mandelbrot ((11), p. 48) this measure only reflects one part of the real market risk, "benign risk". The remaining "wild risk" is often neglected by researches, unless they use stable Pareto distributions.

Active traders and speculators value another type of volatility: even if the price in the end of the day stays the same and varies within a narrow band of values, the frequency at which it bounces between its ups and downs defines their profit, as they exactly work on these short term variations. An appropriate measure of such kind of volatility would be the number of price ticks arriving per unit of time.

6.1.1 Value-at-Risk

Value-at-Risk, or VaR, at the $100(1-\alpha)\%$ confidence level is generally defined by the upper 100α percentile of the loss distribution and is denoted as $VaR_\alpha(Z)$, where Z is the random variable of loss.

In the case of the foreign exchange market, there is no proper term of loss, as we are speaking about exchange rates rather then prices of an asset. It if however possible to adapt the definition of VaR to the forex market if we regard an exchange rate of the currency pair as the price of an asset. By evaluating VaR for it, we get the value of the exchange rate which will not be reached will $(1-\alpha)\%$ of certainty, and thus the limit of trader's potential loss. One can be looking for the VaR value both sides of the current price - the value of interest is determined by the way the currency pair is defined (e.g. EURUSD or USDEUR) and the position, long or short, taken by a trader on this currency pair.

Yamai and Yoshiba (17) test the VaR evaluation of risk for non-smooth equity market conditions. They particularly find that VaR fails to take into account fat tail properties of asset returns. Instead, authors introduce a so called *Distribution of exceedances* $m_\theta(Z) = \max(Z, \theta)$, denoted by $F_m(x)$. Z is being larger than θ with *tail probability* $p = 1 - F(\theta)$. The distribution

$$F_m(x) = 1 - p(1 + \xi \cdot \frac{x-\theta}{\sigma})^{-1/\xi}, x \geq \theta. \tag{6.1}$$

is defined by three parameters:

- tail index ξ,
- scale parameter σ, and
- tail probability p.

Under this distribution, VaR is calculated as

$$VaR_\alpha(Z) \approx \theta + \frac{\sigma}{\xi}((\frac{p}{\alpha})^\xi - 1) \tag{6.2}$$

6.1.2 Expected Shortfall, or Expected Tail Loss

The VaR is a rather simplistic measure that only gives the level of loss. However, the investor does not know anything from VaR about the potential loss beyond this limit. An investment with VaR of 10 000 USD is not necessarily less risky than that with the VaR at 20 000 USD, if its potential maximum loss is 100 000 USD vs. 50 000 USD of the second asset. This type of risk if often referred as tail risk.

An extension of the VaR definition is the Expected Shortfall measure, otherwise called Expected Tail Loss. While using this measure, one assumes the loss is already beyond the VaR level. The Expected Shortfall measures the expected loss under these conditions, i.e. is the conditional expectation of loss, when the loss exceeds the VaR level ((2), (3)). In other words, it calculates how severe the average loss is, if VaR exceeded (12):

$$ETL_{a100\%}(r) = E(l|l > VaR_{(1-a)100\%}(r)), \tag{6.3}$$

where

- r is the return given over time horizon,
- $l = -r$ is the loss.

$ETL_{a100\%}(r)$ is also denoted $CVaR_{(1-a)100\%}(r)$ meaning conditional VaR.

6.1.3 Ratios

Three ratios are commonly used to evaluate the risk of an investment:

1. Sharpe Ratio (15) is a measure of risk-adjusted performance of an investment asset or a trading strategy. It is defined as:

$$S = \frac{E[R - R_f]}{\sigma}, \tag{6.4}$$

   The major shortcoming of this ratio is the underlying assumption of a normal distribution of residuals.

2. Stable-Tail Adjusted Return Ratio (STARR) (12) is the ratio between expected return and its conditional value at risk:

$$\rho(r) = \frac{E(r - r_f)}{CVaR_{(1-a)100\%}(r - r_f)} := STARR_{(1-a)100\%} \tag{6.5}$$

3. Rachev ratio (R-ratio) (13) with parameters α and β is defined as:

$$\rho(r) = \frac{ETL_{\alpha 100\%(r_f - r)}}{ETL_{\beta 100\%}(r - r_f)} := R - ratio(\alpha, \beta), \tag{6.6}$$

where α and β are in $[0, 1]$. The idea of this ratio is to maximize the level of return and get insurance for the maximum loss. It thus, out of three presented ratios, provides the most flexibility in terms of underlying distribution and desired levels of confidence,

For both STARR and R-ratio, a lower absolute value negative result indicates a higher risk. We calculated the values of VaR and ETL (10%) on minute and daily data for the period from 1st March 2009 till 31st May 2009. ETL was calculated based on the assumption that the errors follow an α-stable distribution. As a result, more than a half of currency pairs showed that the risk increases with the frequency of the data, i.e. the minute data was more risky than the hourly data.

As can be observed in the table, the risk increases as one uses higher frequency data. This is an important remark, because it shows that the foreign exchange market does not display fractal properties as suggested by Mandelbrot (11), even if the charts are visually very similar. Low frequency daily data and high frequency minute data on the same underlying currency pair do not have the same properties. The practical conclusion is however as expected: the trading on high frequency data is more risky than using longer term information.

6.2 Multivariate Measures of Volatility

A fluctuation in the exchange rate of a particular currency pair does not necessarily reflect a change in economic conditions of one of countries involved. Due to interconnection of world currencies, important change in one currency pair can even influence exchange rates of currency pair which do not involve the given currency. This is particularly true for major currencies like USD, GBP, EUR. Thus changes in exchange rates should be examined simultaneously.

The co-movement of exchange rates can be studied by comparing the sequence of exchange rate quadratic variations (4). Let X_t be exchange rate in the moment t, $t \in [0, T]$. Let $\triangle$ be a partition of the interval $[0, T]$ such that $\triangle = \{0 = t_0 < t_1 < ... < t_n = T\}$. Let $\{\triangle_n\}$ is a sequence of whose maximum interval tends to 0 as $n \to \infty$. Then

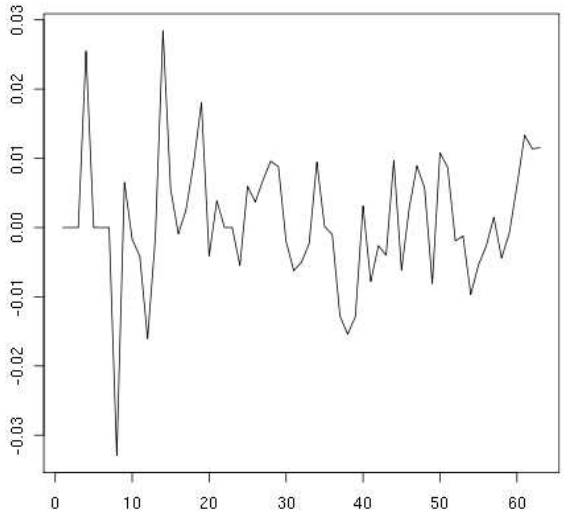

Figure 6.1: Daily returns, NZDSEK.

$$< X_t > \equiv plim\{< X >_t^{\triangle_n}\}, \tag{6.7}$$

where

$$\{< X >_t^{\triangle_n}\} = \sum_{k=0}^{t-1} (X_{t_{k+1}} - X_{t_k})^2, \tag{6.8}$$

is the quadratic variation. The figures 6.1 to 6.4 shows several examples of daily returns calculated over three months from 1st March 2009 till 31st May 2009, for NZDSEK, USDSGD, USDHKD and EURCHF.

It can be observed that:

- The lines are not smooth, meaning that periods of high risk alternate randomly with periods of low risk;
- High risk periods are generally shorter than low risk periods, and tend to cluster together;
- Periods of high risk on different currency pairs are close or even coincide, which witnesses for co-movements in the exchange rates.

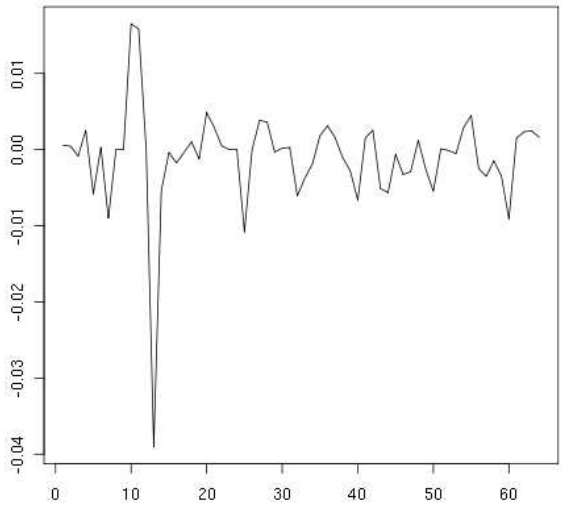

Figure 6.2: Daily returns, USDSGD.

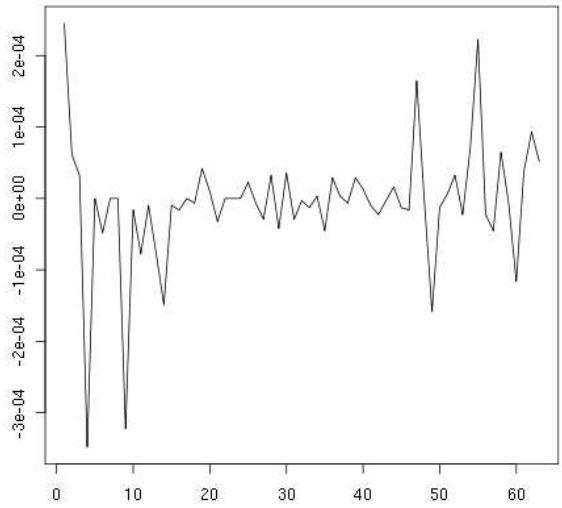

Figure 6.3: Daily returns, USDHKD.

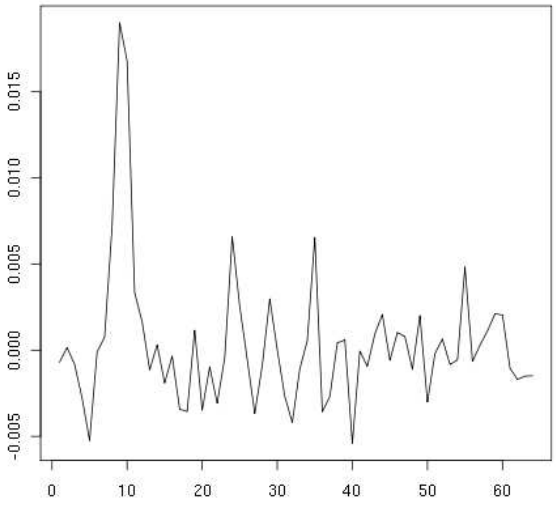

Figure 6.4: Daily returns, EURCHF.

6.2.1 Global Hazard Indicator

Brousseau and Scacciavillani (4) proposed an alternative Global Hazard Indicator (GHI) as a forward looking market indicator attempting to take into account not only the risk related to values of two particular currencies, but also of any other currency susceptible to move an exchange rate. To derive the formula, authors use geometrical approach, where bilateral variances are measured by the length of the vector between two currencies on the circle.

The GHI derives the expected bilateral volatility $\sigma_{M1,M2}$ between currencies $M1$ and $M2$ from the prices of the forex options and is generalized for joint indication of volatility of three currencies as follows:

$$GHI = \frac{2\sigma_{USD,M}\sigma_{USD,JPY}\sigma_{M,JPY}}{\frac{\sqrt{(\sigma_{USD,M}+\sigma_{USD,JPY}+\sigma_{M,JPY})(-\sigma_{USD,M}+\sigma_{USD,JPY}+\sigma_{M,JPY})}}{(\sigma_{USD,M}-\sigma_{USD,JPY}+\sigma_{M,JPY})(\sigma_{USD,M}+\sigma_{USD,JPY}-\sigma_{M,JPY})}} \tag{6.9}$$

GHI is definitely interesting in terms that it attempts not only to take into account past data, but also the market's expectations of the future movements through forex options. However, due to market efficiency considerations discussed in the chapter 4, this measure should be regarded only as

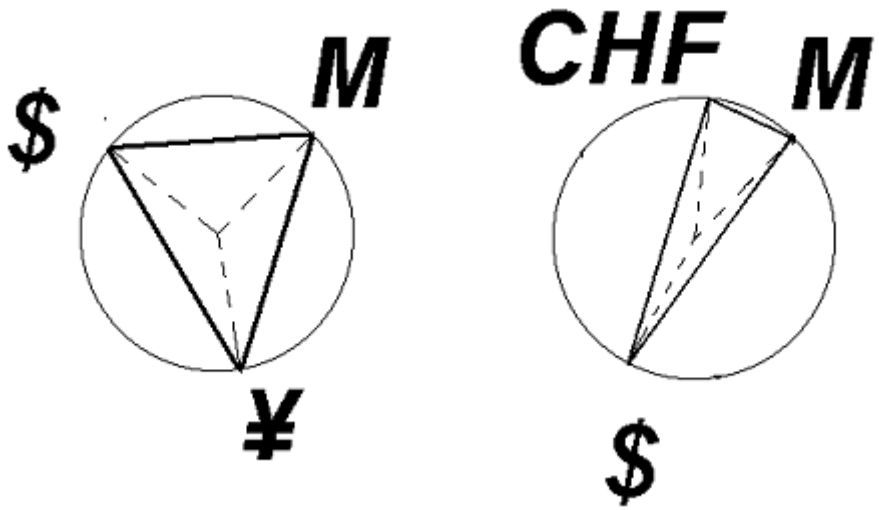

Figure 6.5: Graphical derivation of the Global Hazard Indicator. Source: (4).

an indication rather than a true predictor of the market volatility.

6.2.2 Generalization of Value-at-Risk and Expected Tail Loss

In the generalization of Value-at-Risk calculations for multivariate case, marginal distributions of asset returns are to be used. We study here the bivariate case only.

The dependence structure between two variables can be described using copulas. A joint distribution $F(x_1, x_2) = P[Z_1 \leq x_1, Z_2 \leq x_2]$ describes dependence and marginal behavior of (Z_1, Z_2). The purpose and the advantage of copula is the separation of this function into the part that describes dependence and the part that describes marginal behavior.

Thus, the joint distribution function C of the standard uniform random variable $(F_1(Z_1), F_2(Z_2))$ is the copula of the random vector (Z_1, Z_2). In general, the distribution function C follows standard uniform distribution $C(u_1, u_2) = Pr[U_1 \leq u_1, U_2 \leq u_2]$. Copulas are invariant for continuous increasing transformation of the marginal distributions.

6.3 Glosten-Milgrom-Harris Model for Time-Varying Volatility

On the equity market, volatility is known to follow an U-shape (9), as the intensity and the volume of trades are higher towards the beginning and the end of the trading day. On the 24-hour forex market however there is no formal trading day, but rather regional sessions that correspond to the trading day on the equity market of the respective region: Japanese, European and American.

Each currency pair involves two currencies, and thus at least two countries whose economy influence the exchange rate. Whenever new information about any of countries arrives, the exchange rate moves. As analogy with equity markets, we suppose that the volatility will be different in the following periods:

- In the beginning and in the end of a trading session in the region of one of currencies.
- As trading session in the region of at least one currency is active
- Tradition session in the region on both are currently closed.

According to the Glosten-Milgrom-Harris model (7), changes in observed transaction prices have permanent part π, affecting future trades, and temporary component τ which reflects the influence on the current trade only. The size of effects equals q, Q_t indicated whether the trader takes a long or a short position. The exogenous term ε_t is the non explained part of the price variation. The model is expressed by the following equation:

$$\triangle p_t = \pi(q_t)Q_t + \tau(q_t)\triangle_t + \varepsilon_t. \tag{6.10}$$

Lyden (9) find evidence of the temporary impact is higher during the first half-hour of trading day

We modify the initial equation of the model. Instead of the price change, we evaluate the number of ticks per unit of time T_t as a measure of price volatility. As an indicator of specific period of time, we introduce the variable S_t having the value of

$$S_t = \begin{cases} 0, \text{ if no session is active,} \\ 2, \text{ if beginning or end of any regional trading session,} \\ 1 \text{ otherwise} \end{cases} \tag{6.11}$$

Currency pair	τ	p-value
EURUSD	4.41	0.00
USDCHF	4.18	0.00
GBPUSD	5.71	0.00
USDJPY	0.63	0.14
USDCAD	1.63	0.00
AUDUSD	0.15	0.55
NZDUSD	0.15	0.32

Table 6.1: τ and p-value for the Glosten-Milgrom-Harris model.

We thus estimate the equation:

$$T_t = \pi(q_t) + \tau(q_t)S_t + \varepsilon_t, \tag{6.12}$$

where $\pi(q_t)$ and $\tau(q_t)$ are assumed to be constants.

If $\tau(q_t)$ is found to be significant, we cannot reject the hypothesis that the volatility is independent from the trading period of the day.

6.4 Evidence of Glosten-Milgrom-Harris Model

The model 6.12 is estimated on the minute data on the seventy currency pairs. The estimated values of the coefficient τ along with its p-value for major currency pairs are presented in the table 6.1. The result for cross and exotic currency pairs are of the same order.

For four currency pairs out of seven, there is non negligible evidence of an increased volatility during the first and the last 30 minutes of either regional equity trading session.

6.5 Excess Volatility Puzzle

Several studies (5) have shown that exchange rate are not explained by macro fundamentals. In particular they are excessively volatile relative to what is predicted by macro based models. Microstructure approaches, as opposed to macro fundamental approach, are not studying the content of the market information, but rather the types of information and the way how it becomes incorporated in the market price. In particular, this approach assumes that

not only exchange rates themselves, but also their changes, i.e. volatility, is not explained by macro fundamentals.

The volatility of exchange rates widely depends on the exchange rate regime. Fixed exchange rate are generally less volatile than flexible exchange rates. The Evans-Lyons (10) micro based model describes the volatility through the change of the price between the periods $t-1$ and t:

$$\triangle P_t = \lambda_1 \triangle R_t + \lambda_2 X_t, \tag{6.13}$$

where

- $\triangle X_t$ change in the order flow between $t-1$ and t,
- $\triangle R_t$ is the nominal interest rate differential, $\triangle R_t = \triangle(i_t - i_t^*)$, where i_t and i_t^2 are respectively nominal interest rates of the first and the second currency in the currency pair,
- λ_1 and λ_2 are positive constants.

6.6 Risk Premia

The "buy and hold" strategy on the equity market is equivalent to investing in one, usually domestic, currency under a given interest rate. A prudent investor however, will easily find investments generating higher profits. Let us look for example at the interest rates proposed on savings accounts and term deposits in EUR in June 2009. Deutsche Bank at this point offered the interest rates on savings accounts up to 3% per annum (Figure 6.6). It may look like a decent rate until someone finds for example the offer from the PrivatBank in Ukraine, also for deposits in EUR (Figure 6.7).

If you keep in mind that private loans in the same Deutsche Bank can be taken under an interest rate as low as 3.99% per annum (Figure 6.8), one might think we are in presence of an arbitrage situation - one can borrow virtually any amount of money in the Deutsche bank under 3.99% and put them on the term deposit in the Privatbank for 1 year under 12%. The Return on Investment is thus ∞ as no investor's money are in the game. The question is then why people are still keeping any of their money in the Deutsche Bank? The main reason for that is the risk. No bank is obviously is fail proof, but the probability that the Deutsche Bank goes bankrupt is the way lower than the probability that Privatbank stops its payments. The potential gain an investor gets corresponds to the risk premium of 8.01% involved in such an operation.

Figure 6.6: Interest rates on savings accounts in EUR in the Deutsche Bank, Germany. Source: www.deutsche-bank.com, 25th June 2009.

Rates for June 10, 2009

Deposit	Term of deposit,month	Basic per cent per annum, %	Bonus for activating agreement by phone when draw up, per cent per annum, %	Bonus for prolong deposit agreement for a new term, per cent per annum, %
Urgent deposits with payment of interest in the end of deposit term				
Standard	1	11,0	0,50 % per annum	1,00% plus basic
	3	10,25	0,25 % per annum	1,00% plus basic
	6	11,75	0,25 % per annum	0,75% plus basic
	9	11,70	0,30 % per annum	0,80% plus basic
	12	12,00	0,50 % per annum	1,00% plus basic
	24	12,50	0,50 % per annum	1,00% plus basic
	36	13,00	0,50 % per annum	1,00% plus basic
Multycurrency	12	12,00	0,50 % per annum	no

Figure 6.7: Interest rates on savings accounts in EUR in the Privatbank, Ukraine. Source: www.privatbank.ua, 25th June 2009.

Figure 6.8: Interest rates on private loans in EUR in the Deutsche Bank, Germany. Source: www.deutsche-bank.com, 25th June 2009.

Several models for assessing risk premia are presented in the Part IV of the book for specific forex models.

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Chapter 7

Trading Costs

Trading on financial markets is related to direct and indirect costs. Some of the costs naturally appear from technical needs, others are imposed by financial intermediaries.

7.1 Direct Costs

The direct costs are the costs related to operations on the market, often depending on the number and the volume of operations.

Spread is the most usual trading cost. It represents the difference between the Bid and Ask price, i.e. the prices at which an asset can be sold or bought. It is measured in basic points. On the forex market it usually starts at 1-3 points for majors and can exceed 100 points for exotic currency pairs and for the period of news announcements.

The basic points for spreads are calculated relative to the contract size, also for the leverages traders. For example, if the leverage is 100:1, a trader needs to have 1000 EUR to buy or sell 1 lot of EURUSD currency pair, i.e. buy or sell 100 000 EUR against USD. In this case, if the spread is 2 points, in the moment of the trade execution the trader pays 20 USD spread, that correspond to the price difference of the full standard lot priced at the bid and the ask prices. The leverage plays no role in this calculation.

Commissions are sometimes charged in addition or alternative to spreads. Commission can be operation related (fixed per operation) or volume related (fixed per lot). Commissions are usually calculated as a fixed amount in a predefined currency.

Swaps reflect a positive or negative amount applied to the floating profit or loss of a position for each trade kept overnight, every trading night. They are a part of charges because the negative swap rates charged by brokers are

always higher than the positive swaps credited. Swaps are usually expressed in per cents. The corresponding charge is calculated as

$$\begin{aligned} \text{swap rate (short \% or long \\%)} &\times \text{pip value} \\ &\times \text{number of lots} \\ &\times \text{number of days} \end{aligned} \tag{7.1}$$

An alternative to swap is reopening the positions. That means that the trading server automatically closes positions in the last moment of the day, and reopens it immediately after the new day begins, usually at the same price. As there is no position opened at the end of the day, swaps are not charged, but traders pay spread for opening a new position.

Another alternative to swaps are commissions. In the case of a so called *Islamic Accounts* no swaps are charged, whatever is the period for which a position is opened. In return, a fixed additional commission per lot is charged when a position is opened.

The origin and the name of such accounts come from Islam. Coran forbids moslems receiving or paying any interests. To meet religious restrictions, banks and brokers replaced swaps by commissions. In the present days and in practice, no one needs to prove being moslem to open an islamic trading account. But in any case, the purpose of such accounts is not speculative, and in the case of abuse, the due swaps and eventual penalties are charged.

7.2 Indirect Costs

Indirect costs are all the costs that are not direct costs, but are still related to the trading activity. These costs are more numerous than the direct costs and are often hidden.

The costs of **entering and exiting the market** are reflected by opening a brokerage account, funding it or withdrawing funds from it. Most of the brokers usually open and close account for free, but put all the charge of the incoming and outgoing payments on the client. Some trading accounts are subject to a periodical fixed or asset depending fee.

Opportunity costs are related to possible alternative not performed investments. Thus, money involved in a trading account cannot be used elsewhere and usually do not generate interests.

A related question is the minimum deposit. Most of the brokers fix a minimum amount which with they can accept opening an account. This amount can vary from 100 to 1 000 000 USD depending on the broker's

TD Waterhouse Annual Interest Rates		
	$CDN	$US
Margin Debit Balances		
Direct Trading All Balances	7.00%	8.25%
President's Account		
$0 - $24,999	6.75%	8.25%
$25,000 - $99,999	6.75%	8.00%
$100,000+	6.00%	7.75%

Figure 7.1: Example of debit interest rates for trading accounts. Source: TD Waterhouse, 18th January 2008.

target audience. This requirement does not depend on the volume of trades the client is going to make. For example, if a client deposits 1 000 000 USD, but trades only using 200 000 USD, his opportunity costs are the return of a possible investment of these 800 000 USD or at least the risk free interest rate on this amount.

Interest rates are charged for the borrowed funds. The leverage on the forex market is usually offered for free whatever is the period for which a position is opened. But for example, in the case of the so called margin account, i.e. leverage accounts for securities, mutual funds and options, an important interest rate is charged on the borrowed amount, whatever is the performance of trades. The illustration below is an example.

Market imperfection, such as lack of **liquidity**, imply delays in order execution and unavailability of the requested price, if a counter party cannot be quickly found. Similar situations are frequent, for example, on the news announcement.

Technical equipment, software and information may become a considerable part of trader's expenses. Intraday trading requires quick and precise calculations any time of the day and in any market conditions. The technical requirements for such market analysis require powerful computers and a reliable internet connection, trading software tools and a good quality quotes and news feed. The hardware and connectivity are paid, with almost no exceptions, by the traders. Brokers often provide their own trading platforms and data feeds for their clients for free. However, many experienced traders prefer having another or additional price feed, analytical software and research analysis subscription. All these services usually cost money.

Sub-intermediaries, i.e. intermediaries between a brokerage company and

the client charge their **agent's fee**. There are two main types of intermediaries:

- Introducing Brokers, whose activity is limited to introducing clients to a brokerage company, and sometimes some basic trading training or advices, and
- Asset Managers, who manage client's funds.

The intermediary's fee can be expressed in an increased spread, usually at 1-2 points, or fixed commission per trade or per lot. Asset Managers can also charge a performance based fee. Combinations of different fee types are possible. Fees are most of the time paid by the client, except cases when a broker remunerates his partners in function of the trading volume of attracted clients.

7.3 Trends in Costs Policies

Trading costs are currently diminishing due to competition and technology development. If, for example, several years ago the EURUSD bid-ask spread of 3-5 point was exceptionally low, now it is not uncommon to have it at 1 point or even less. The fraction of the basic point, i.e. the fifth digit, already plays an important role to get a competitive advantage for brokers.

7.4 Influence of Costs on Trades

Passive asset managing **strategy** is defined as Buy-and-Hold strategy, i.e. according to a decision made once, the assets bought or sold are kept so for a long period. **Active strategy** means constant improving of the asset allocation according to the latest available information on the market. Each re-balancing operation is related to trading costs. The question that arises here is weather the additional return after re-balancing covers the re-balancing costs. Or, alternatively, can an actively managed portfolio perform better than a passively held portfolio, if the trading costs are taken into account.

The answer of this question surely depends on the style of the active portfolio management. Additional return may only cover additional trading costs, while in some cases positive excessive income can be generated by an active management.

Part III

Market Analysis Used in Practice

Chapter 8

Technical analysis

Technical analysis is the study of market action, primarily through the use of charts, for the purpose of forecasting future price trends (Murphy, 1986). The main data used by the technical analysis is the present price, and the main assumption is that the actual price fully reflect all the available information. While technical analysts use various tools, the study of price charts is primary. For this reason the technical analysts are sometimes called chartists.

Browning (1) gives examples that different technical specialists can make opposite forecasts regarding the same market situation. In spite of the argued nature of the technical analysis approach, it is widely used by traders on financial markets.

This chapter overviews some methods of technical analysis and discusses their effectiveness for price forecast on the foreign exchange market.

8.1 Terminology

8.1.1 Charting basics

The charts are graphical representation of past exchange rate onto two-dimensional system: prices and time. The charting system can be included in the trading platform or to be a separate software.

Time frames. Almost all the graphs represent prices at regular intervals of time. For example, the 1-hour graph will take one exchange rate value per hour, usually the close price, and will represent it on the graph. Usually the following time frames are used: 1-minute (M1), 5-minute (M5), 15-minute (M15), 30-minute (M30), 1-hour (H1), 4-hour (H4), 1-day (D1), 1-week (W1) and 1-month (MN). Some traders can surely use custom time frames for their

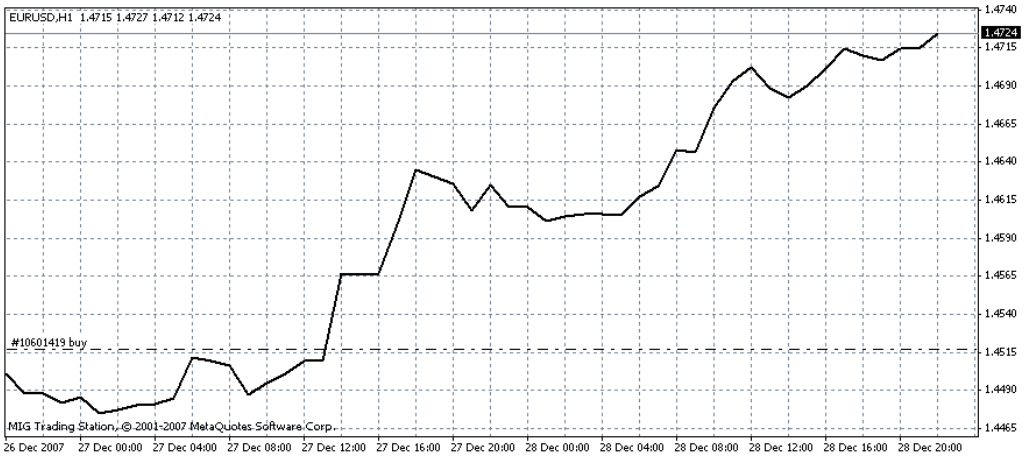


Figure 8.1: Line chart.

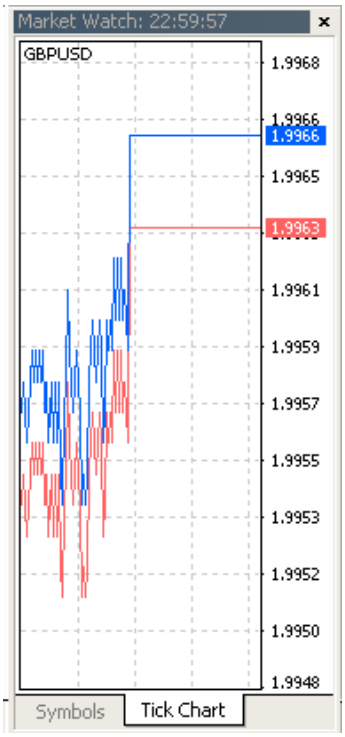
Figure 8.2: Bars.

technical analysis and graphical representation.

Types of charts. There are three regular types of graphs: *Line chart*, *Bars* and *Candlesticks*. With the line graphs, one can better visualize trends. But bars and candlesticks contain more information, namely the open, highest, lowest and close price for each period of time. For this reason, these graphs are usually preferred for charts analysis. The candlesticks are sometimes called Japanese candles.

Figure 8.3: Candlesticks.

The last type of graphs is a *Tick Chart*. It has no time frame, and record every price tick, i.e. consequently each price becoming available on the market. This type of chart is rarely used for the technical analysis, but most for choosing the exact moment for placing a position.



Bulls and Bears. The upwards trend on the market is called *Bullish*, and the downwards trend is respectively *Bearish*. Bullish market means that the number of buyers (Bulls) is higher than the number of sellers (Bears). In the opposite case, the market is called Bearish. A short term trend against the main trend of the market is called *Correction*.

Support and Resistance. Support and Resistance levels are the levels, at which the Technical Analysts believe the actual exchange rate trend will stop and reverse. The Support level is the lower level, to which the price is expected to go down, and then bounce up. However, if the price crosses the resistance level, it is believed to continue dropping down. The Resistance is the opposite to Support level, it is a ceiling for the price variations. It is considered that the price will either go up to it and then drop down, or, if

Figure 8.4: Support and Resistance levels.

the price crosses the resistance level, it will continue rising. If a Support or a Resistance level is touched by the price that went then into an opposite direction, one says that the level was "tested".

Pivot Points. Pivot Points are defined a the level at which the market changes direction for some, short to mid-term, period. In other words, Pivot Points is an attempt to predict Support and Resistance levels. They are simply calculated based on the current Open, High, Low and Close prices, from which 17 different values are derived 8.1.

$$
\begin{aligned}
R_4 &= PP + (High - Low) * 3 \\
Mid - point(R_4) &= \frac{R_4 + R_3}{2} \\
R_3 &= High + (PP - Low) * 2 \\
Mid - point(R_3) &= \frac{R_3 + R_2}{2} \\
R_2 &= PP + (High - Low) \\
Mid - point(R_2) &= \frac{R_2 + R_1}{2} \\
R_1 &= 2 * PP - Low \\
Mid - point(R_1) &= \frac{R_1 + PP}{2} \\
PP &= \frac{Open + High + Low + Close}{4} \\
Mid - point(S_1) &= \frac{PP + S_1}{2} \\
S_1 &= 2 * PP - High \\
Mid - point(S_2) &= \frac{S_1 + S_2}{2} \\
S_2 &= PP - (High - Low) \\
Mid - point(S_3) &= \frac{S_2 + S_3}{2} \\
S_3 &= Low - (High - PP) * 2 \\
Mid - point(S_4) &= \frac{S_3 + S_4}{2} \\
S_4 &= PP - (High - Low) * 3
\end{aligned}
\tag{8.1}
$$

If a currency pair exchange rate is above the PP, it is considered to be overbought, otherwise - oversold. The Figure 8.1 shows an example of pivot points on GBPUSD.

8.1.2 Indicators

A common tool for charts analysis are indicators. Here the most frequent are described.

Moving Average. The indicator shows at each period of time the simple or exponential average of the last several quotes. The formula

$$MA_t = \frac{\sum_{i=0}^{n-1} P_{t-i}}{n}, \tag{8.2}$$

Figure 8.5: Pivot Points on GBPUSD. Source: www.investopedia.com, 29th July 2009.

Figure 8.6: Moving average indicator ($n = 7$).

Figure 8.7: MACD indicator with periods $(12, 26)$.

where P_{t-i} is the exchange rate value at the moment $t - i$ can be applied open, close, highest, lowest, average, medium or any other price of any regular time period.

MACD. The Moving Average Convergence/Divergence indicator shows the difference between fast and slow exponential moving averages of closing prices. It was developed in 1960s by Gerald Appel, and was widely used in 1980s. But 1990s and 2000s, it proved to be highly unreliable.

Bollinger Bands. Bollinger Bands were invented by John Bollinger in the 1980s. This indicator is used to measure highness or lowness of the price relative to previous trades. The Bollinger Bands are plotted a certain number of standard deviations away from the actual price. When the markets become

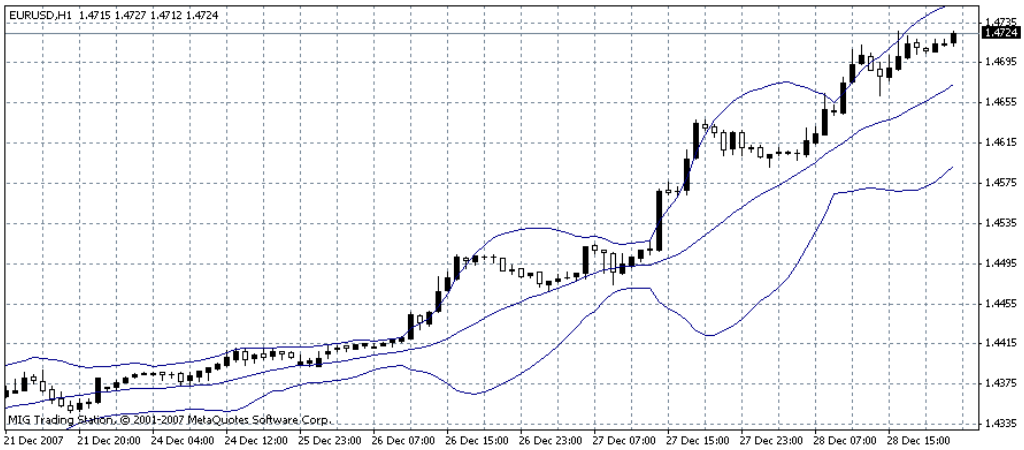


Figure 8.8: Bollinger Bands indicator with the period 20 and 2 deviations distance from the current price.

more volatile, the bands widen and they contract during less volatile periods.

Commodity Channel Index. The Commodity Channel Index (CCI) was originally introduced by Donald Lambert in October 1980, published in Commodities magazine. The typical formula for the CCI index is

$$CCI = \frac{1}{0,015} \frac{P_t - SMA(P_t)}{\sigma(P_t)} \tag{8.3}$$

The Commodity Channel Index is often used to detect if a currency is overbought/oversold indicator. The CCI typically oscillates above and below a zero line. The values below -100 mean the instrument is overbought, and the values above +100 indicate that a currency pair is oversold on the market.

Momentum. The Momentum indicator indicates the difference the between today's closing price and the close N days ago. It are calculated as

$$Momentum = P_t - P_{t-N}. \tag{8.4}$$

The Momentum generally shows if the instrument continues the trend. Crossing zero upwards can be used as the signal to buy. The opposite is valid for selling.

Parabolic SAR. The Parabolic SAR (Stop and Reverse) was developed by J. Welles Wilder, Jr, to detect trends. When a price goes up, the Parabolic SAR appears below the price and converges upwards towards it. On a downtrend, the indicators is shown above the market price and converges downwards. The general formula of the indicator is:

$$SAR_{t+1} = SAR_t + \alpha(EP - SAR_t), \tag{8.5}$$

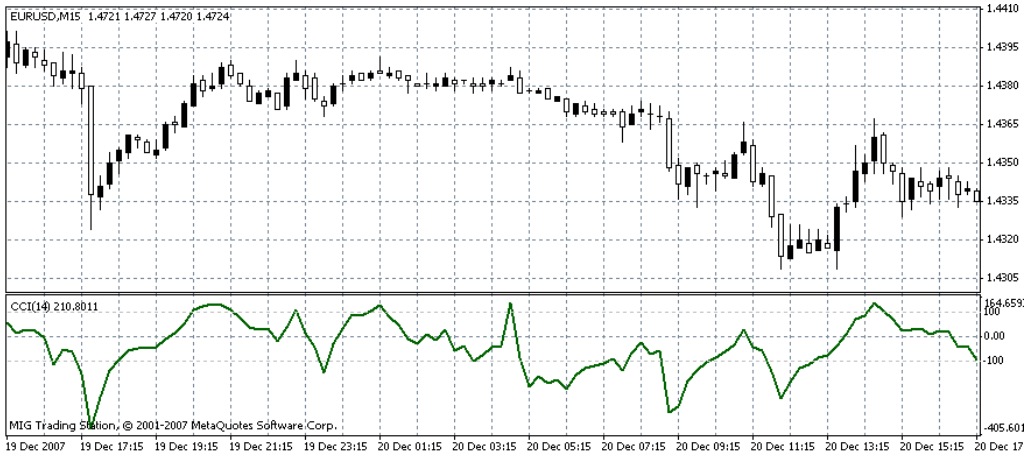


Figure 8.9: Commodity Channel Index with the period 14.

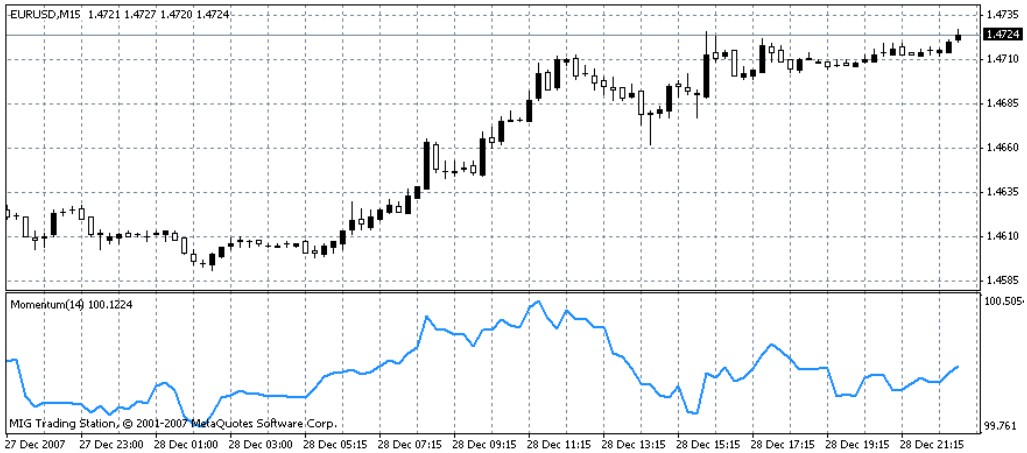


Figure 8.10: Momentum indicator with the period 14.

Figure 8.11: Parabolic SAR indicator.

where EP is the extreme point of the trend.

Relative Strength Index. The Relative Strength Index (RSI) was first developed by J. Welles Wilder June 1978, and published in Commodities magazine. To calculate RSI, for each day, the values of U and D are calculated:

$$U = \begin{cases} P_t - P_{t-1}, \text{ if } P_t > P_{t-1} \\ 0, \text{ otherwise} \end{cases} \tag{8.6}$$

and

$$D = \begin{cases} P_{t-1} - P_t, \text{ if } P_{t-1} > P_t \\ 0, \text{ otherwise} \end{cases}, \tag{8.7}$$

where P_t is the close price.

$$RS = \frac{EMA(U,n)}{EMA(D,n)}, \tag{8.8}$$

where n is a period over which the Exponential Moving Average is calculated. And finally,

$$RSI = 100 - 100 \times \frac{1}{1+RS}. \tag{8.9}$$

The currency is considered to be oversold if the RSI is below the 20 line, and overbought if the indicator is above 80. Depending on the market conditions, the respective levels 30 and 70 can be used.

Stochastic Oscillator. The Stochastic Oscillator was first suggested by George Lane in the 1950s. The indicator compares the closing price of

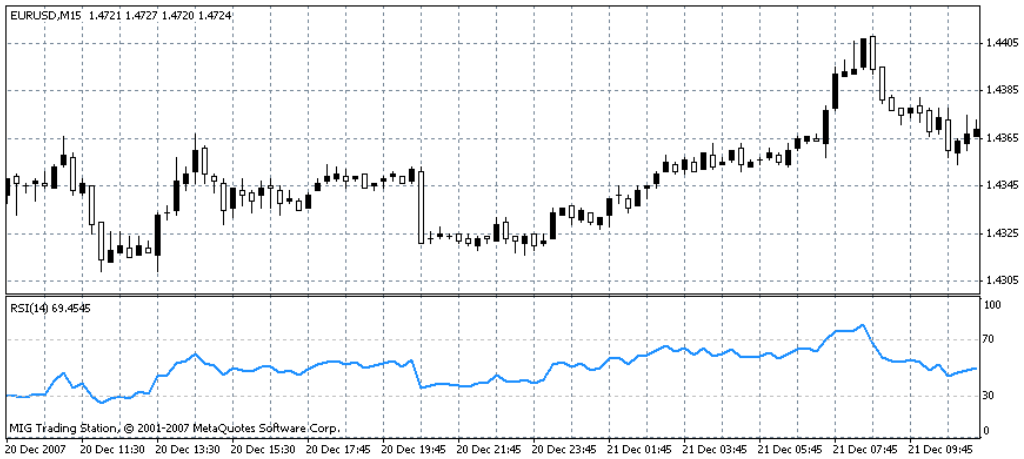


Figure 8.12: Relative Strength Index with period 14.

a currency pair to its price range over a certain period of time. The usual formula for the Stochastic Oscillator is

$$Stoch = \frac{P_{close} - P_{low}}{P_{high} - P_{low}}. \tag{8.10}$$

Two stochastic oscillator indicators are typically calculated, a fast (%K) and slow (%D). %D is usually a simple moving average of %K over the last 3 of its values.

8.2 Principles of Technical Analysis

Speaking in a very simplified way, technical analysis studies various price patterns. Then it assumes that if one pattern starts forming, then the market will follow it. Based on this approach, it attempts to forecast the market price. Thus, three main principles are on the base of the technical analysis:

1. Market reflects all the information available. Important event and news announcements have no significant influence on the actual price.

2. Market price follows trends. That means the market will the most probably follow the actual trend.

3. History tend to repeat itself. The past trend pattern will repeat in future.

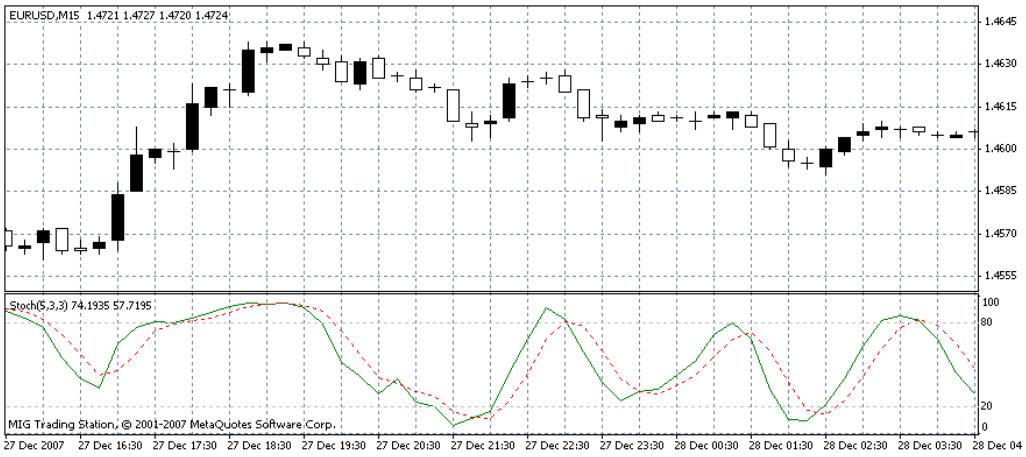


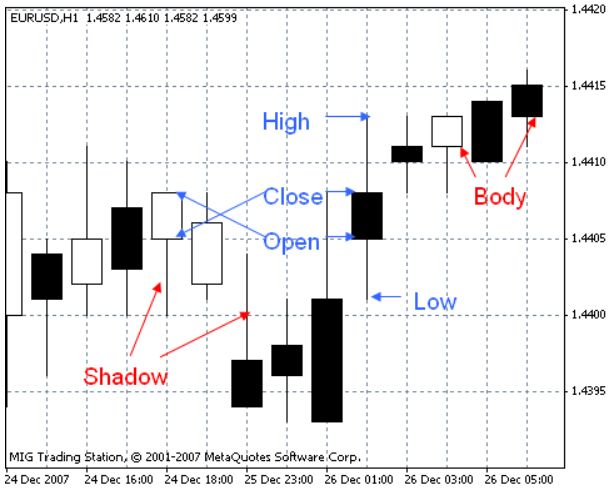
Figure 8.13: Stochastic Oscillator with %K period 5 and %D period 3.

The approach of the technical analysis also assumes that the price itself as a resulting process is more important than the reason "why" behind it, i.e. macro fundamentals, news, etc. It assumes that all the known information is readily reflected in the market price. This last assumption does not mean that the price mirrors the underlying value, it probably doesn't: according to the assumptions of the technical analysis, the market is being moved by buyers and sellers, according to their expectations, as well as rational and irrational expectations. This is what makes the market fluctuate.

8.3 Technical Analysis Schools

The first Technical Analysis was developed by Japanese traders in XVII-XVIIIth century and used candlesticks. Today, there are numerous schools of technical analysis. They differ in their approach and the way to analyze and forecast the market. Some traders purely follow one of the technical analysis approach, others combine several approaches. The approaches of different schools can be contradictory. It is considered that the most profitable approach of the technical analysis is to trade along the trend.

8.3.1 Candlestick Charting



The candlestick chart consists of candlesticks corresponding to regular time periods. The graphical representation of each candlestick depends on four prices: Open, High, Low and Close. The part of the candlestick between the open and the close price is called Body.

Candlesticks is usually of different color depending on if the Open price is higher than the close price. The distance between the Open/Close prices and High/Low are represented with a line and called Shadow. Some candlesticks pattern have specific names: hammer, doji, marubozu, etc.

Some affirmations used in candlestick analysis are the following:

1. The longer the body is, the more intense the buying or selling pressure.

2. Short shadows indicate that trading action was concentrated near the open and close. Candlesticks with long shadows show that trades extended well outside the interval between the open and close.

3. Candlesticks where the open price is close to the close price, is considered to be neutral. It also indicates that selling or buying pressure diminishes.

4. Alternated bullish and bearish candlesticks indicate a battle between selling and buying pressure. The result depends on the length of the respective candlesticks.

5. Before making decision, one needs to analyze up to four weeks period of price candlesticks.

Numerous respective positions of candlesticks are analyzed, have their own names (Star, Harami, Hammer, Hanging Man, etc.) and are largely described in the respective literature.

Figure 8.14: Triple complex trend in Dow Theory.

8.3.2 Dow Theory

This technical analysis theory was developed by Charles H. Dow, the founder and first editor of the Wall Street Journal and co-founder of Dow Jones and Company. Dow theory is based on six basic assumptions:

1. There are three types of trends on the markets:

   - uptrend,
   - downtrend, and
   - triple complex trend, consisting of an upward or downward trend, followed by a short trend in an opposite direction, and then continuing the initial trend.

2. Trends have three phases:

   - the accumulation phase, when the counter-trend operations are made mainly by the informed traders,
   - the public participation phase, when the price changes, trend reverses and speculations are made by non informed traders, and
   - the distribution phase, when the informed investors close their positions.

3. The market quickly incorporate all news as soon as it becomes publicly known.

4. Related exchange rates should go along. If it is not the case, a change will happen.

5. Trends are confirmed by volume. If a strong movement is accompanied by high volume, the trend represents a true market direction.

6. Trends continues until a signal indicating it ended. However in practice, the detection of whether one sees a temporary movement or a trend reversal is ambiguous.

The Dow Theory is sometimes classified under Market Timing approach (see below).

8.3.3 Elliott Waves

Ralph Nelson Elliott, an accountant, developed the concept of market waves in the 1930s. His idea was that any human activity is cyclical, and the market is not an exception.

The optimism of traders is changed by pessimism and back again. According et R.N. Elliott, the market prices alternate between three and five waves at all degrees of trend. The waves are divided onto "motive" and "corrective" ones. Thus, the price patters are a kind of fractals[1].

8.3.4 Fibonacci Levels

Leonardo of Pisa, later known as Leonardo Fibonacci, is an Italian mathematician who lived in Italy in XII - XIII centuries. Fibonacci studies different natural phenomena, numbers, proportions.

Fibonacci numbers are well known. This is a sequence of numbers 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, ..., where each number is the sum of two previous numbers. Remark, that the ratio of any number to one of the next higher number is close to 0.618, for example, $89/144 = 0.618056 \approx 0.618$. The ratio between alternate numbers approaches 0.382, like $55/144 = 0.381944 \approx 0.3819$. These proportions can be found in nature, architecture and art.

Technical analysts observed that in some cases the levels of price at 38.2% and 61.8% between the minimum and the maximum prices in a period of time, form support and resistance levels. Like the other technical analysis approaches, this statement is based on observations and lacks a formal proof.

[1] A fractal is "a rough or fragmented geometric shape that can be split into parts, each of which is (at least approximately) a reduced-size copy of the whole"(5)

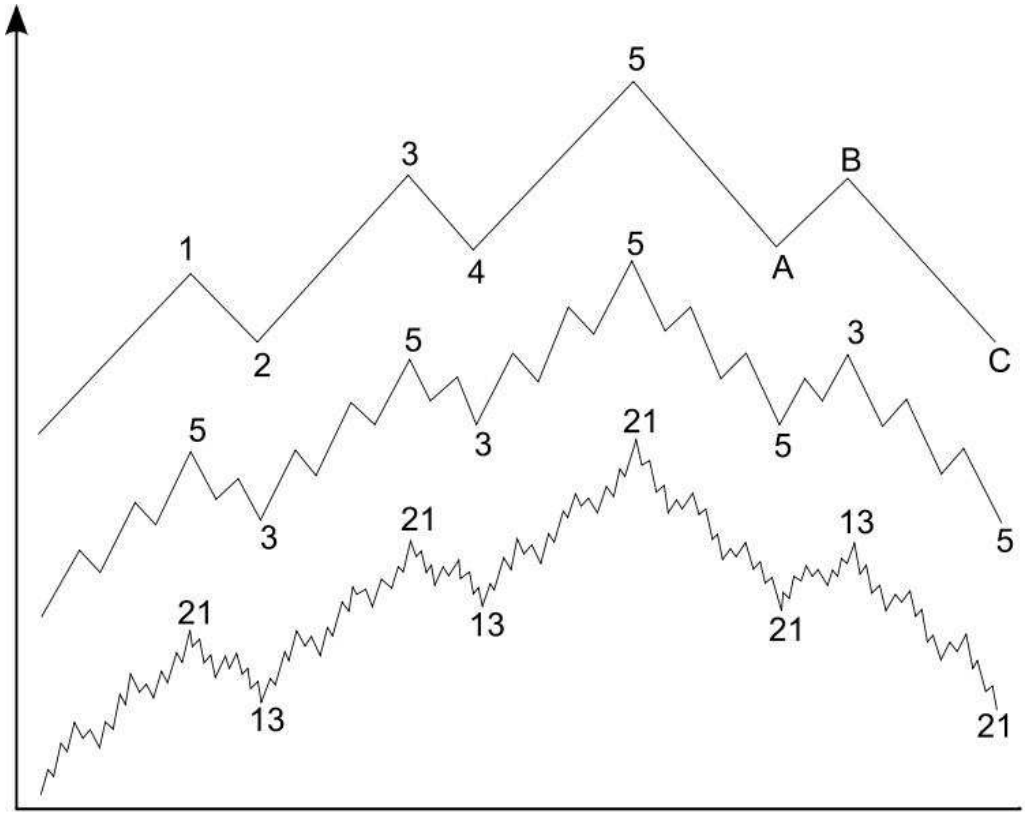


Figure 8.15: Elliott waves. Source: (4).

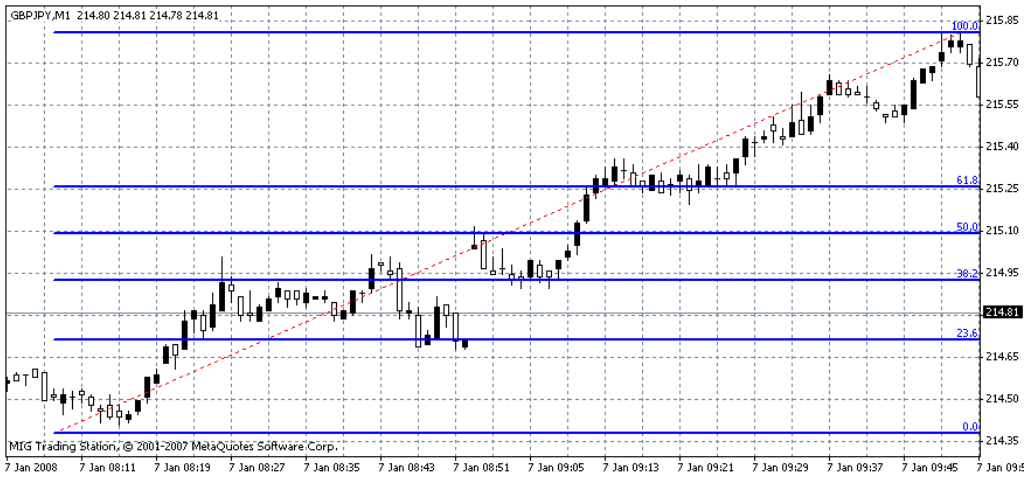


Figure 8.16: Fibonacci levels.

However, the use of the classical mathematical concept in the new context is interesting and can eventually be investigated further, in analogy with other domains of science. Three most used "Fibonacci levels" are 0.382 or 38.2%, 0.500 (50%) and 0.618 (61.8%).

8.3.5 Tom DeMark's Market Timing

Market Timing attempts to predict future market prices, based on market and economic conditions. The methods of Market Timing come from both technical and fundamental analysis. It takes into account the situation on the whole market, rather than analyzing an instrument separately.

The market moves in trends only 25% to 30% of time. At a non-trending market the use of the Moving Average and some other indicators is low. Tom DeMark was searching for some rules applicable on a non-trending market.

TDMA1 is a Moving Average indicator developed by Tom DeMark. It is used to identify potential trend reversals. It is calculated as follows:

1. Start criteria: the current bar true high is the lowest true high of the last 13 bars. The true high is True $\text{High}_t = \max\{\text{High}_t, \text{Close}_{t-1}\}$

2. The value plotted is

$$TDMA1_t = \frac{1}{5}\sum_{i=0}^{4} \text{True High}_{t-i} \tag{8.11}$$

3. This calculation is for 4 additional bars, and then:

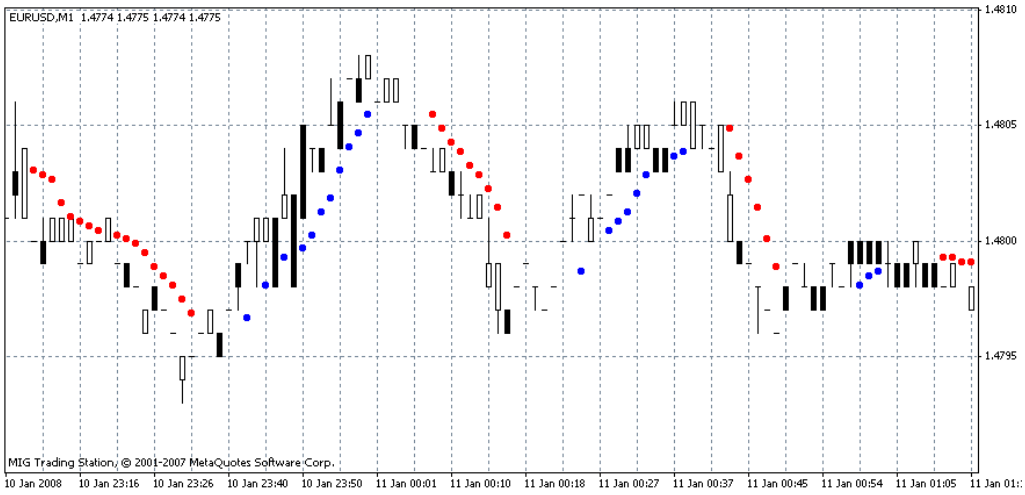


Figure 8.17: Tom DeMark Moving Average.

- If all the True High of the price bars are lower than 12 previous price High, the calculation is continued for another 3 bars;
- If not, the calculation stops.

4. If a close price of a bar is above the calculated TDMA1, this is sign of potential trend reversal. This trend reversal is confirmed if the next bar open above the breakout close and the of the next bar is above its open price.

Two other indicators Tom DeMark developed are called DeMark Combo and DeMark Sequential.

The TD Sequential indicator makes a hypothesis that the price reversals are a result of the market exhaustion, and it aims identifying such moments in advance. It includes three steps:

1. Setting up. Nine consecutive daily close prices should be lower than the close prices of four previous days for a buy position, or, respectively, higher than the previous four daily close prices for a sell position.

2. Filtering. To confirm the conclusion made on the first step, the highest prices of the two last days must intersect the lowest prices of three or four previous days, to place a buy position. For a sell position respectively, the lowest prices of the last two days must intersect the the highest prices of three to four previous days

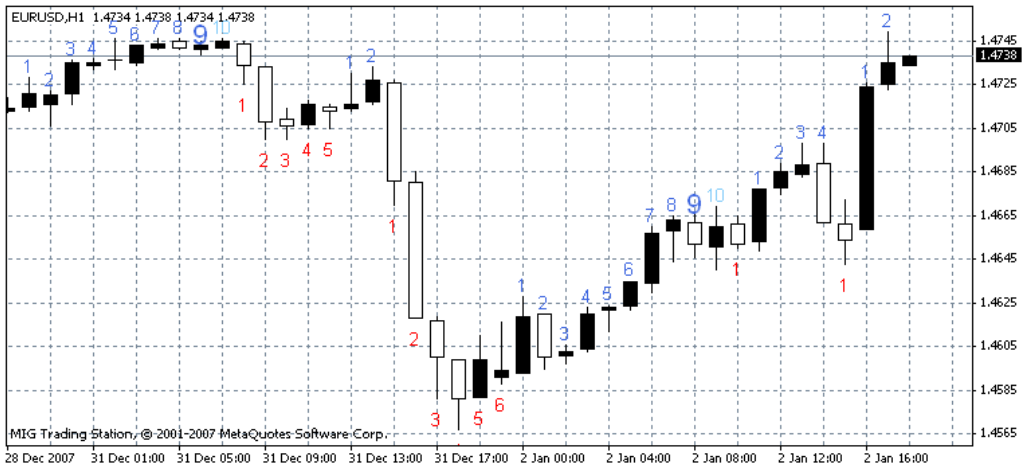


Figure 8.18: Tom DeMark Sequential indicator.

3. Countdown. A buy position is opened lower or equal to the close price two periods earlier. A sell position is opened higher or equal to the close price two periods earlier.

The DeMark Combo indicator is basically an advanced version of TD Sequential. It does not require intersections, and its rules for Countdown are more strict.

8.3.6 Gann Analysis

The Gann Angles approach was developed by W. D. in 1935. The main Gann's hypothesis is that markets are cyclic.

Each angle divides the time-price plane onto parts. The most important angle is 45^o, called 1×1, when one time unit corresponds to one price unit. Practically that means that one moves one point per day. Other important angles are 2×1, moving 2 points per day, 3×1, 4×1, 8×1 and 16×1. Drawn together, going up from the bottom left or going down the upper left corner, these angles form a *Gann fan*.

The forecasting using the Gann approach, one has to study three things only: price, time and pattern. There are five steps in constructing Gann angles:

1. Determine the time unites.

2. Determine the coordinates of the upper or lower left point, from which the angles will be drawn.

Figure 8.19: Tom DeMark Combo indicator.

3. Determine the patterns to use. The most common are 1×1, 1×2 and 2×1.

4. Draw the angles.

5. Look for similar patters in later periods and find cycles.

According to Gann, if the price stays above an ascending angle the market is strong. If the price stays below the descending angle, the market is weak. The strength of the market depends on the angle the comparison is made to. If the price crosses one of the angles, it will tend to go to the next angle, ascending or descending. The angles that are not crossed by the prices are sometimes called *Support and Resistance Levels*.

8.4 Criticism of Technical Analysis

> "I realized technical analysis didn't work when I turned the charts upside down and didn't get a different answer."
>
> Warren Buffet

The technical analysis was widely criticized by academic researches for being unscientific, by loosing traders for being inefficient, as well as by traders using one approach and blaming their colleagues from another technical analysis school. Different analysts using the different or even the same technique, often may have different and even contradictory forecasts about the future development of the market prices.

Indicators and Charts. The charts are by definition correct and most of the indicators are not wrong. But the question is if one can really call them indicators, ir, better to say, do these lines and figures indicate anything useful for the future forecasts. Without having any future information, all the indicators are based on the past information. So the technical analysis indicators are delayed indicators, and inform traders about the changes after these changes happened or at least started happening.

Efficient Market Hypothesis. Almost all the technical analysis approaches suppose that the market is efficient, i.e. all the information is incorporated in the price. As numerous studies suggest (e.g. (2), p. 168.), this suggestion is far from the reality. The market prices rather reflect only a part of the information available.

Dow Theory. The efficiency of some approaches is doubtful. It can be statistically proven that, for example, the Dow Analysis is not more efficient than a simple "buy and hold" strategy (3).

Elliott Waves are criticized for being unprovable and do not agree with the efficient market hypothesis.

Market Timing was criticized for its approach of *Curve Fitting*: as soon as the model is adapted to the out-of-sample data, this data is not out-of-sample anymore.

Gann analysis. The major problem of the Gann analysis is the scale selection. Gann does not give strict rules for defining it. And this technical detail is so important that one may have completely different results depending on the initial point and scale selection. The scale may also vary over time, depending on the absolute value of price and the market volatility. Thus, the charting is completely individual and arbitrary, as well as the results got from this analysis.

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Chapter 9

Fundamental analysis and Trading Psychology

Fundamental analysis aims pricing securities and currency pairs taking into account economic, political and social factors. The analysis is made on the past and the present prices, and tries to take into account all the available information, including the latest news announcements. Most of times its purpose is to forecast the future development and provide basis for investment decisions.

There are two common views on the fundamental analysis:

1. It is possible to find out mispriced assets on the market and, by trading these assets between the present moment and the time when market adjusts its price to its intrinsic value, get positive profit.

2. All relevant information is incorporated in the asset price. "Trend is your friend" - no matter what is the intrinsic value of an asset, the future prices are only defined by past prices and traders' emotional behavior.

Same information about fundamentals becoming known to foreign exchange market participants can be evaluated in different ways. These differences in opinions and traders' behavior are due not only to different methodologies used, but also to overreaction and similar anomalies. Trading psychology is definitely an important part of market behavior analysis.

9.1 Defining Mispriced Assets

Traditionally on the equity market the intrinsic value of an asset can be calculated with a certain precision. Most of times, these value estimations are

based on the expected cash flows potentially generated by the asset - dividends, coupons, selling price, etc. This approach is more broadly accepted by the market practice, rather then the accounting approach evaluating the company's total assets and liabilities, but failing to appropriately take into account such intangible assets like trade marks or customers' loyalty.

Foreign exchange market is somewhat different in this respect. The value of currency does reflect the state of the country economy. Unlike a company, the country cannot be priced in terms of assets and liabilities. Money however generate quite easily definable cash flow in for of interests, except that this flow is in the same units - same currency.

It is however possible to use one currency, e.g. USD, as reference currency to evaluate the exchange rates and interest rates of another currency, say EUR. Thus, if investing from USD into EUR now, holding EUR for one period of time, then converting the investment amount back into USD, generates more income then the interest rates on the USD, then EUR can be considered as underevaluated relative to the USD, and such an investment strategy should be followed.

In practice, there are considerations that often prevent from profitable using this investment strategy:

- The Interest Rate Parity, which states that

$$1 + i_A = \frac{r_{p,AB}(1 + i_B)}{r_{f,AB}}, \tag{9.1}$$

  where i_A and i_B are interest rates on currencies A and B respectively, $r_{p,AB}$ is the present exchange rate, $r_{f,AB}$ is the forward exchange rate, holds.

- Even if, as shown in the chapter 4, the relationship above does not hold, the trading costs will almost surely reach the level or even exceed the potential profit.

9.1.1 Top-Down and Bottom-Up Approaches

There are two ways to approach fundamental analysis. An investor applying the top-down method starts his analysis with global state of the economy, taking into account both domestic and international data - GBP, interest rates, exchange rates, inflation. Then he narrows the study to a selected industry, its prices, technology, production output, as well as national and international competition. The final step is to analyze a particular company. An investor favoring bottom-up approach starts with analyzing the

business regardless the country and industry, then analyzes the environment surrounding the company.

In case of foreign exchange market, a variant of the top-down approach would be to study the regional situation, for example Asia, then pick up the currency corresponding to selected criteria, say the Singapore Dollar. Finally this currency can be traded against a reference currency that the investor may consider stable for his goals, e.g. Swiss Frank or British Pound.

The top-down approach for currencies can also descend to the industry level. For countries in which a particular industry plays an important role, the state of that industry will heavily influence the currency. An immediate example are oil and gold prices, related to US dollar. The figure 9.3 shows the daily close prices of Brent Oil vs. USD, Gold vs. USD and EURUSD exchange rates.

A simple linear regression

$$P_{EURUSD,t} = a_0 + a_1 P_{Oil,t} + \varepsilon_t, \tag{9.2}$$

where

- $P_{EURUSD,t}$ is the current exchange rate of EURUSD at the moment t,
- $P_{Oil,t}$ is the current price of Oil in USD at the moment t,
- a_0, a_1 are coefficients,
- ε_t is the error term,

has explanatory power of $R^2 = 7.8\%$. This quick experiment shows that the EURUSD exchange rates are at almost 8% are explained by the oil prices movements. The same linear model applied to daily data on EURUSD regressed on the price of the gold gives the R^2 as low as 0 - gold is today the way less significant for the US and European economy than the oil.

9.1.2 Methods of Fundamental Analysis

Traditional fundamental analysis for equity market concentrates its study of a raw of macroeconomic and financial indicators and ratios. Some of them are taken from published number and constitute common knowledge for all market participants. Others are based on investor's estimation, usually referring to some future values, and can significantly differ from one analyst to another.

On the foreign exchange market terms like Price/Earnings ratio or discount factor cannot be strictly applied. The most important macro fundamentals usually analyzed are

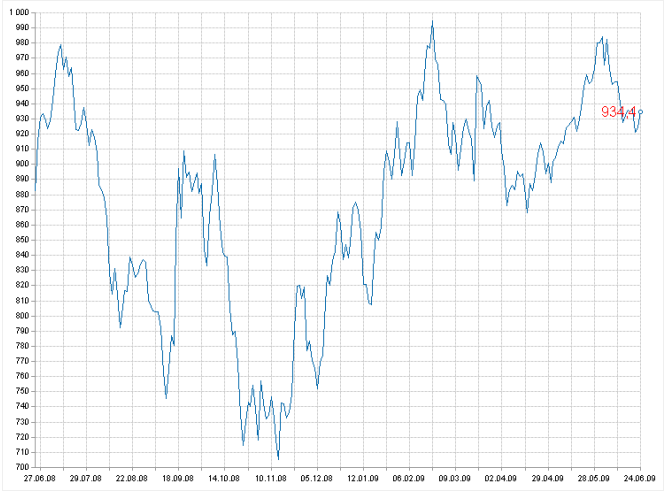

Figure 9.1: Daily close prices of Gold vs. USD. Source: www.finmarket.ru, 26th June 2009.

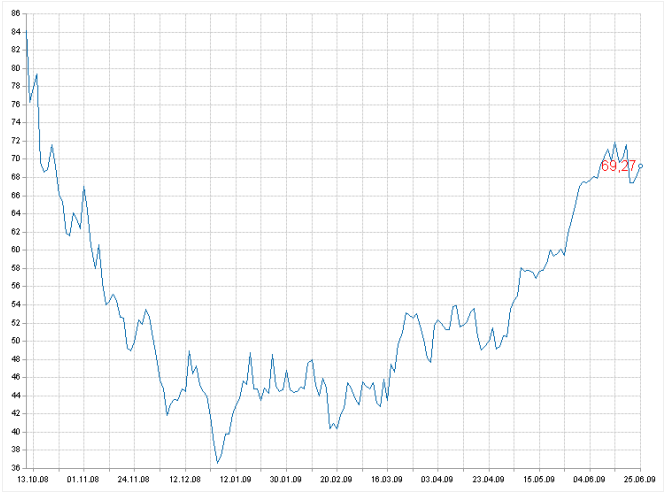

Figure 9.2: Daily close prices of Brent Oil vs. USD. Source: www.finmarket.ru, 26th June 2009.

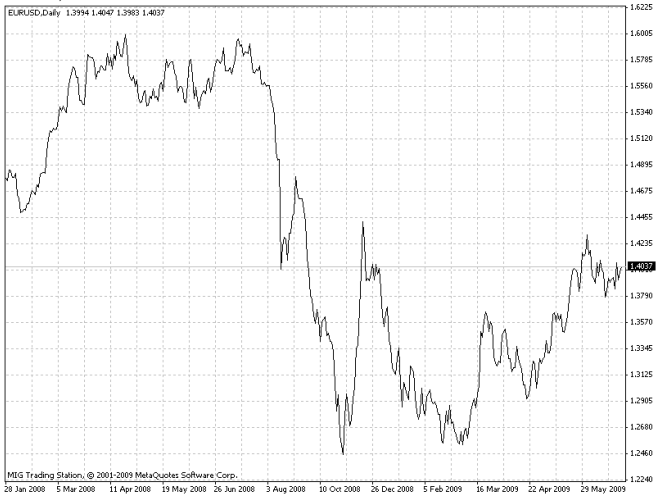

Figure 9.3: Daily close prices of EUR vs. USD. Source: MIG Trading Station Software, www.migfx.com, 26th June 2009.

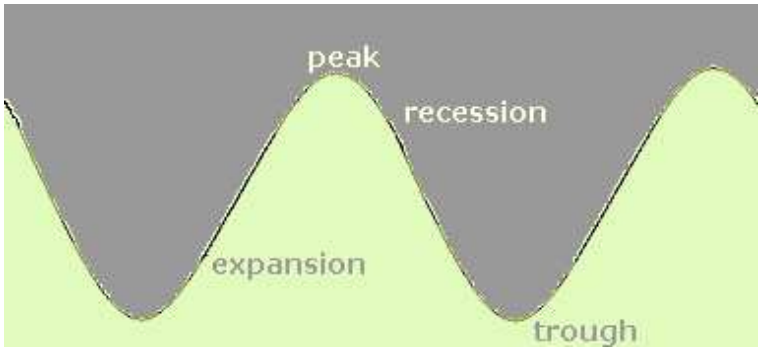

Figure 9.4: Business cycle. Source: www.forexrealm.com, 25th June 2009.

- **Interest rate.** Ceteris paribus, an increase in interest rates will make the currency more expensive, as more investors will want to buy it, thus generating more demand for it, in order to invest and get higher interest rates.
- **Gross Domestic Product (GDP)** is the primary indicator of economic activity of a country. Higher GDP is usually a predictor of higher interest rates, and thus increasing value of the domestic currency. Gross National Product (GNP), including consumer spending, government spending, investments and net exports, is an alternative measure.
- **Employment situation.** Increase in unemployment rate is usually perceived as a sign of weak economic activity, which leads to lower interest rates, and thus devaluates the currency.
- **Trade balance** deficit will usually imply selling the currency and thus predict its weakening .
- Stage of the **business cycle.** The economy is considered to go through cycles, i.e. having periods of expansion, peaks, recessions and troughs. Expansion usually, ceteris paribus, evaluates the domestic currency, which goes down in value again during the recession periods.

A series of secondary indicators like number of building permits delivered, estimated inflation or the activity of Central Banks, can also be used for analysis. The influence of every indicator is not isolated - interdependencies may not be neglected. As two countries increase their interest rates, while each of them may expect their currency to evaluate, the exchange rate

between two currencies would be defined by their *relative* raise of interest rates, and one currency may devaluate towards another. On the other hand, some apparent correlations between economic indicators and exchange rates can be due to pure chance.

Timing is an important consideration for fundamental analysis. An announced change of interest rates or the yearly GDP are susceptible to produce the effect on exchange rates several times:

- In the moment of announcement of projected values, i.e. the market forms its expectations in advance;
- During the period of change, the market may correct, especially if it overreacted initially, if the actual evolution is different from projected or any new events influences the macro fundamental;
- As official statistics about the past period is announced.

Although correlation can be observed between macro fundamentals and exchange rates, macro-based models generally fail to explain price movements on the forex market (see next Part IV for more details).

9.1.3 Criticism of Fundamental Analysis

Fundamental analysis is broadly used by many investors, and it is definitely useful as a rule of thumb to consider the impact of main economic events on the market. Unfortunately, it lacks precision, and it is not uncommon to see two fundamental analysts, having the same data set, coming to opposite conclusions.

Moreover, the big number of academic researches ((4) as an example) failed to find a meaningful stable relationship explaining exchange rates by macroeconomic fundamentals. The explanatory power R^2 of macro models generally do not exceed several percent, which is definitely too low as a foundation of serious investment decisions.

9.2 Trading Psychology

Despite of the political importance of Central Banks, their volume of transactions is negligible relative to the whole market. The biggest Central Banks have their total currency reserves at (state of 2003, source: www.babypips.com):

- Bank of Japan - 550 billion USD,

- Bank of China - 346 billion USD,
- European Central Bank - 220 billion USD.

The daily turnover of the forex market is about ten times greater than these bank reserves.

Macro fundamentals fail to adequately explain the behavior of foreign exchange rates. In search for the missing component explaining market movement, analysts started analyzing human factors.

Investing and trading decisions, even if based on models and calculations, are still ultimately made by people who tend to be sometimes wrong in their judgements, overreact on news, underestimate risks and simply miss important information.

9.2.1 Particularities of Trading Behavior

Leaving calculation errors outside, traders are known to suffer from the following phenomena:

- **Heuristics:** investors make decisions based on approximations and rules of thumb, rather than precise models. This is particularly true in hectic market conditions, during news announcements or when sophisticated tools would be too slow or inaccessible.
- **Bounded rationality:** individual intentionally choose to restrict their analysis to limited set of information, because of lack of resources to process all the available data set.
- **Status quo bias:** investors tend not to change their behavior and opinion, unless are really forced to. Additional factor here are the trading costs, which usually penalize investors who trade actively and recalibrate their portfolio frequently based on new arriving information.
- **Herd behavior:** traders tend to do what all others do, most of time rationing that the majority cannot be wrong.
- **Framing** or circumstances: the way the situation is presented from both trader's personal and market point of view will affect the way people react. An announcement of a positive move in interest rates would normally move the value of the currency up. Yes, unless the announced increase is below the investors' expectations, in which case the value would rather go down.

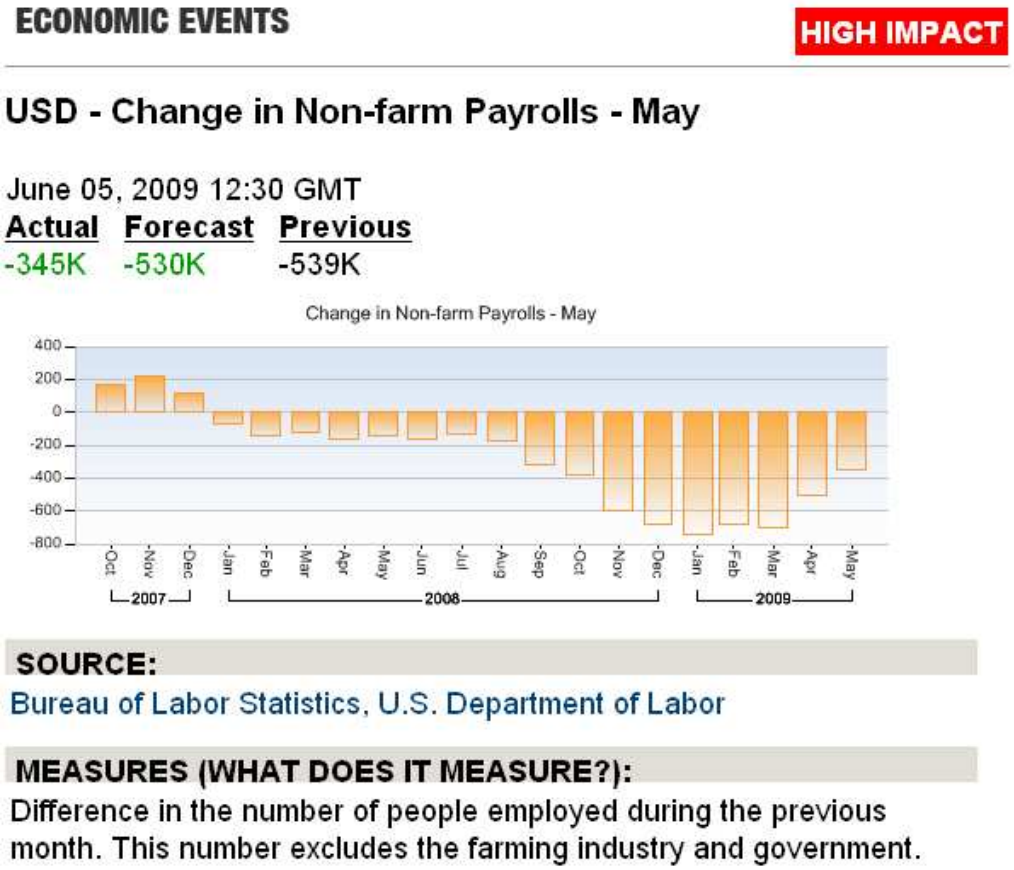

Figure 9.5: Non Farm Payrolls announcement on 5th June 2009. Source: www.fx360.com, 26th June 2009.

Behavioral economic and behavioral finance learn these and many other market anomalies in details. The important question for us is rather how to encompass this irrational behavior in the model for intraday foreign exchange trading.

According to the some researches (e.g. (6)), while traders' behavior may induce distortions, the market price will still be close to the intrinsic value of the asset. We argue that such distortions may persist short term, but will be corrected afterwards by the market. Let us take the example of Non Farm Payrolls announcement on the first Friday of the month, 5th June 2009.

As can be seen on the figure above, the announced number was negative, which supposedly should bring the dollar value down. On the other side, it was 35% less than expected. If we analyze the EURUSD minute by minute

Figure 9.6: Non Farm Payrolls announcement on 5th June 2009, EURUSD minute by minute quotes, 30 minutes prior and 60 minutes after. Source: MIG Trading Station, MIG Investments SA, www.migfx.com, 26th June 2009.

quotes 30 minutes prior and 60 minutes after the moment of announcement[1], the following explanation is plausible.

1. In the moment A the announcement was made and the market price dropped by 60 points in less than ten minutes, down to the point B.

2. At the point B the market realizes it may have overreacted, and corrects itself to the point C.

3. From the point C, it moves down to D again. Overall, the fluctuations are each time smaller and oscillate around a common trend line shown in red.

[1]Note that the time on the trading station is CET rather than GMT. The Non Farm Payrolls were announced at 12.30 GMT, or 14.30 CET.

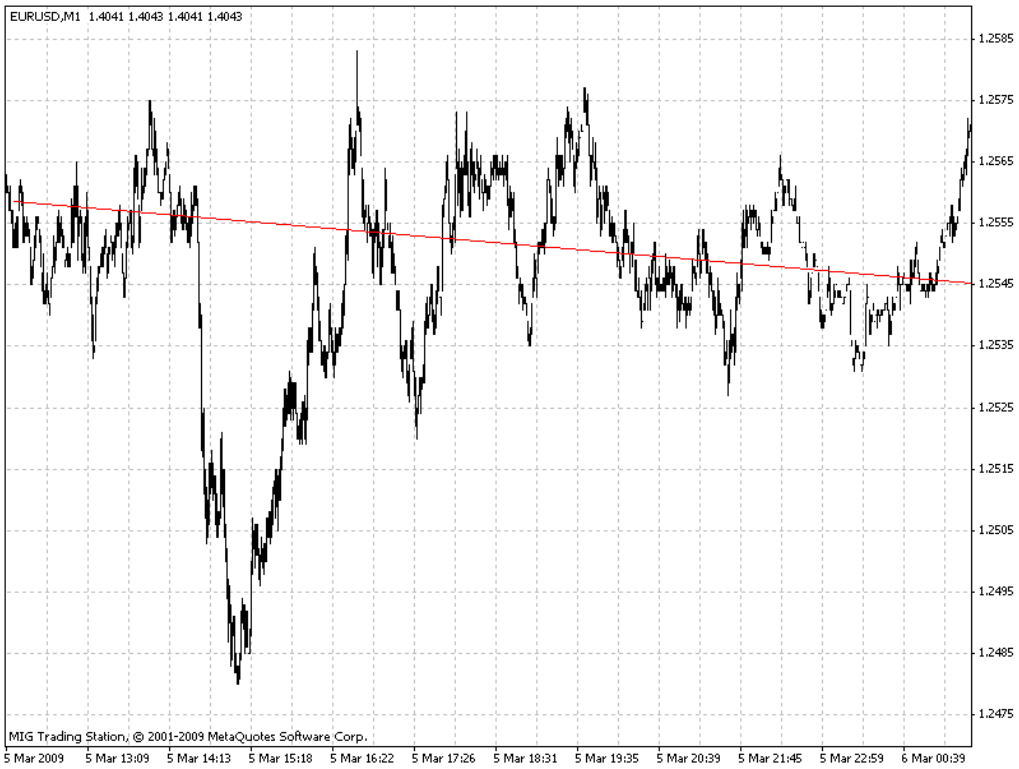

Figure 9.7: Non Farm Payrolls announcement on 5th June 2009, EURUSD minute by minute quotes, trading afternoon. Source: MIG Trading Station, MIG Investments SA, www.migfx.com, 26th June 2009.

4. The biggest profit could have been simply made by someone who, based on the expected negative announced value placed a short EURUSD position at O, and closed it at D.

The next figure shows minute by minute quotes of the trading afternoon of the same day. Same behavior can be observed longer term: market overreacted first, then corrected itself. Oscillations fluctuate around a common trend line.

9.2.2 Self-Fulfilling Forecasts

"What people believe will happen, will happen."

M.Mainelli

Does irrational human behavior make the market behave irrationally? To a certain extend, the answer to this question is positive. Let some important

group of traders believe the prices will go up. As a consequence they buy the currency, which generates demand for this currency, and which pushes the prices up indeed, no matter if the initial belief of traders was right or wrong! Self-fulfilling forecasts may move the market significantly, usually for some short period of time, until the market corrects itself, or better to say, when more traders start acting "reasonably" based on correct market forecasts and thus move the prices back to equilibrium.

9.2.3 Automated Systems

If human behavior is so imperfect, can the cool blooded reasoning of a computer replace it? We don't have any evidence of it so far. Many traders partially or fully automate their trading strategies, but no strategy known to the authors, can adequately analyze the market over long term and adapt to changing environment. Most of automated strategies, if profitable at all, work only in certain market conditions or have a limited useful life span, until market conditions change.

The website www.mql4.com provides a database of nearly 1500 freely available scripts for automated strategies shared between a community of 28 600 registered members (state 25th June 2009). We ran a simulated trades, as if each of these scripts was doing live trading on an account with initial deposit of 10 000 USD, decision based on minute-by-minute data (unless the strategy explicitly requires another time frame), trading EURUSD currency pair, with default settings of the strategy ("as is"), starting on 1st January 2008 and until 25th June 2009 or until the loss equals the initial deposit, whichever comes first. If a strategy requires to be run on a higher time frame, the period of testing will be extended appropriately, to examine a comparable variety of possible trading situations. The charts below present visually the evolution of the balance and equity on the simulated trading accounts. The backtesting of four most popular strategies of the data base gave the following result: none of it generated a consistent profit and, in most of cases, generated a consistent loss. Specific numbers are given below the respective figures on the next page.

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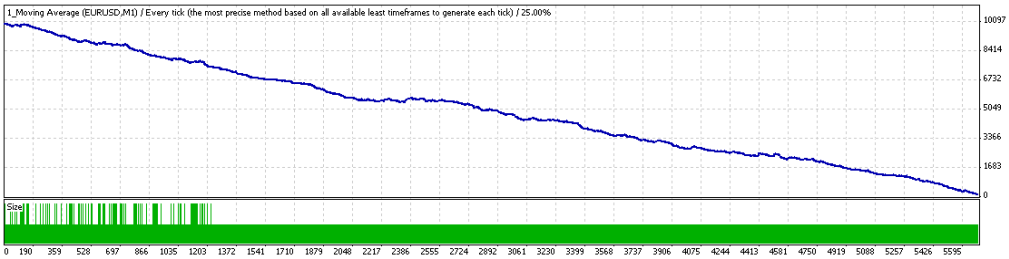

Figure 9.8: Strategy "Moving Average". Last position closed 27.10.2008. ROI=-100% over 10 months.

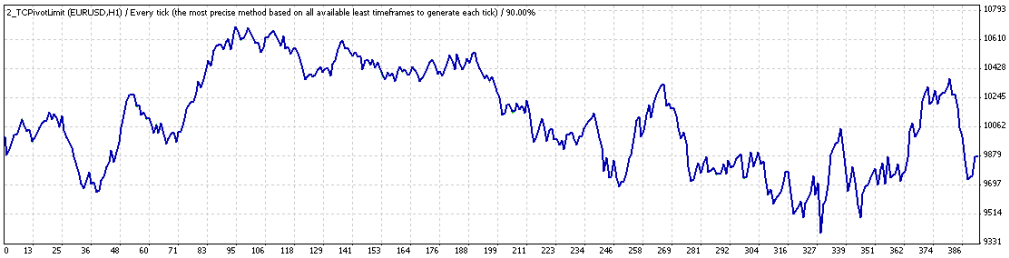

Figure 9.9: Strategy "TCPivotLimit". Time frame: hourly data. Testing period 01.01.2006-25.06.2009. Final balance 9876 USD. ROI=-1.2% over 42 months.

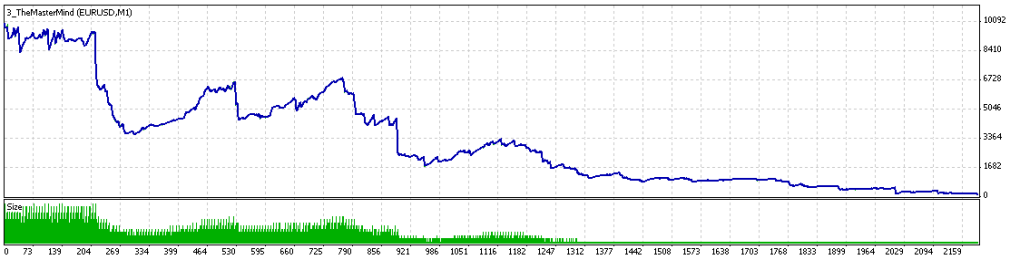

Figure 9.10: Strategy "MasterMind". Last position closed 12.2.2008. ROI=-100% over 1.5 months.

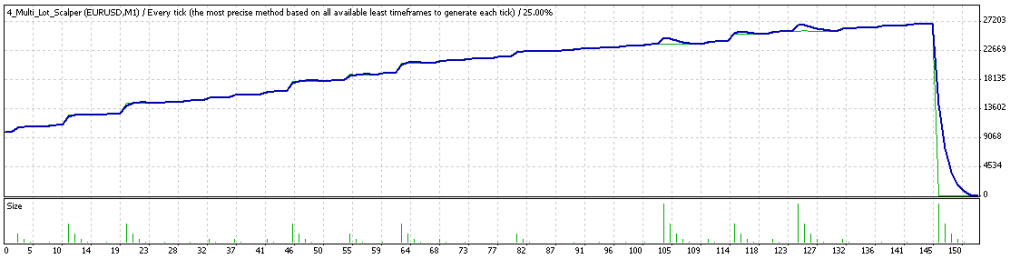

Figure 9.11: Strategy "Multi Lot Scalper". Last position closed 30.01.2008. ROI=-100% over 1 month.

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Part IV

Models for Foreign Exchange Market

Chapter 10

Applicability of Equity Market Models to the Foreign Exchange Market

Literature is abundant in equity market models reflecting different financial phenomena one can observe everyday. While the forex charts may look quite similar to equity patterns, the underlying processes and the external factors influencing these movements are quite different. The question is then if it makes sense to attempt to explain and forecast forex market movements using the models applied on the equity market.

10.1 Common Properties of Financial Markets

Financial markets of different types show similar properties. First of all, the form of the data to be analyzed. Time series in form of prices, ratios, indices or macro economic indicators constitute the basic information. Prices can usually be observed in continuously during the trading hours. Macroeconomic values change according to the evolution of the economy and become known through official news announcements or less formal sources. This information is usually publicly known and can be quantified and analyzed.

Causality relationships between variables is usually going the same way. For instance, it is usually the government announcements that move prices, and not vice versa. At least, the relationship is usually analyzed this way. Variables will normally stay in a same or similar relationship regardless of the asset traded.

Human factors is a consideration for any market which is not fully automatic. People tend to make mistakes, be emotional and overreact, whatever is the market they are acting on. Behavioral finance is applicable to any field of trades and explain human related phenomena.

Econometric tools are so universal that the same approach can be applied to electronics, geology, medicine and finance. A computer will run regression of the prices over interest rates with the same accuracy as over the outside temperature. Mathematical tools are indeed universal and virtually any model of one financial market can be transposed to another.

10.2 Specific characteristics of the Foreign Exchange Market

The reasoning behind econometric models is in each situation different in many respects. It definitely has to account for apparent and hidden relationship, type of data, its availability and reliability. The particularities of each specific market should be studied very closely.

The exchange rates do not float as freely as shares prices. Some currencies are strictly controlled under fixed exchange rates regimes. Those that are allowed to float freely, are still watched closely.

Central Banks intervention is another phenomena on the foreign exchange market that does not happen on stocks, bonds or futures market. Central Banks sometimes announce their intentions in advance, sometimes not. These impacts are usually relatively short in time, but high in impact. They also pursue a particular goal of the government or of a group of people. In other words, the whole market is being moved intentionally to a predefined state decided by a group of interest. Such interventions are common on the foreign exchange, but rather unheard of on the equity markets.

The information involved in determining an intrinsic value of a stock is at three levels: country, industry and company, the last being often determinant. As for the value of a currency, it is primarily determined by the state of the countries economy, and sometimes significantly influenced by certain industries of major importance.

Unlike the equity markets, most of the information determining the price is public and known through public announcements. There are no internal decision, company policies or trade and production secrets susceptible to be used to manipulate prices. Thus, there is no phenomena as insiders' trading on forex.

The last but not least, if left alone in case of buy and hold strategy, share

are expected to increase in value, as the underlying company is expected to prosper and generate profits. The currencies, in the contrary, tend to devaluate due to inflation.

In summary, we conclude that even through some basic tools from the equity markets can be applied on forex, analysts should be extremely cautious, analyze all the underlying assumptions and related processes, and their relevance for the currency exchanges. Forex specific models are definitely to be developed.

Chapter 11

Models Based on Macroeconomic Fundamentals

Specific forex models are expected to be more adequate for modeling processes on the foreign exchange market than for example some commonly used equity market models. In forex modeling, one takes into account

- the market structure: organization of the largest spot currency markets, management of the credit risk, taking into account asymmetric information and entry barriers, and
- the information structure: price variation in spot currency markets, defined by dispersed non public information

The number of participants of the foreign exchange market is important, but the interest in modeling is fully reflected two considerations only. Central Banks need to estimate before and evaluate the impact after their intervention on the money market. Investors, asset manager and traders, on the other hand, require an estimation of the return and a forecast for their performance in order to generate profit. While many studies concentrate on Central Banks requirements, we are trying to bring answers to the second group of market participants - corporations and individuals having a commercial interest on the forex market.

There are two basic groups of models depending on the main underlying assumptions:

- macro-based, assuming that the exchange rates depend on macroeconomic fundamentals
- micro-based, describing market microstructure

This chapter overviews the macro based models in search of elements that can be potentially used for explaining intraday price movements. There are two most important models used in macro: money-income model and Taylor-rule model.

11.1 Money-income model

In this model, the macro fundamentals are expressed as follows:

$$f_t = m_t - m_t^* - \gamma(y_t - y_t^*) + q_t - (v_t - v_t^* + \alpha\rho_t), \tag{11.1}$$

where
- m_t is the log nominal money supply,
- y_t is the log nominal output,
- q_t is the real exchange rate,
- ρ_t is the forex risk premium, and
- * marks foreign variables

In this model the discount factor

$$b = \frac{\alpha}{1+\alpha}, \tag{11.2}$$

where α is the interest semi-elasticity of money demand in both countries. In practice, b showed to be close to 1 (6).

11.2 Taylor-rule model

In the Taylor-rule model, the fundamentals are defined by the equation 11.3.

$$f_t \equiv (p_t - p_t^*) - \frac{1}{\phi_0}[\rho_t + \phi_1(y_t^g - y_t^{*g}) + \phi_2(\pi_t - \pi_t^*) + u_t - u_t^*], \tag{11.3}$$

where
- p_t is the log nominal price level,
- y_t^g is the "output gap",
- π_t stands for inflation.

The discount factor

$$b = (1+\phi_0)^{-1}, \tag{11.4}$$

where ϕ_0 is the coefficient on the spot rate in the Taylor interest rate rule. As a consequence of actual monetary policy, ϕ_0 are small, which again implies b close to unity.

11.3 Risk Premia Models

Several authors ((7), (13)) show that the foreign exchange risk depends on exogenous factors. Often, the macroeconomic data and monetary interventions really explain much of the foreign exchange movements, but this approach makes the forecast, especially the long term forecast, almost impossible.

Wickens and Smith (13) suggested using three models:

- Benchmark, by reformulating the definition of the forex efficiency
- Inter-temporal consumption based model
- Monetary model of exchange rate

Derviz (4) proposes a multi-factor international asset pricing model that determines the exchange rate taking into account risk factors in the economy. The asset pricing model is decomposed into the standard ICCAPM n-arbitrage and an additional equation relating he autarktic currency price to the foreign exchange order flow.

Over the short term, the market maintains automatically the Uncovered Interest Rate Parity at no-arbitrage equilibrium relation. The factors that induce the short term volatility are:

- Adjustment to exogenous interest rate news (intuitive dynamics)
- Microstructure of demand formation
- Inefficiency on the short term arising out of the adjustment process (but efficiency on the long term if no information bias)
- If interval between the exogenous news is shorter than the market settling time, or if there is an information bias, the volatility on the long run

Thus, the microstructure and the information bias jointly explain the persistent deviations from the uncovered interest rate parity. Balaji (1) proposes a measure for volatility and inefficiency, taking into account the market parameters and transaction costs.

For long term analysis and forecast, an alternative theoretical models was presented by Cumperayot (3). It introduces additional risk factors based on the volatility of macroeconomic fundamentals. Taking into account the cointegration between the exchange rate and the macroeconomic factors, one deducts the equilibrium exchange rates.

11.3.1 General Equilibrium Model

In particular, Engel (5) speaks about the Sticky Price General Equilibrium Model. Prices are perfectly flexible and output fluctuations happen only as a consequence of supply shocks. The foreign risk premium has its origin in the correlation between supply shocks to output and shocks to the money supply. The volatility of exchange rate in itself does not result in a risk premium: the monetary shocks that do not influence consumption, will not increase the riskiness of holding domestic or foreign nominal assets. Inversely, monetary shocks may cause changes in output and consumption. The main findings of the author are:

1. The existence of the risk premium in flexible-price general equilibrium models depends on the correlation of exogenous monetary shocks and aggregate supply shocks. In sticky-price models, the risk premium arises endogenously. The forex risk premium is directly related to the volatility of exchange rates.

2. In the sticky-price models, the distribution of aggregate supply shocks has no influence on the foreign exchange risk premium.

3. The risk premium is different for the home and the foreign investors.

4. Opposite to standard general equilibrium models that are not reliable if risk premiums are very large, a sticky-price model can account for much larger risk premiums.

11.3.2 Portfolio Balance Model

The portfolio balance model considers the source of money creation as an important factor. For example, money supply can be changed by a central bank by buying domestic bonds or foreign bonds, or alternatively intervene on the foreign exchange market. This model thoroughly takes into account:

- net supply $\overline{B}$ of domestic and foreign bonds F,
- current account deficit CA,
- trade balance T,
- monetary base M, and
- total financial wealth W.

The equilibrium is described by the following relationships ((2), (10)):

$$\dot{W} = Fp\dot{S} \tag{11.5}$$

$$0 = \frac{\partial m}{\partial i}\dot{i} + \frac{\partial m}{\partial W}\dot{W} \tag{11.6}$$

$$0 = \frac{\partial b}{\partial i}\dot{i} + \frac{\partial b}{\partial W}\dot{W} \tag{11.7}$$

$$Fp\dot{S} = \frac{\partial f}{\partial i}\dot{i} + \frac{\partial f}{\partial W}\dot{W} \tag{11.8}$$

This model being based on macro fundamentals provide rather a tool for monetary decisions and modeling, then the foreign exchange trading, especially the intraday trading. However, the Portfolio Balance Model can be a basis for specific trading models (8).

11.3.3 Stochastic Discount Factor Theory and Model

The stochastic discount factor (SDF) model has the obvious advantage of permitting the researcher to select discount factors. Actually, many widely used models like the Capital Asset Pricing Model (CAPM) of Sharpe (12) and even Black-Scholes options pricing are particular cases of the SDF model(11).

In the simplest form for the forex market, the model can be presented as follows.

$$E_t R_{t+1} = E_t s_{t+1} - f_t = E_t \triangle s_{t+1} - [f_t - s_t] = \phi_t, \tag{11.9}$$

where

- $R_{t+1} = i_t^* + \triangle s_{t+1} - i_t$ is the excess return for domestic investors while investing in foreign currency,
- s_t is the logarithm of the domestic price of foreign currency,
- $f_t = s_t + i_t - i_t^*$ is the forward rate,
- $f_t - s_t$ is the forward premium,
- i_t, i_t^* are the domestic and foreign interest rate respectively.

If $\varepsilon_{t+1} = R_{t+1} - E_t[R_{t+1}]$, then 11.9 can be rewritten as

$$R_{t+1} = \alpha + \beta[f_t - s_t] + e_{t+1}, \tag{11.10}$$

where $e_{t+1} = \phi_t + \varepsilon_{t+1}$.

This model is the most appropriate for a short term use. Smith and Wickens (13) compared the different implementations of the SDF models, and proposed a using a multi-variate GARCH-in-mean model.

11.3.4 Evans-Lyons Model

Evans and Lyons (9) depart from the Taylor-rule model and the uncovered interest rate parity. Their model has two main features:

- the discount factor b is very close to 1
- information about future fundamentals arrives simultaneously to all agents, agents revise their forecasts accordingly and simultaneously

The model is estimated by the regression 11.11.

$$\triangle s_{t+1} = a_0 + a(i_t - i_t^*) + \varepsilon_t, \tag{11.11}$$

where

- s_t is the logarithm of the domestic price of foreign currency,
- i_t, i_t^* are the domestic and foreign interest rate respectively.

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Chapter 12

Models of the Spot Foreign Exchange Market Microstructure

Micro-based models attempt to describe the behavior of the market, discover laws of its functioning, short-term reactions. As this analysis is based on early signs and leading indications, it is closer to technical analysis on one side and is more used for short term trades. It is for instance not uncommon to have a long term bullish trend on the market, confirmed by fundamental analysis of macroeconomic variables, while many investors and traders take advantage of short term downturns on the market, forecasted based on technical analysis and short term market movements. As a consequence, this type of analysis is the most used for intraday trading.

Another shortcoming is that the future spot exchange rates are very difficult to forecast based on the present values of macro fundamentals. If we consider the spot exchange rate

$$s_t = (1-b)\sum_{i=0}^{\infty} b^i E_t f_{t+i}, \tag{12.1}$$

where s_t is the log nominal exchange rate, b is a parameter, f_t stands for the value of macro fundamental in the moment t, we get after reorganization of it:

$$\triangle s_{t+1} = \frac{1-b}{b}(s_t - E_t f_t) + \varepsilon_{t+1}, \tag{12.2}$$

with

$$\varepsilon_{t+1} \equiv (1-b)\sum_{i=0}^{\infty} b^i (E_{t+1} - E_t) f_{t+i+1}. \tag{12.3}$$

As b approaches unit, i.e. as we attribute more weight to more recent observations of the macro fundamental, the explanatory power R^2 of the model drops below 1% (3). On the other hand, the explanatory power micro-based models can go as high as 60%, for example in case of orders flow model (2).

The common assumptions of macro-based models are the following:

- all the public information is reflected in the exchange rate
- all relevant information is publicly known
- there is no external intervention on the market and no economic shocks

It is commonly accepted that these assumptions are very simplistic and quite far from the market practice. Micro based models on their turn focus on the process through which the relevant information becomes available to the market participants, and thus influences their expectations and current exchange rates.

Researches have shown a great deal of analysis and imagination in taking into account different macro-economic variables, but all of them were unsuccessful - none of macro models gave any significant explanatory power or a reliable approach safe to use for forecasting.

12.1 Market Structure

It is traditionally assumed that the market structure is determined by market risk, asymmetric information and entry barriers. Lyons (5) rather affirms that it is primarily dependent on the credit risk.

An important change in the foreign exchange market happened within last fifteen years. In 1990s, the most of trades were passed by dealers directly between them. With the introduction of the e-trading technology, at least a half of trades on the market are inter-dealer trades assisted by brokers. These two types of market structure can be described as auction structure and dealership structure respectively. In the case of auction structure, the risk of trades of trades is taken completely by the individual trader and, in case all the dealers have the same expectations relative to the market price, we can be in the presence of a situation where no trades take place. In case of dealership, such kind of market break down is virtually improbable, as brokers and market makers incorporate their risk evaluation in the trading costs, and thus in the quotes they provide to traders. As a consequence,

brokers rather give quotes with higher bid-ask spreads, than stop operations completely.

Another factor that limits possible operations is the credit limit. It is not uncommon to observe, on a hectic forex market, two participants having to stop trading with each other, because their mutual credit is exhausted. These participants are not necessarily individual traders, but can also be banks. In the case of dealership, the "credit" usually takes form of a deposit made at a brokerage company. The trader is then allowed to trade as long as his total loss, taking into account unrealized loss for opened positions, does not exceed his deposit. Usually the trader gets a notification close to the zero point, called "margin call". If additional funds are not deposited within specified time limit or, as market turns, the opened positions do not generate positive or less negative result, all the trader's opened positions would usually be closed, preventing him from breaking his credit limit, i.e. having a debt that exceeds the exposure he is able to face.

It has commonly been accepted so far that all or almost all information on the forex market is public. This is not only a simplifying assumption of most macro models, but a simple logical reasoning that is the exchange rates refer to the state of the whole economy there may not be private information about it. Indeed, unlike in an individual company, there are no insiders in the economy, meaning owners, directors and people close to them. There are no company profits or payoffs like in the case of bonds and shares.

In the model of the partially decentralized forex market, described by Derviz (1), traders have access to quotes provided by their dealer, and to some paid better quality quotes and superior information about fundamentals. Traders make their trading decisions based on the eventual difference between the two sources. Thus, the lowest ask and the highest bid become the equilibrium prices at each moment of the continuous time.

In terms of real world trading conditions, most of the modern brokers provide their clients with high quality quotes and news, like Dow Jones or Bloomberg, usually free of charge for clients. Clients can hardly get any significant advantage by using alternative information sources. If we still assume that additional information sources may provide some competitive advantage, the question is if the cost of the information does not equal or exceed the possible advantage.

However, private information on forex still exists. Variables like participant's risk aversion, money demand, transaction demand, orders flow, etc. do define the exchange rates, and are not necessarily known to all market participants.

The *signed* volume has been ignored for a long time, while its use is crucial and makes difference while aggregating the information. The order flow does

not necessarily reflect the actual demand, as not every market participant will be able to pass his trade and thus not any shift in demand will induce transactions. On the other side, the unsigned volume would also include the volume of transactions made by the market maker, i.e. transactions non initiated by the market maker, but induced by his role on the market - being present and ready to absorb excess demand and shock against a remuneration. Thus it makes sense to use the signed volume and the term "excess demand".

Uncovered total return parity (UTRP) reflects the exchange rate forecasts for a given period of time through the difference in total returns on a pair of representative securities. Total returns should reflect yields to maturity at any given moment of time. In case of decentralized dealership, the deviations from UTRP naturally come because of subjective estimates made by different market participants. The broker can learn some market information by observing the orders frow of its clients. The Partially Decentralized Multiple Dealership model establishes a link between the order flow observed by the broker, Bayesian filtering of fundamentals known by the dealer and the behavior of the UTRP.

The micro structure models are often associated with high frequency data and short term forecasts. Indeed, information coming for example through the order flow stays non public for short period only, until it is incorporated in the exchange rates. Also, to be able to make short term forecasts, more recent information has to be used at each moment. As a consequence, high frequency data is required.

However, it is not absolutely correct to associate the micro models with short term forecasts only. As micro models are interested in mechanisms of how the market function, how information is incorporated in price and how market participants interact, with the development of new tools and new models, it is not impossible that micro models will deliver accurate forecasts over longer periods on time.

12.2 Aggregation

The foreign exchange market aggregates the information: the individual risk preferences, firm's productivities, money demands, edging demands, etc. Assumption that dispersed information is rapidly summarized in public information is dubious. Models of exchange rate (monetary models, portfolio balance models, new open-economy macro models) abstract completely from information aggregation. Two observations are important:

- The public information approach is not realistic and has a low explana-

tory power (see chapter 4).

- Recent empirical work on exchange rates using "dispersed information approach" are inversely, quite successful.

The order flow can be perceived as the information aggregation tool (4). Here one means the order flow received by a market maker, being passive side and just accepting trades, from clients who actively trade. As it is possible that all the relevant information is not publicly known, the orders flow is an important source of information. As the forex trading is decentralized, brokers with important number of clients have informational advantage from the received order flow.

12.3 Orders Flow Model

Evans and Lyons (3) continue the idea of the micro-based model and concentrate on the orders flow. They assume that it contains information on relevant fundamentals for two reasons:

- Traders who aim making profit on the foreign exchange market initiate trades when they believe they have information they can take advantage of, and
- Market participants who cover their other activity through forex market operations, all together, represent the current state and direction of economy.

Note that it is crucial to take into account the *signed* orders flow, rather than unsigned. Imagine a trader approaching a market maker to sell 10 lots of EUR vs. USD. Another trader comes in the same time with a request to buy 20 lots of EUR vs. USD. The unsigned order flow merely indicates that the volume of transactions reached 30 lots. The signed order flow however, will be $-10 + 20$, which gives $+10$ as an outcome, and provides the valuable information to the market maker that the market expects a rise of the price.

The model is based on the following assumptions:

- All relevant information is assumed to be public;
- The aggregate order flow x_{t+1} during period t follows an $AR(1)$ process $x_{t+1} = \lambda x_t + v_{t+1}$, where v_{t+1} - i.i.d., mean zero shock with variance σ_v^2;
- Market makers learn the true aggregate order flow with a one-period delay.

The relevant expectation (that of the market maker):

$$s_t = (1-b)\sum_{i=0}^{\infty} b^i E_t^m f_{t+i}, \tag{12.4}$$

where E_t^m is the expectation conditioned on market makers' information at the start of period t - this difference is crucial, as micro-based models attempt to explain the process of incorporation of available information into prices. This model concentrates on the process by which market makers obtain information. So we have:

$$\delta s_{t+1} = (\frac{1-b}{b})(s_t - E_t^m f_t) + \varepsilon_{t+1}^m, \tag{12.5}$$

$$\varepsilon_{t+1}^m \equiv (1-b)\sum_{i=0}^{\infty} b_i (E_{t+1}^m - E_t^m) f_{t+i+1}. \tag{12.6}$$

In this way, changes in spot rate ε_{t+1}^m come from the present value of revisions in market makers forecasts of future fundamentals.

The sources from which market makers get information about fundamentals include the order flow. It does not necessarily mean traders are more informed then the market makers. In reality they may pass trades based on any other information or even without aiming a profit from the forex operations. However, if the total order flow shows an important volume of transactions in a particular direction, it may make the market maker revise its expectations about the macro fundamentals.

Because the order flow needs some time to be observed and aggregated, before it is being reflected in the spot prices, the order itself has a predictive power. Assume brokers observe a part of the order flow at the moment t, and aggregate it at the moment $t+1$:

$$x_{t+1} = \lambda x_t + \upsilon_{t+1}, \tag{12.7}$$

where υ_{t+1} is i.i.d. mean zero shock with variance σ_υ^2. Each market maker is indexed by i and the order flow he observes during the period t by denoted by

$$x_{t+1}^i = x_{t+1} + \varepsilon_{t+1}^i, \tag{12.8}$$

where ε_{t+1}^i is an i.i.d zero mean shock with variance σ_ε^2. The unexpected part of the order flow can thus be expressed as

$$\begin{aligned} x^i_{t+1} - E^i_t x^i_{t+1} &= x_{t+1} - E^i_t x_{t+1} + \xi^i_{t+1} \\ &= \upsilon_{t+1} + \lambda\psi\upsilon_t + \xi^i_{t+1}, \end{aligned} \tag{12.9}$$

where

- $\psi \equiv \frac{\sigma^2_\xi}{\sigma^2_\upsilon + \sigma^2_\xi}$ and
- E^i_t is the expectations conditioned on the information the market maker i has at the start of the period t, i.e. Ω^i_t.

The above described process is an MA(1) process with a specific component ε^i_{t+1}, which means the present information is correlated with past innovations of the aggregate order flow υ_t. However, it does not necessarily mean the market makers immediately incorporate the information they receive into quotes they provide to traders. Market makers can also choose first to trade using this information on their advantage. Only when all market makers learn x_t, the value of υ_t becomes public.

Lyons and Evans (3) put this idea into the model of orders flow:

$$\triangle f_t = \phi \triangle f_t + u_t + \delta\upsilon_t,$$

$$x_t = \lambda x_{t-1} + \upsilon_t. \tag{12.10}$$

In this model, u_t is observed permanently, and υ_t becomes known only in the end of the period. From the standpoint of an individual market maker $E^m_t f_{t-1} = f_{t-1}$, $E^m_t f_t = (\phi+1)f_{t-1} - \phi f_{t-2} + u_t$, so $f_t - E^m f_t = \delta\upsilon_t$. And the model can be rewritten as

$$\triangle s_{t+1} = \frac{1-b}{b}(s_t - E^m_t f_t) + \frac{1}{1-b\phi}u_{t+1} + \frac{[1+\phi(1-b)]\delta}{1-b\phi}(x_t - \lambda x_{t-1}). \tag{12.11}$$

For this model, the lagged order flows have forecasting power even when the discount factor is close to unity, because the coefficient on the last term is limited by $\frac{\delta}{1-\phi}$ as $b \to 1$.

In practice, the one estimates the model consisting in two independently estimated equations:

$$\triangle s_{t+1} = b + a x^{AGG}_t + e_{t+1} \tag{12.12}$$

and

$$\triangle s_{t+1} = b + \sum_{j=1}^{6} a_j x_{j,t}^{DIS} + e_{t+1}, \tag{12.13}$$

where

- x_t^{AGG} is aggregated order flow from six last periods of time,
- $x_{j,t}^{DIS}$ is the order flow from segment j.

The first equation estimates the forecasting power of the aggregated flow, then the second detects the input of each of the disaggregated flow individually.

Evans and Lyons (3) compare the true, ex-ante forecasting performance of a micro-based model against both a standard macro model and a random walk. The forecasting is examines for a short term period, one day to one month. Over 3 years of testing, it is shown that the micro-based model consistently outperform both random walk and the macromodel. This does not imply that past macro analysis has overlooked key fundamentals: finding consistent with exchange rate being driven by standard fundamentals.

An important reserve to be put on this models is whether the actual demand of the market is adequately reflected by the order flow. It is not uncommon to have a situation when there is an actual demand, but there is no transaction generated due to eventual limits on credit lines, trading hours or technical limitations or issues.

One should also analyze of any type of transactions are equally informative and important for the price formation. The aggregated order flow may come from many small traders each of which has its own source of information and beliefs about the market. This same net position can be generated by one transaction of an institutional client or a small bank - his source of information may be more reliable on one side, but if it is erroneous, it will generate a more important distortion on price than that serving retail clients.

Also, an important question to ask, whenever market makers know the identity of their clients, is whether orders flow generated by corporations, financial institutional and banks are more susceptible to influence the market makers perception of the market and thus the price formation.

The last remark is related to the type of orders received by the market makers. There are two types of orders: market order with immediate execution and pending orders - revocable or irrevocable, with or without expiration date, with a prespecified non market price at which the order is placed if the market hits the target price before the order expired. While it is that the first type of orders should be taken into account, the answer is less obvious for the

pending orders. Should they be taken into account at all? On one side they do reflect the traders' expectation regarding future prices and even provide more details in the form of a target price. On the other hand, especially if pending orders can be revoked without financial penalty, these belief's of traders are not backed by real money and may simply reflect an attempt of an arbitrage strategy trying to catch the price "just in case". If the answer on the first question is still positive and pending orders should be taken into account, an important timing question arises - at which moment these positions have an actual influence on the market? Does it happen in the moment when the position is placed and the information about it is already available to the market maker? Or this order should rather be incorporated in the order flow in the moment of its activation when a trader commits real money into the operation? The answer on this second question has more influence if pending orders are allowed to stay active for longer time periods, eventually several days or even longer.

12.4 Evidence of Orders Flow Model on the Modern Foreign Exchange Market

To test the model described in the previous section, we take data from the foreign exchange market for the period from 1st March 2009 till 31st May 2009. The data reflects the volume of trades going through the dealing desk of a market maker. For each day of trades, there following data is analyzed:

1. Total number of lots of each currency pair bought by traders through the company,

2. Total number of lots of each currency pair sold by traders through the company,

3. Average price (quote) of the currency pair for each trading day, calculated as $\frac{Open+High+Low+Close}{4}$.

The analysis was done for each of the following currency pairs[1]:

[1]AUD - Australian Dollar, CAD - Canadian Dollar, CHF - Swiss Frank, CZK - Czech Koruna, DKK - Danish Krona, EUR - euro, GBP - Great British Pound, HKD - Hong Kong Dollar, HUF - Hungarian Forint, JPY - Japanese Yen, MXN - Mexican Peso, NOK - Norway Krona, NZD - New Zealand Dollar, PLN - Polish Zloty, SEK - Swedish Krona, SGD - Singapore Dollar, TRY - Turkish Lira, USD - United States Dollar, ZAR - South African Rand

AUDCAD	EURHKD	GBPNZD	SGDJPY
AUDCHF	EURHUF	GBPPLN	TRYJPY
AUDJPY	EURJPY	GBPSEK	USDCAD
AUDNZD	EURNOK	GBPSGD	USDCHF
AUDUSD	EURNZD	GBPTRY	USDCZK
CADCHF	EURPLN	GBPUSD	USDDKK
CADJPY	EURSEK	HKDJPY	USDHKD
CADSGD	EURSGD	NOKJPY	USDHUF
CHFJPY	EURTRY	NOKSEK	USDJPY
CHFNOK	EURUSD	NZDCAD	USDMXN
CHFPLN	EURZAR	NZDCHF	USDNOK
CHFSGD	GBPAUD	NZDDKK	USDPLN
EURAUD	GBPCAD	NZDJPY	USDSEK
EURCAD	GBPCHF	NZDSEK	USDSGD
EURCHF	GBPDKK	NZDSGD	USDTRY
EURCZK	GBPHUF	NZDUSD	USDZAR
EURDKK	GBPJPY	SEKJPY	
EURGBP	GBPNOK	SGDHKD	

Table 12.1: List of analyzed currency pairs.

The trades are taken from a sample with trading hours weekly from Sunday 23.00 till Friday 23.00. For the daily data, Sunday evening data was merged with Monday data, this providing 25 hours of trading information for Mondays and 23 hours of trading for Fridays.

Figures 12.1-12.5 show the plots of daily exchange rate variations vs. scaled order flow of a market maker.

The daily data on CADSGD, CHFNOK, CHFPLN, EURDKK, EURHKD, EURHUF, EURNOK, EURPLN, EURSEK, GBPDKK, GBPNOK, GBPPLN, GBPSEK, GBPSGD GBPTRY, HKDJPY, NOKSEK, NZDDKK, NZDSEK, SGDJPY, TRYJPY, USDCZK, USDDKK, USDHKD, USDHUF, USDMXN, USDNOK, USDPLN, USDSEK and USDSGD is insufficient for the estimation. These currency pairs were omitted for the experiment. We assume that the current order flow t is already known to the market maker. We also suspect the volatility clustering, i.e. current change in price depends on previous changes in price. We thus estimate the improved model 12.14 for the remaining currency pairs.

$$\triangle s_{t+1} = b + \sum_{j=0}^{6} a_j x_{j,t}^{DIS} + \sum_{j=0}^{6} c_j \triangle s_{t-j} + e_{t+1}, \tag{12.14}$$

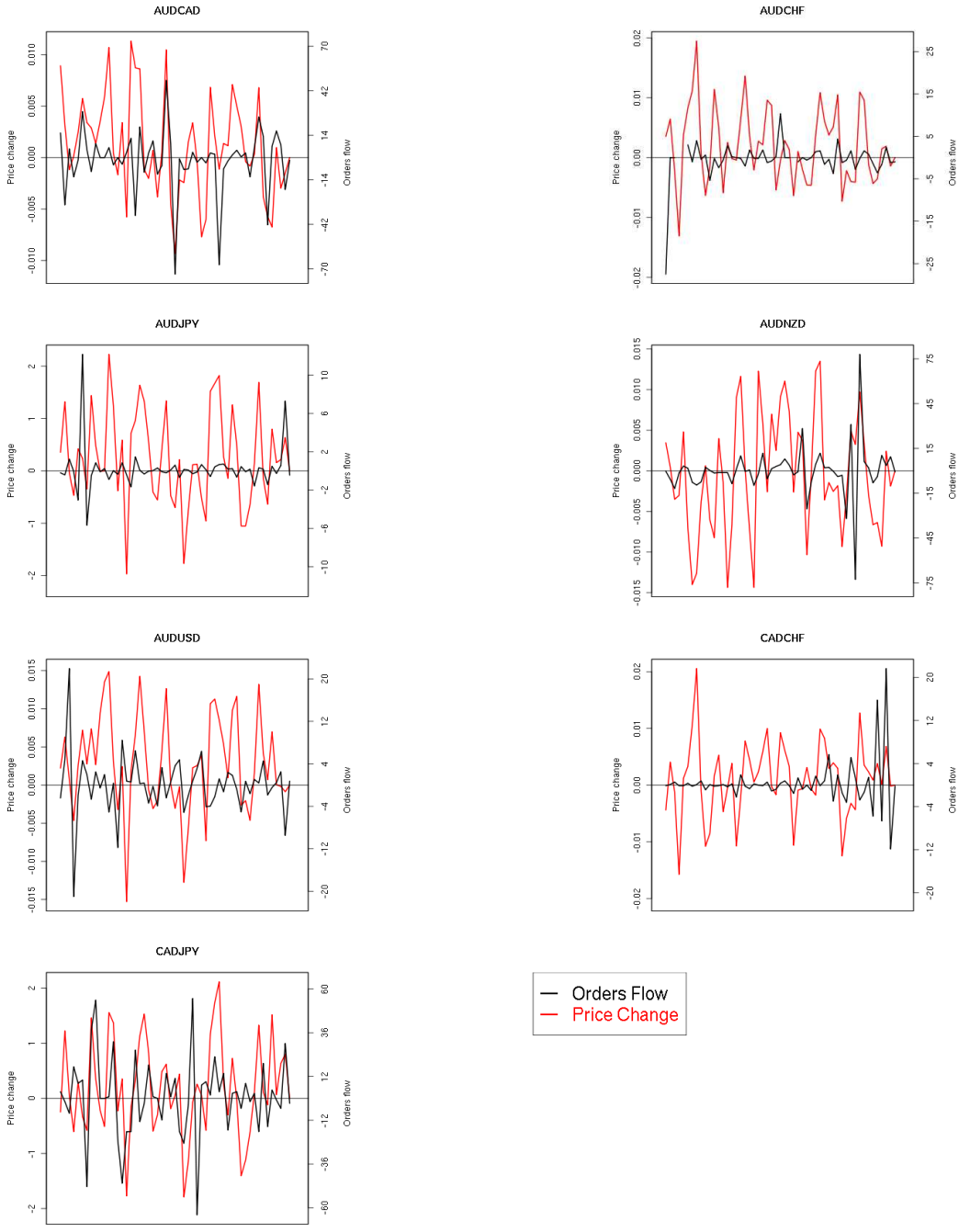

Figure 12.1: Daily exchange rate variations vs. orders flow.

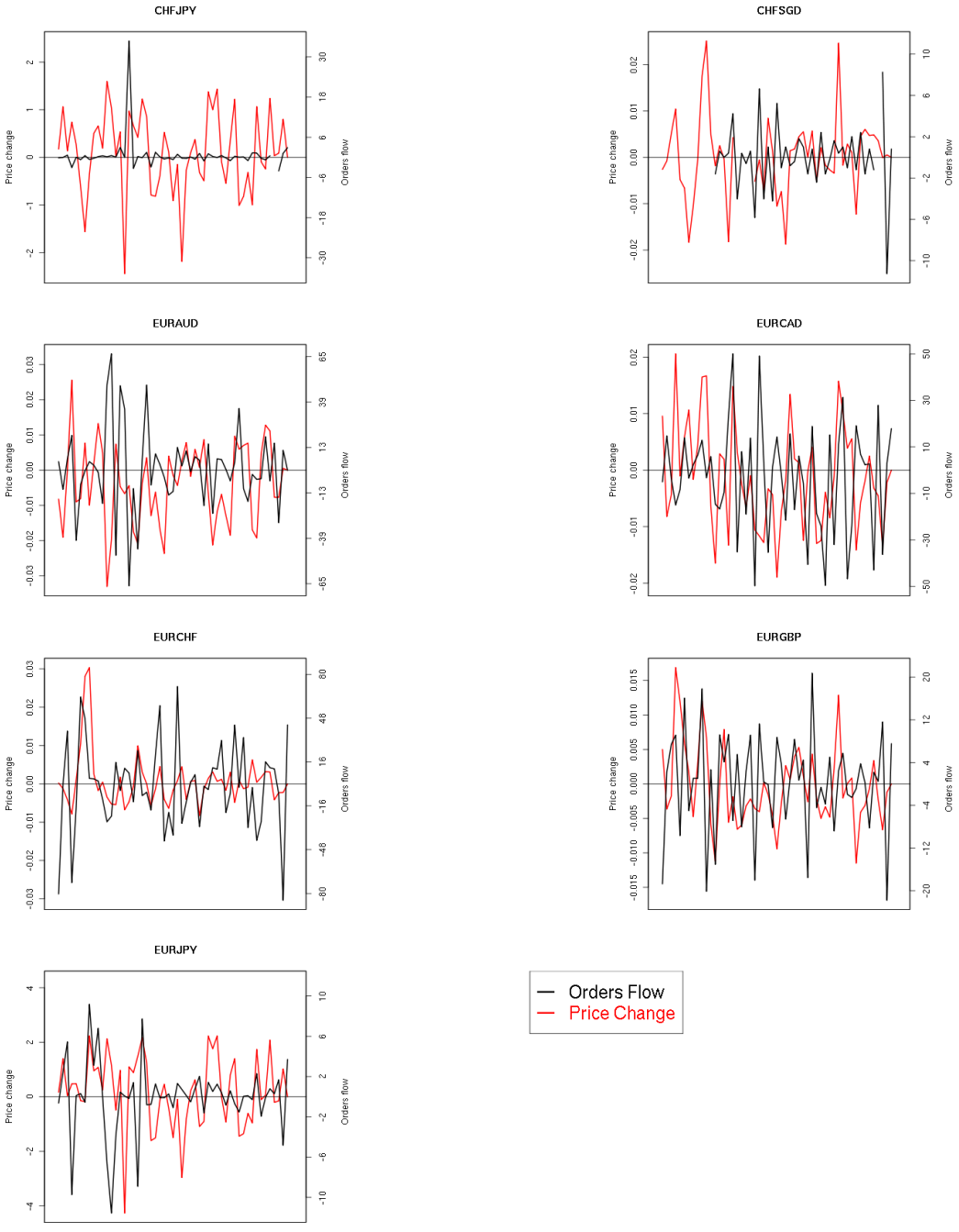

Figure 12.2: Daily exchange rate variations vs. orders flow.

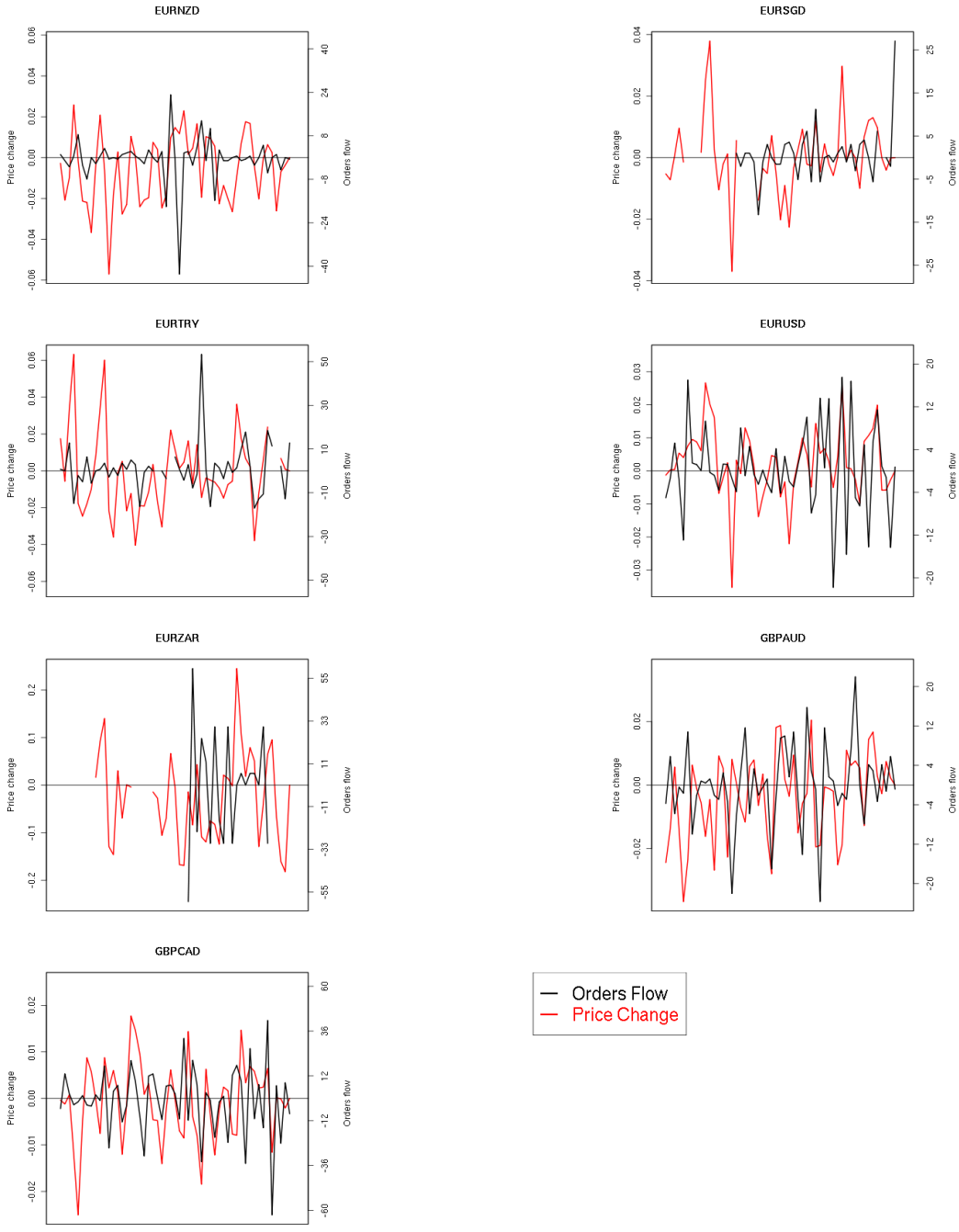

Figure 12.3: Daily exchange rate variations vs. orders flow.

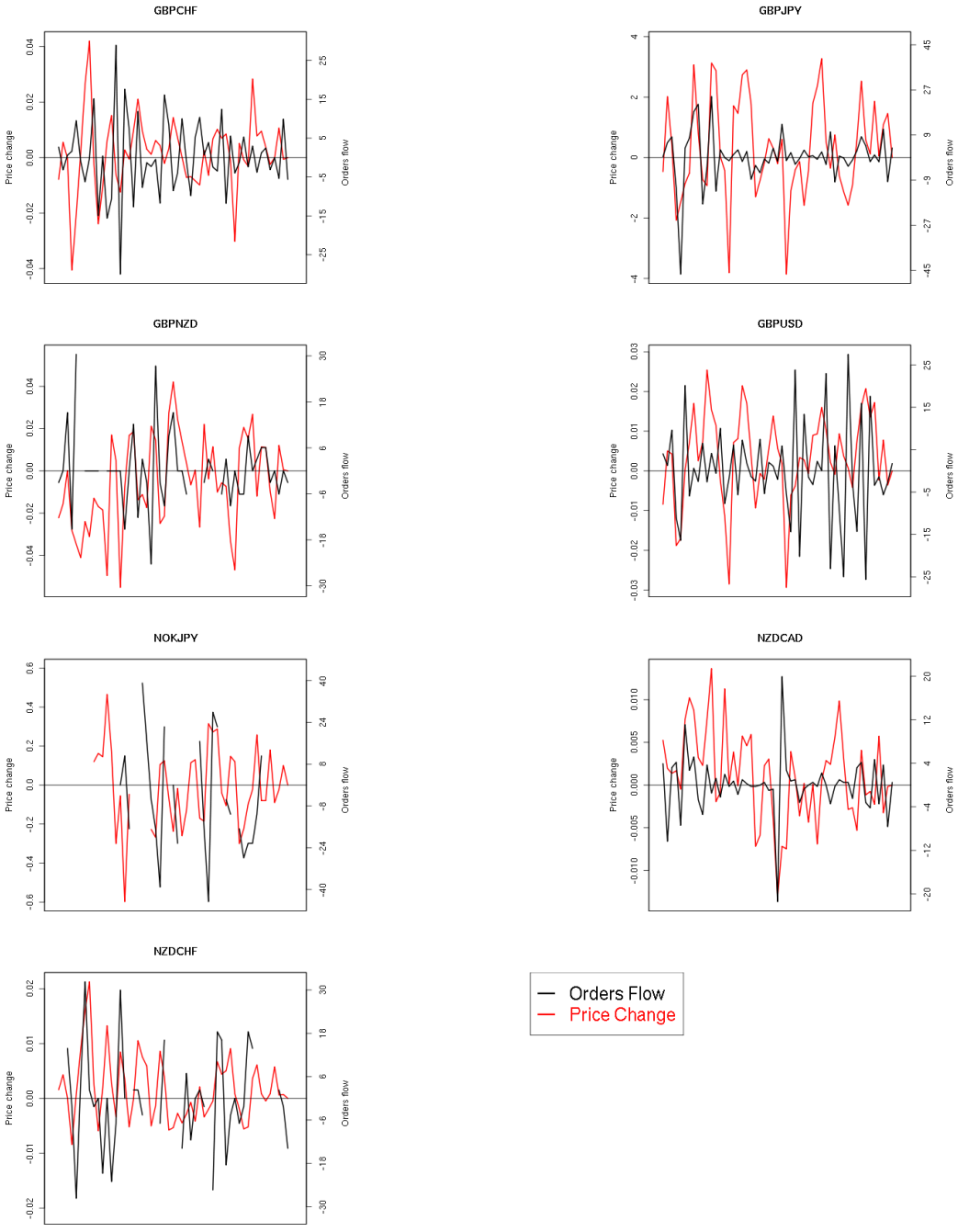

Figure 12.4: Daily exchange rate variations vs. orders flow.

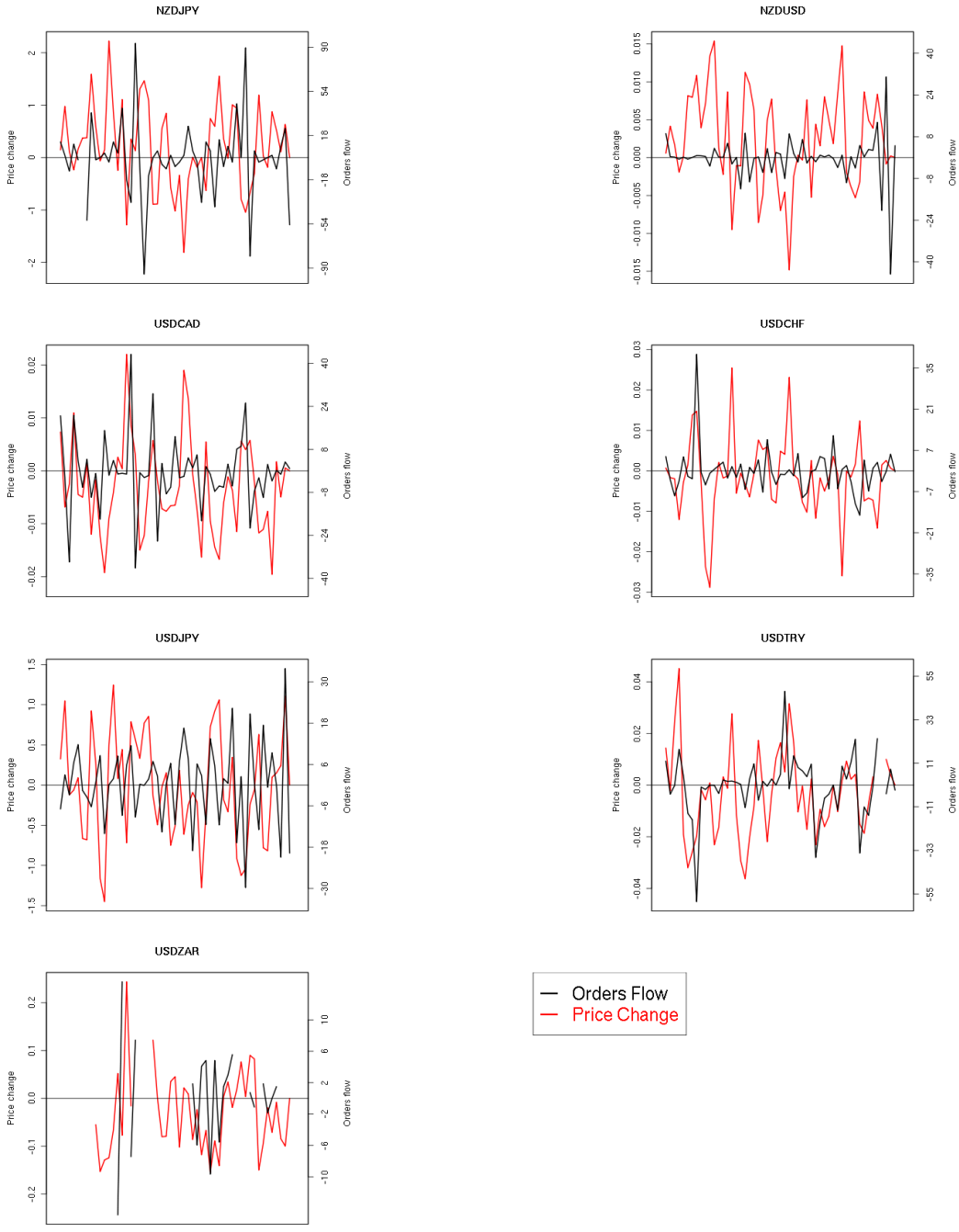

Figure 12.5: Daily exchange rate variations vs. orders flow.

Currency pair	R^2, %	Currency pair	R^2, %
AUDCAD	20.24	EURZAR	33.87
AUDCHF	45.55	GBPAUD	35.84
AUDJPY	25.69	GBPCAD	25.89
AUDNZD	35.84	GBPCHF	43.89
AUDUSD	24.69	GBPJPY	38.24
CADCHF	29.24	GBPNZD	36.63
CADJPY	34.64	GBPUSD	45.56
CHFJPY	25.15	NOKJPY	46.96
CHFSGD	43.62	NZDCAD	29.79
EURAUD	15.95	NZDCHF	37.22
EURCAD	19.66	NZDJPY	23.39
EURCHF	45.21	NZDUSD	28.63
EURGBP	35.31	USDCAD	31.23
EURJPY	29.22	USDCHF	32.95
EURNZD	25.44	USDJPY	29.48
EURSGD	36.88	USDTRY	40.17
EURTRY	27.48	USDZAR	64.26
EURUSD	43.53		

Table 12.2: R^2 of the Orders Flow model estimated on daily data.

The estimation process was iterative, whenever a coefficient was not significative, the corresponding variable was eliminated. The R^2 for the estimated models are given in the table 12.2 for each currency pair.

As can be observed, the orders flow model have decent explanatory power of price changes of actively traded currency pairs. It will be thus admitted as basic model for further exploration. Its step-by-step analysis is presented below.

Comparison with random walk. We are interested to know if the suggested model is any better than a simple random walk. We estimate the equation 12.15.

$$\triangle s_t = a_0 + e_t, \tag{12.15}$$

where $e_t \sim N(\mu, \sigma)$. The results of this calculation are have shown R^2 at zero for all the currency pairs without exception. In other words, the suggested orders flow model outperforms the random walk approximation, in average by 15.9% taking into account the currency pairs for which an

Currency pair	In-sample	Out-of-sample	Currency pair	In-sample	Out-of-sample
AUDCAD	20.24	32.59	EURZAR	33.87	12.13
AUDCHF	45.55	0	GBPAUD	35.84	0
AUDJPY	25.69	14.60	GBPCAD	25.89	0
AUDNZD	35.84	0	GBPCHF	43.89	34.64
AUDUSD	24.69	4.66	GBPJPY	38.24	41.32
CADCHF	29.24	0	GBPNZD	36.63	0
CADJPY	34.64	0	GBPUSD	45.56	41.93
CHFJPY	25.15	0	NOKJPY	46.96	0
CHFSGD	43.62	0	NZDCAD	29.79	3.21
EURAUD	15.95	9.18	NZDCHF	37.22	11.81
EURCAD	19.66	0	NZDJPY	23.39	0
EURCHF	45.21	0	NZDUSD	28.63	0
EURGBP	35.31	44.60	USDCAD	31.23	0
EURJPY	29.22	16.90	USDCHF	32.95	39.28
EURNZD	25.44	16.61	USDJPY	29.48	0
EURSGD	36.88	0	USDTRY	40.17	2.40
EURTRY	27.48	0	USDZAR	64.26	0
EURUSD	43.53	1.34			

Table 12.3: R^2 of the Orders Flow model for in-sample and out-of-sample data.

appropriate orders flow model was found.

In-sample and out-of-sample data. Orders flow model estimated for the period 1st March 2009 till 31st May 2009 is now applied to out of sample daily data from 1st June 2009 till 15th June 2009. R^2 for in-sample and out-of-sample data are compared in the table 12.3.

As can be observed, for those cases where the model could explain the out-of-sample variations, the R^2 was well comparable for the in-sample data.

High-frequency data. As our primary purpose is to build a model for intraday trading, higher frequency data is to be analyzed. The same procedure as described above, is now applied to hourly and minute-by-minute data over the same three month period of time. For the hourly data, last 6 periods are taken into account in the model. The number of past periods is increased to 30 for the minute-by-minute data. For each model, variables with non significant coefficients are iteratively removed. The calculated R^2 are shown in the table 12.4.

Currency pair	Daily data	Hourly data	Minute data	Currency pair	Daily data	Hourly data	Minute data
AUDCAD	20.24	18.49	10.41	EURZAR	33.87	4.09	-
AUDCHF	45.55	21.91	11.56	GBPAUD	35.84	19.18	15.37
AUDJPY	25.69	20.79	19.06	GBPCAD	25.89	18.49	14.60
AUDNZD	35.84	18.27	7.21	GBPCHF	43.89	27.63	16.84
AUDUSD	24.69	20.83	15.18	GBPJPY	38.24	20.90	22.35
CADCHF	29.24	21.82	9.82	GBPNZD	36.63	22.33	-
CADJPY	34.64	22.34	16.9	GBPUSD	45.56	21.36	19.31
CHFJPY	25.15	22.71	15.88	NOKJPY	46.96	9.60	-
CHFSGD	43.62	19.89	9.96	NZDCAD	29.79	19.75	6.16
EURAUD	15.95	21.09	15.07	NZDCHF	37.22	22.08	7.57
EURCAD	19.66	19.94	12.10	NZDJPY	23.39	22.24	14.57
EURCHF	45.21	26.80	8.71	NZDUSD	28.63	22.46	9.64
EURGBP	35.31	24.80	12.93	USDCAD	31.23	22.77	11.26
EURJPY	29.22	22.49	21.38	USDCHF	32.95	43.59	10.47
EURNZD	25.44	22.54	11.18	USDJPY	29.48	22.44	11.42
EURSGD	36.88	4.98	14.29	USDTRY	40.17	19.76	-
EURTRY	27.48	24.27	-	USDZAR	64.26	4.22	1.79
EURUSD	43.53	15.24	14.40				

Table 12.4: R^2 of the Orders Flow model for daily, hourly and minute-by-minute data.

The results obtained at this step are indeed interesting. As can be observed, the coefficient of determination steadily declines as the frequency of the data increases.

Analyzing the residuals. For each equation, we now calculate the series of residuals and approximate the distribution of these series

- first by normal distribution,
- then by alpha-stable distribution.

Several residual patterns and their estimated distributions are presented on the figures 12.6.

To evaluate quantitatively, which distribution is more appropriate to describe the data, we will use the Integral of difference (10).

$$I = \frac{1}{2}\int_{-\infty}^{\infty} |f_{X,e}(x) - f_{X,th}(x)|dx, \tag{12.16}$$

where

- $f_{X,e}$ is the empirical frequency,
- $f_{X,th}$ is the estimated, theoretical, probability distribution function.

This integral is always $0 \leq I \leq 1$ and can be interpreted as a part of the residuals' behavior, unexplained by the suggested distribution. In our particular case, we calculate

$$I_n = \frac{1}{2}\int_{-\infty}^{\infty} |f_{X,e}(x) - f_{X,normal}(x)|dx \tag{12.17}$$

$$I_\alpha = \frac{1}{2}\int_{-\infty}^{\infty} |f_{X,e}(x) - f_{X,\alpha-stable}(x)|dx \tag{12.18}$$

The table 12.5 shows the values the integrals 12.17 and 12.18, for each currency pair, as well as the residuals distribution selected on the basis of this calculation.

As can be observed, for all series with no exceptions, the α-stable distribution described the behavior of residuals more appropriately than the respective normal distribution.

Institutional vs. retail traders. To test whether institutional investors are better informed than individual traders, or, better to say, if their expectations are taken into account more seriously by market makers, we re-estimate the model 12.12 separately for the following groups of traders:

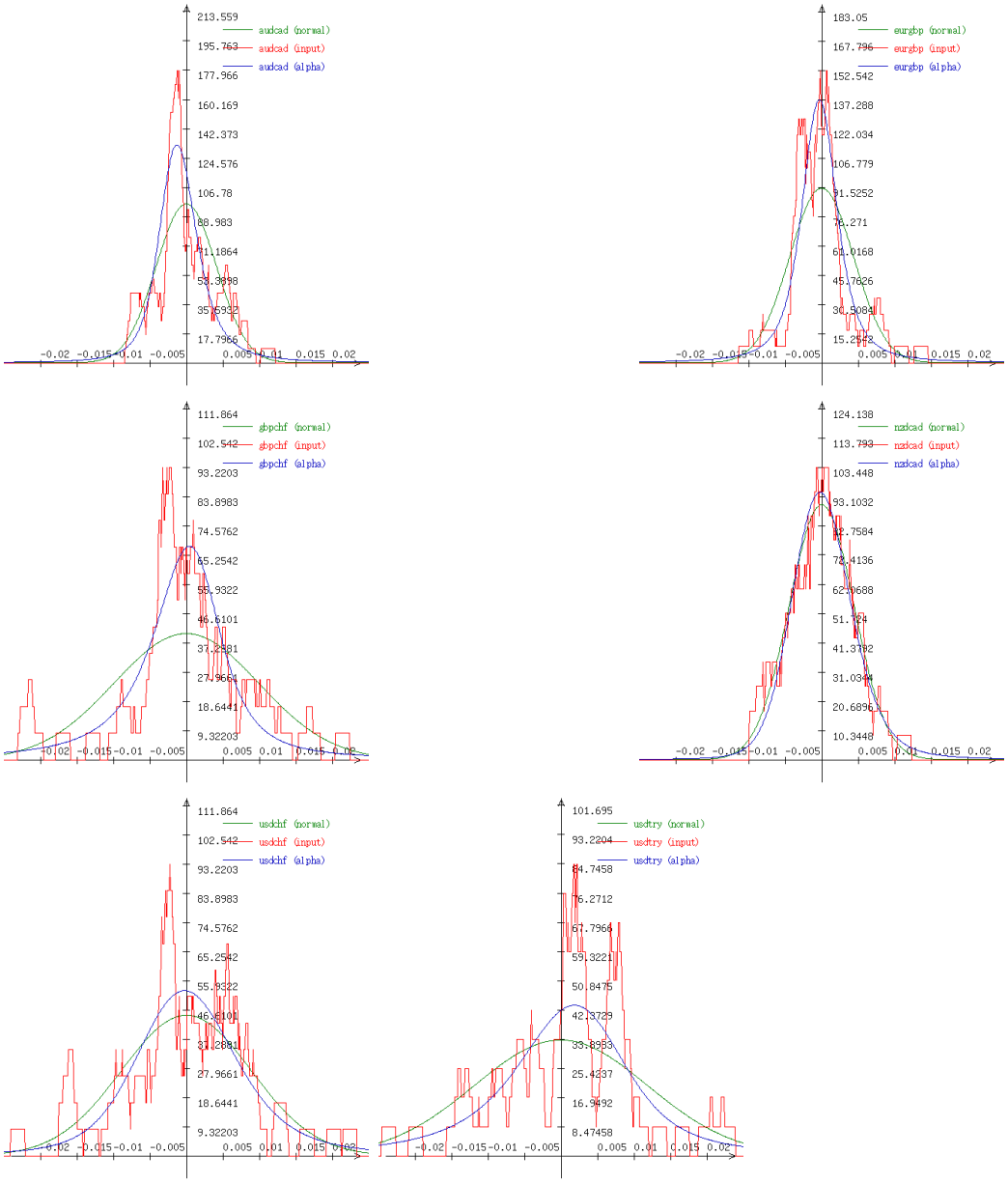

Figure 12.6: Empirical distribution functions (input) and their approximations with normal and alpha-stable distributions.

Currency pair	Integral of difference		Better res. distr.
	Normal	α-stable	
AUDCAD	0.0814	0.0448	α-stable
AUDCHF	0.0952	0.0555	α-stable
AUDJPY	0.1108	0.0776	α-stable
AUDNZD	0.0874	0.0473	α-stable
AUDUSD	0.1063	0.0545	α-stable
CADCHF	0.1193	0.0519	α-stable
CADJPY	0.1222	0.0783	α-stable
CHFJPY	0.1169	0.0756	α-stable
CHFSGD	0.1206	0.0484	α-stable
EURAUD	0.1033	0.0413	α-stable
EURCAD	0.1096	0.0462	α-stable
EURCHF	0.1947	0.0468	α-stable
EURGBP	0.1399	0.0426	α-stable
EURJPY	0.1304	0.0855	α-stable
EURNZD	0.1286	0.0504	α-stable
EURSGD	0.1075	0.0472	α-stable
EURTRY	-	-	-
EURUSD	0.1481	0.0540	α-stable
EURZAR	-	-	-
GBPAUD	0.0881	0.0564	α-stable
GBPCAD	0.0986	0.0508	α-stable
GBPCHF	0.1342	0.0426	α-stable
GBPJPY	0.1367	0.0937	α-stable
GBPNZD	-	-	-
GBPUSD	0.1483	0.0626	α-stable
NOKJPY	-	-	-
NZDCAD	0.1888	0.0554	α-stable
NZDCHF	0.1338	0.0488	α-stable
NZDJPY	0.1252	0.0803	α-stable
NZDUSD	0.1476	0.0768	α-stable
USDCAD	0.1904	0.0857	α-stable
USDCHF	0.1716	0.0603	α-stable
USDJPY	0.1665	0.0740	α-stable
USDTRY	-	-	-
USDZAR	0.4074	0.2974	α-stable

Table 12.5: Comparison of normal and α-stable residuals distribution estimation using the Integral of difference, for minute data.

Currency pair	Big	Medium	Retail	Currency pair	Big	Medium	Retail
AUDCAD	10.35	10.36	10.42	EURZAR	-	-	-
AUDCHF	11.55	11.55	11.56	GBPAUD	15.39	15.40	15.38
AUDJPY	19.05	19.03	19.06	GBPCAD	14.53	14.57	14.60
AUDNZD	7.24	7.19	7.21	GBPCHF	16.79	16.86	16.83
AUDUSD	15.20	15.20	15.19	GBPJPY	22.35	22.34	22.36
CADCHF	9.83	9.81	9.82	GBPNZD	-	-	-
CADJPY	16.90	16.90	16.90	GBPUSD	19.27	19.29	19.31
CHFJPY	15.89	15.89	16.89	NOKJPY	-	-	-
CHFSGD	-	9.93	9.95	NZDCAD	6.10	6.14	6.16
EURAUD	-	15.05	15.09	NZDCHF	7.51	-	7.57
EURCAD	12.10	12.07	12.10	NZDJPY	14.56	14.58	14.57
EURCHF	8.72	8.71	8.69	NZDUSD	9.63	9.71	9.62
EURGBP	12.92	12.90	12.93	USDCAD	11.26	11.29	11.26
EURJPY	21.34	21.34	12.38	USDCHF	10.56	10.45	10.46
EURNZD	11.18	11.17	11.18	USDJPY	11.48	11.43	11.42
EURSGD	-	-	14.29	USDTRY	-	-	-
EURTRY	-	-	-	USDZAR	-	1.81	1.79
EURUSD	14.17	15.09	14.40				

Table 12.6: R^2 (%) estimated for big, medium and retail clients, on the minute-by-minute data. "-" means transactions data is not available.

- Big traders: balance on the trading account exceeding 1 000 000 USD or equivalent in another currency,
- Medium traders: trading balance between 200 000 and 999 999 USD or equivalent,
- Retail traders: trading balance below 199 999 USD.

The R^2 for each group of clients calculated on the minute data is presented in the table 12.6.

Observing the results, we conclude that the predicting power of the order flow does not change depending on the financial size of traders generating the this order flow.

Instant execution and pending orders. Finally, in all the previous analysis pending orders were not taken into account at all until they become an active order, e.g. until the trader commits real money into a position,

following his estimations of the market evolution. However, pending orders themselves give additional information to the market makers about the price changes the trades expect.

We re-estimate the model on the minute data and two variant of order flow calculation:

- Initially used order flow of instant execution transactions,
- Alternative order flow of both instant execution and pending orders transactions.

Using the alternative order flow, we assume that the market makers base their price estimation taking into account the pending orders. Thus the pending orders are considered when they are placed and become known to the market maker, instead of the moment real money are committed into the trading operation.

The results of the estimation using the alternative order flow gave exactly the same coefficients and coefficients of determination as the initial model using the order flow for instant execution positions only.

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Chapter 13

Other Models for Forex Market and Special Cases

After having discussed both macro and micro approach to modeling the exchange rates dynamics, it is important to note that these two model types are not incompatible. In is typically assumed for macro approach that all the relevant information is publicly known and is reflected in current market prices. If any of these assumptions is relaxed, the order flow does explain a part of the exchange rates variations.

On the other hand, the micro approach does not claim the macro fundamentals do not define exchange rates. It rather says the order flow is more dynamic and forecasts those fluctuations better. The flow of orders merely reflects the belief of market participants materialized in form of their real money put into play.

A core distinction between the two approaches is the role of trades in price determination.

Fundamentals have little to no importance for intraday trading, and that the exchange rates are too much more volatile than any fundamental. As a remedy to that situation, a hybrid model, taking into account both short term and long term variations, was proposed by (16). The model has the following form:

$$\delta P_t = f(i, m, z) + g(X, I, Z) + \varepsilon_t, \tag{13.1}$$

where

- $f(i, m, z)$ is the macro component of the model,
- $g(X, I, Z)$ is the micro component of the model,
- i - nominal interest rates,

- m - money supply,
- z - other macro determinants,
- X - order flow,
- I - dealer's net positions,
- Z - other micro determinants.

13.1 Portfolio Shifts Model

Macro models are typically estimated on a monthly frequency data and have the form

$$\triangle p_t = f(\triangle i, \triangle m, ...) + \varepsilon_t, \tag{13.2}$$

where

- $\triangle p_t$ is the change in the log nominal exchange rate of the month,
- $\triangle i$ is the change in domestic and foreign interest rates i,
- $\triangle m$ is the change of money supply over the month,
- ε_t is the residual.

In this model, there is no place for the order flow in determining the price, any of its effects would be absorbed by the residual ε_t.

Micro approach generally leads to the following form of the model

$$\triangle p_t = g(\triangle x, \triangle I, ...) + \nu_t, \tag{13.3}$$

where

- $\triangle p_t$ is the rate change over two transactions,
- $\triangle x$ is the change in order flow,
- $\triangle I$ change in the net dealer position,
- ν_t is the residual.

Lyons and Evans (6) propose a new model which combines both macro and micro approach:

$$\triangle p_t = f(\triangle i, ...) + g(\triangle x, ...) + \eta_t. \tag{13.4}$$

The main difficulty in using this model is that the macro part of it is usually estimated based on monthly data, while the micro-part is often determined on high-frequent values - daily, hourly or even tick-by-tick. A fair and meaningful trade-off can be using daily data for both macro and micro variables, getting more frequent data for the first and aggregating the latter.

The two processes assumed in the portfolio shifts models are the following:

- As a portfolio shift occurs, it is not publicly known. It is manifested in orders on the forex market, the initial volume of which goes through market makers and then are completed by inter-dealer operations. The market learns about the shift by observing these operations.
- The shift is important enough to move the market price.

If the demand is perfectly elastic, then currencies are perfect substitutes and the Portfolio Shifts model approaches the Portfolio Balance model. But in the opposite case the portfolio shifts model is different. It has a constant asset supply and defines demand components - driven by public and non-public information. The later is reflected by portfolio shifts.

Lyons and Evans (6) estimate the Portfolio Shifts model in the following form:

$$\triangle P_t = r_t + \lambda \triangle x_t, \tag{13.5}$$

or

$$\triangle P_t = \beta_1 \triangle (i_t - t_t^*) + \beta_2 \triangle x_t + \eta_t \tag{13.6}$$

where

- $\triangle P_t$ is the change of the price between periods $t-1$ and t,
- r_t is the public information increment,
- λ is a positive constant,
- $\triangle x_t$ is the order flow,
- i_t is nominal dollar interest rate,

- i_t^* is nominal non dollar interest rate,
- β_1, β_2 are parameters,
- η_t is the residual.

Tests show that this model produces better than random-walk results for both in-sample and out-of-sample data, the forecasting being more precise over shorter period of time (39 days) rather than for a longer period of 89 days.

13.2 Evidence of the Portfolio Shifts Model

To test if the Portfolio Shifts Models is applicable to the Foreign Exchange, we estimate the following equation

$$\triangle s_{t+1} = b + \sum_{j=0}^{6} a_j \sum_{i=0}^{6} x_{j+i,t}^{DIS} + \sum_{j=0}^{6} c_j \triangle s_{t-j} + dr_t + e_{t+1}, \tag{13.7}$$

Overnight LIBOR rates announced daily, taken from www.dowjonesclose.com/liborrates.ht state of 29th June 2009, are taken for the values of the public information r_t. The iterative estimation was done in the same way as in the previous chapter. The table 13.1 allows for comparison of the R^2 between Orders Flow model and Portfolio Shifts model.

It can be observed that the addition of the macro economic variable does consistently improve the quality of modeling.

13.3 Evans-Lyons Model

Even though micro approach is most of time applied on high-frequency data, it stays valid on lower-frequency observations. Lyons (16) asked the question whether microstructure tools can be applied to exchange rate, taking into account two main aspects:

1. **The determination puzzle**: exchange rates are virtually unexplained by macro fundamentals, especially on short time periods;
2. **The excess volatility puzzle**: exchange rate are the way more volatile than the best measures of fundamentals.

Currency pair	R^2 Portfolio Shifts, %	R^2 Orders Flow, %	Currency pair	R^2 Portfolio Shifts, %	R^2 Orders Flow, %
AUDCAD	22.23	20.24	EURZAR	34.00	33.87
AUDCHF	46.17	45.55	GBPAUD	35.84	35.84
AUDJPY	26.31	25.69	GBPCAD	27.13	25.89
AUDNZD	42.67	35.84	GBPCHF	43.89	43.89
AUDUSD	25.04	24.69	GBPJPY	39.37	38.24
CADCHF	29.25	29.24	GBPNZD	39.51	36.63
CADJPY	35.05	34.64	GBPUSD	46.38	45.56
CHFJPY	25.15	25.15	NOKJPY	46.69	46.96
CHFSGD	43.79	43.62	NZDCAD	31.87	29.79
EURAUD	16.07	15.95	NZDCHF	49.10	37.22
EURCAD	19.85	19.66	NZDJPY	28.17	23.39
EURCHF	49.55	45.21	NZDUSD	31.58	28.63
EURGBP	35.44	35.31	USDCAD	31.44	31.23
EURJPY	30.43	29.22	USDCHF	33.04	32.95
EURNZD	31.84	25.44	USDJPY	29.73	29.48
EURSGD	36.90	36.88	USDTRY	42.71	40.17
EURTRY	27.95	27.48	USDZAR	75.08	64.26
EURUSD	43.73	43.53			

Table 13.1: Orders Flow model and Portfolio Shifts model estimated on daily data

The determination puzzle has been based on several simple observations. First of all, there are persistent time gaps between exchange rate and macro fundamental. The volatility of forex quotes largely exceeds that of macro fundamentals, and it persists even if the information about macro fundamentals does not change at all. The excess volatility arises in the model for new reason: rational exchange rate errors feed back into fundamentals that the exchange rate is trying to track.

The question is that if one cannot use macro fundamentals, what can be used. The first option are extraneous variables, like speculative bubbles. The second alternative is irrationality, e.g. avoidable expectations errors.

The macro and micro parts of the equation are not necessarily independent. It is rather the order flow that mostly determines the price, but macro fundamentals underly the process.

Let a periodic payoff on foreign exchange

$$R_t = \sum_{i=1}^{t} \triangle R_i, \tag{13.8}$$

where

- R_t periodic payoff,
- $\triangle R_i$, i.i.d. $N(0, \sigma_R^2)$, represent the public macroeconomic information, e.g. changes in the interest rates.

Market is supposed to be organized in the form of decentralized dealership and trades are performed in three rounds:

Round 1: dealers vs. public.

Round 2: dealers among themselves to share risk.

Round 3: dealers among themselves to share risk more broadly.

The orders of the round 1 are the core of the model, because they are known to the market maker, but not yet to the public. This order flow, through the adjustment of the estimation of the future market price by the market maker, moves the exchange rate.

The proposed equation for the price in the end of the day in the model is ((16), (5)):

$$P_t = \beta_1 \sum_{\tau=1}^{t} \triangle R_\tau + \beta_2 \sum_{\tau=1}^{t} X_\tau \tag{13.9}$$

and thus the change in price is

$$\triangle P_t = \beta_1 \triangle R_t + \beta_2 X_t, \tag{13.10}$$

β_2 being a positive constant. Intuitively, the term $\beta_2 X_t$ represents the absorption of the random order flow that took place in the beginning of the day. The value of the parameter β_2 is so that the there are no overnight positions, i.e. no positions left opened after the round 3. Even if such an assumption is a simplification of the real market process, there are two contradictive remark to be given here:

1. The mechanisms like rollovers and swaps (in the meaning defined earlier in this book) used by most market makers actually either close all clients positions in the end of the day, or at least approximate such an operation:
   - Some market makers automatically close all their clients' positions just before the end of the day, and reopen right after the beginning of the next day. Usually a regular fee is charged for this transaction.
   - Sometimes, to approximate closing and reopening positions, market makers and brokers simply charge the corresponding fee for positions opened overnight. This fee is usually justified by the fact the amount engaged in opened positions, usually leveraged, produces positive or negative interest rate for one day.
2. It is actually irrelevant for the simplification of the Lyons-Evans model if positions kept overnight are reopened or not. Even if all positions are closed automatically and then reopened in the beginning of the next day, they only reflect a stronger belief of traders into a certain future direction of the market, as they keep positions in spite of the costs they incur.

Authors finally estimate the following equation:

$$\triangle p_t = \beta_0 + \beta_1 \triangle (i_t - i_t^*) + \beta_2 X_t + \eta_t, \tag{13.11}$$

where

- $\triangle p_t$ is the change in the log spot rate between days $t-1$ and t,
- $\triangle (i_t - i_t^*)$ is the change in the overnight interest rate between days $t-1$ and t, and

- X_t is the inter-dealer order flow between days $t-1$ and t.

On the tested sample, the models showed to have a quite high R^2, between 45% and 64%, most of which is due to the orders flow X_t.

The authors describe the order flow and exchange rate dynamics. The authors define two fundamental macro fundamentals:

- Exchange rate determinants include extraneous variables, modeled as rational speculative bubbles
- Irrationality. The exchange rate can be determined in part from avoidable expectational errors.

In this particular case, the authors study the macroeconomics of asset pricing, the domain that has a large set of new developed models. The most important variable in those models is the order flow.

13.4 New Evans-Lyons model

Slightly alternative market mechanism is described in the new Evans-Lyons model (11).

Three important aspects of this new model are

1. Specification of the production technology for dispersed information,
2. Information available for financial pricing,
3. Mechanism that aggregates individual information sets into equilibrium actions.

The model describes the prices forming in four periods of time:

- Period 1. Quoting. Each agent holds domestic and foreign currency, as well as domestic capital. They announce the price at which they are ready to buy or sell the foreign currency. Quotes are publicly observable.
- Period 2. Trading. Each agent chooses the amount of foreign currency he wants to buy or sell to another agent. Exchanges generate the order flow, which is not known to all agents in the same time.

- Period 3. Quoting. All agents again give their quotes for exchange rates and one-month interest rates for domestic and foreign currencies. The interest rates reflect the rates at which agents are willing to lend or borrow funds.

- Period 4. Trading and real decisions. Agents select the final asset allocation they want to make.

Decisions of market participants are either consumption-savings related or aim financial and asset allocation purposes. After a series of simplifications and assumptions, the model showed the following empirical results. There are persistent gaps between exchange rates and macro fundamentals, which explains by the fact that exchange rates reflect all public information which is not necessarily all information. The excess of the exchange rates volatility takes place because of rational errors. Exchange rate change even if there are no news on macro fundamentals released. On the other hand, whenever the news about a macro fundamental is released, it does not necessarily move the price.

13.5 Dynamic Models

Most trading volume on the forex market comes from the inter-dealer trading. These transactions on their turn are defined by the non-dealer demand and supply. As Fan and Lyons (14) suggest, the extreme exchange rate movements have different sources. The high frequency movements are associated with flows from financial institutions, while the low frequency changes are mostly caused by non-financial corporations activity.

Most of models are designed for "normal" market conditions, i.e. no shock, no news announcements, no extreme events. However, trading on important news is a considerable part of the forex trading. Price movements are clearly provoked by the new announced values of macro fundamentals, and the adjustment is usually instantaneous or at least does not take longer than one hour period. In the moment of news announcement, the newly arriving information is considered to be and is probably very close to be really public. Detailed study of market conditions and liquidity changes around the news announcements and Central Banks interventions was presented in the Chapters 4 and 5.

Additionally, practically used statis and dynamic models should usually be recalibrated periodically to match the changing environment and market conditions.

13.6 Hybrid Models

Any of the presented models are not necessarily and strictly used in the presented form only. They can contribute to one another. For example, Medeiros (3) suggested a hybrid model by including to the basic Evans-Lyons model (6) additional variables representing a country-risk premium. Tests performed on the Brazilian foreign exchange market showed data, showed that the model had a good R^2, which was further improved by a GARCH estimation.

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Chapter 14

New Model for Forex Intraday Trading

As a conclusion of the performed study, a new model is to be presented. It takes into account every test performed all over the study as a building block towards an improved model for high frequency foreign exchange modeling.

14.1 Framework

Below is the summary of main the findings made so far by the present research and a description of the framework for the new model.

1. **Market participants.** While taking into account the activity of all market participants, the target "users" of the developed model are active traders aiming speculative profit on the foreign exchange market, as well as brokerage companies and market makers.

2. **Trading Mechanisms.** It is assumed that no regulatory restrictions apply to trading. Transactions are done electronically by traders via brokerage companies and market makers. The electronic transmission of information is assumed to be immediate. No additional delay is present in case of trading via an intermediary broker.

3. **Trade Instructions.** Traders use immediate execution and pending orders on any available currency pair. Price for immediate execution has to be specified, i.e. there are no requests on "best possible" price.

4. **Market Efficiency.** The market is not efficient in strong and semi-strong form. Interest rate parity does not hold at all times. Carry

trades are not consistently profitable. Market showed to be efficient in a weak form on minute data.

5. **Liquidity.** No major market crashes are happening. Major and small news announcements are coming regularly. The market liquidity is high and does not change depending if regional equity trading sessions is being active or not. The market liquidity does not change around the news announcements.

6. **Volatility and Risk Premia.** Volatility is appropriately measured by the Expected Tail Loss, as well as by the R-ratio. It changes over time. Traders are risk averse. No evidence of hot potato trading was found. Volatility was found to be increased during the first and the last 30 minutes of either regional equity trading session. Foreign Exchange Market does not display fractal properties. Trading short term on higher frequency information is generally more risk than trading over long term.

7. **Trading Costs.** Trading costs are not negligible and are supposed to be incorporated in the spread. No other fee are applied.

8. **Technical Analysis.** As the market is shown to be efficient in a weak form, the technical analysis cannot provide consistently accurate prediction.

9. **Fundamental Analysis and Trading Psychology.** Fundamental analysis is susceptible to provide correct predictions. Certain industries are susceptible to move the currency exchange rates. Market prices are influenced by human behavior, in particular the overreactions.

10. **Applicability of Equity Market Models to the Foreign Exchange Market.** Equity models are generally not applicable to forex market as is, but can provide ideas and econometric tools.

11. **Macro Based Models.** Models based on macro fundamentals alone fail to explain the forex intraday market movements. The simple intuition behind is that macro fundamentals do not generally change during the day, while prices are moving permanently.

12. **Models for Forex Market Microstructure.** Models for market microstructure, in particular the model of orders flow, most appropriately explain the market behavior, comparing to other studied models:

- Introduction of previous values of price changes (adding an $AR(n)$ part) improves the coefficient of determination.
- Model is appropriate for the out-of-sample forecast.
- Predicting power of the order flow does not change depending on the financial size of traders generating this order flow.
- α-stable distribution is appropriate to model the behavior of residuals.
- Ceteris paribus, the quality of the model decreases as the data frequency increases.
- Addition of macro fundamentals to build a hybrid model improves the forecasting ability of a model.

14.2 New model

Taking into account the considerations above, we start the construction of the new model based on the basic order flow model. In order to account for volatility clustering, i.e. when periods of high volatility are usually followed by other periods of high volatility, GARCH approach is to be used.

Next, we have seen that the addition of a macro fundamental improves the quality of the model. We include the overnight interest rate, as it both reflects the a macro characteristic of the economy and a part of the trading costs.

The data chosen for modeling should usually match the trading time horizon. However, as it was shown, the forecasting power of a model decreases as the data frequency increases. We thus decide to include a lower frequency data into equation. From the market standpoint, this decision is confirmed by the practice, when traders usually require that data on several time frames agree on the expected direction of the market, before they engage in a trading transaction.

Technically, we observed that series showed heavy tails. To account for this data specification, we admit the residuals follow an α-stable distribution ((3), (4), (5)).

Finally, for the best fit, instead of a simple linear regression, we are looking for a more complex relationship in a spline form ((1), (2)).

$$\triangle P_{t+1} = \alpha_0 + \sum_{j=0}^{k} \alpha_{1j} \triangle P_{t-j} + \sum_{j=0}^{l} \alpha_{2j} \triangle P^l_{t-j} + \sum_{j=0}^{m} \alpha_{3j} r_t + \alpha_4 i + \varepsilon_t, \quad (14.1)$$

and

$$\sigma_t^2 = \beta_0 + \sum_{j=1}^{p} \beta_{1j} \varepsilon_{t-j}^2 + \sum_{j=1}^{q} \beta_{2j} \sigma_{t-j}^2, \tag{14.2}$$

where

- $\triangle P_t$ price change in the moment t,
- $\triangle P_t^l$ price change in the moment t, on a lower frequency time frame,
- r_t order flow,
- i interest rates,
- α_i - parameters.

The distribution of residuals, i.e. the unexplained part of the price changes, can be approximated by an α-stable distribution. Due to extremely high market liquidity, the model will also stay valid for news announcements periods.

The purpose of the research is not only to develop a model, but also to make this model usable for everyday live trading. The order flow used in the model above is not known to most traders on the market such as speculators or hedged in interest arbitrageurs. However the order flow is positively correlated with the market liquidity, which can on its turn be reflected by the number of price ticks arriving in each particular moment of time. The model suggested for this group of market participants is the following:

$$\triangle P_{t+1} = \alpha_0 + \sum_{j=0}^{k} \alpha_{1j} \triangle P_{t-j} + \sum_{j=0}^{l} \alpha_{2j} \triangle P_{t-j}^l + \sum_{j=0}^{m} \alpha_{3j} v_t + \alpha_4 i + \varepsilon_t, \tag{14.3}$$

and

$$\sigma_t^2 = \beta_0 + \sum_{j=1}^{p} \beta_{1j} \varepsilon_{t-j}^2 + \sum_{j=1}^{q} \beta_{2j} \sigma_{t-j}^2, \tag{14.4}$$

where v_t is the number of price ticks in the period t

14.3 Evidence of the New Model

The new model is being estimated in three steps:

1. Apply the Multivariate Adaptive Regression Splines (MARS) to the first equation of the model.

2. Estimate the residuals using $GARCH(p, q)$.

3. Estimate the parameters of α-stable distribution of residual errors using McCulloch or any other method.

The "market makers' model" is estimated on the minute data over the last three months from 1st March 2009 till 31st May 2009. As a lower frequency time frame, hourly data is selected. To demonstrate that the model keeps the R^2 on the same level also for the out-of-sample data, tick-by-tick data between 1st and 15th of June 2009 is used. Same estimations are repeated for the "traders' model" with the same results in terms of quality of modeling.

There are three very positive results out of testing this model:

- The model for market makers having the private information about the order flow is as good as the model for traders observing the price volatility.

- This model outperforms all the previously tested models on the minute data.

- The out-of-sample performance of the model is as good as its in-sample performace.

One more observation about the model worth being mentioned here. As the equation was estimated, the MARS regression provides the analysis of impact of each independent variable on the dependent variable. Several typical charts describing this impact are presented on the figure 14.1.

As can be observed, the previous changes in price have the influence on the current change in price most of time only in their second part. In other words, increases in previous changes in price have more impact on the present change in price, than the decreases of them. This relationship has not been explored in details so far, but it is definitely another interesting research topic.

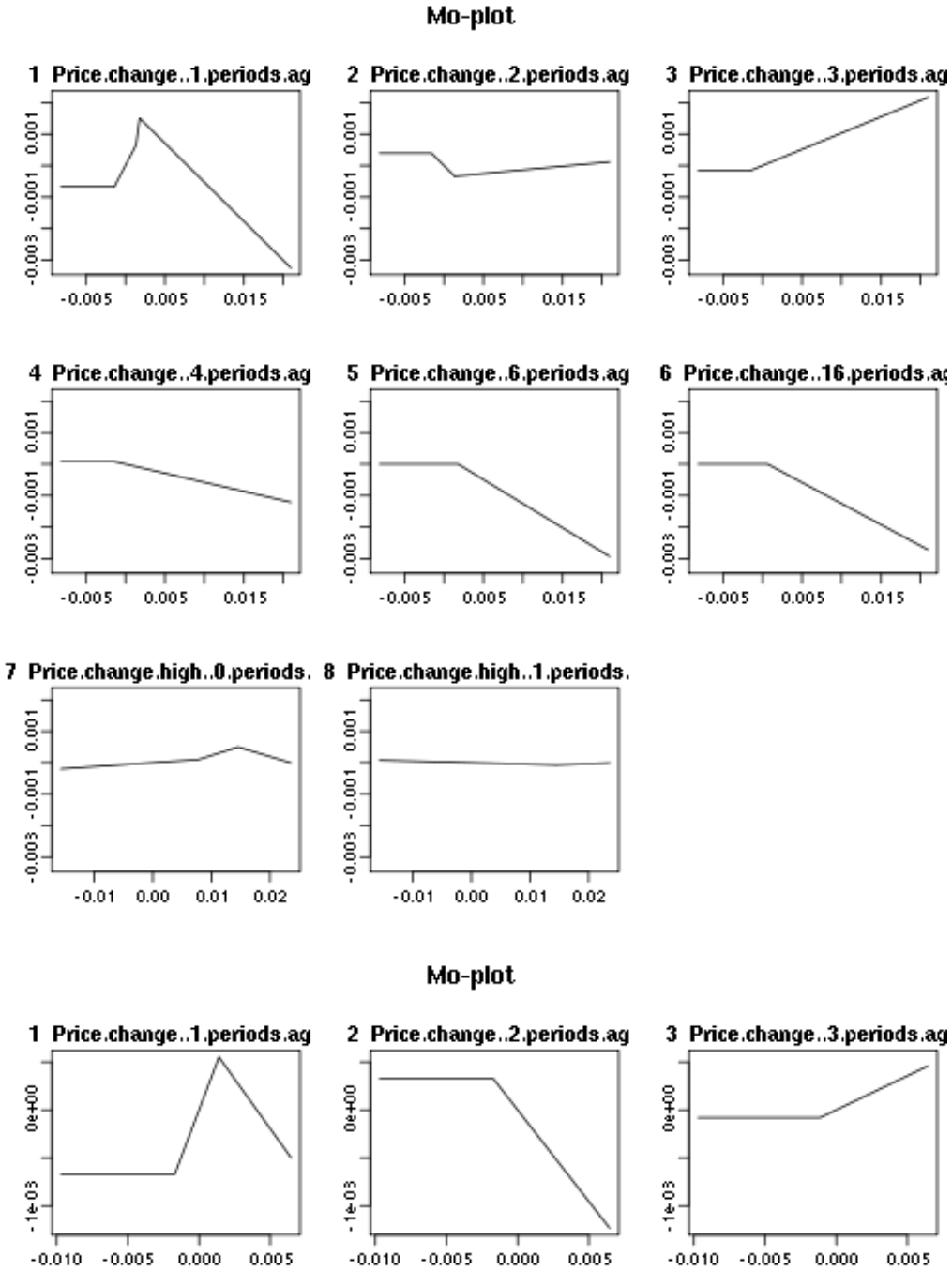

Figure 14.1: Influence of independent variables on the dependent variable in the new model for intraday trading.

Currency pair	R^2, in-sample	R^2, out-of-sample	Currency pair	R^2, in-sample	R^2, out-of-sample
AUDCAD	10.96	13.04	EURZAR	-	-
AUDCHF	13.48	16.97	GBPAUD	15.37	17.20
AUDJPY	20.08	20.52	GBPCAD	13.98	16.71
AUDNZD	7.59	7.81	GBPCHF	18.64	19.02
AUDUSD	16.53	17.80	GBPJPY	23.35	22.18
CADCHF	12.67	15.67	GBPNZD	-	-
CADJPY	18.28	20.59	GBPUSD	21.17	19.81
CHFJPY	17.29	18.34	NOKJPY	-	-
CHFSGD	9.48	11.97	NZDCAD	18.18	1.78
EURAUD	16.11	16.04	NZDCHF	10.39	8.69
EURCAD	14.20	15.36	NZDJPY	15.58	17.18
EURCHF	13.37	15.56	NZDUSD	10.14	11.98
EURGBP	14.83	15.32	USDCAD	14.15	18.81
EURJPY	22.48	21.95	USDCHF	15.88	22.19
EURNZD	12.10	14.23	USDJPY	15.79	8.66
EURSGD	13.70	15.82	USDTRY	-	-
EURTRY	-	-	USDZAR	64.26	
EURUSD	18.89	23.70			

Table 14.1: R^2 of the estimated new "market makers'" models, in-sample and out-of-sample data, in %.

14.4 Concluding remarks

The primary mission of the thesis was to an econometric model for risk evaluation and price forecast for intraday spot foreign exchange trading. By observing the result, we conclude that the goal was successfully achieved. The study first investigated various aspects of the foreign exchange market: liquidity, volatility, efficiency. Then, practical and theoretical approaches were considered, and macro, micro and hybrid models were explored and tested. Based on the observed market properties and models characteristics, the step beyond was made: a new model for exchange rates forecasts was proposed.

Two variants of the new model were developed: one for market makers observing the order flow, one for traders who do not have this information. As the main purpose of the practically used models is the price forecast, the forecasting ability of the model was chosen as the main evaluation criteria.

Both variants of the new model have the same modeling quality, which is as good in-sample as out-of-sample. The R^2 of this model is higher than the R^2 of any other model tested here on the minute data. Thus the new model outperforms the currently existing models.

However, some questions arose during the study and remained unresolved so far. First of all, the predicting power of the model, while better than that of the other models for a high-frequency data, can be further improved. This is particularly critical for its practical use. Also, it was observed that the positive and negative price innovations have different magnitude of impact on the market price. This phenomena remained so far unexplained and will be explored further, eventually in conjunction with market psychology studies. The future studies will attempt to bring answers to these questions.

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