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The Impact of the 2007-2009 Financial Crisis on the Relationship between Central Bank Rates and the Corresponding Interbank Interest Rates in 2002-2014

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Examiner: Post-doctoral researcher Elena Fedorova

ABSTRACT

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The role of central banks throughout the global financial system has become even more important during and after the events of the financial crisis. In order to stabilize the market conditions and provide solid ground for future development, the central banks use discount rate as their primary monetary policy tool in many developed and emerging economies.

The purpose of this thesis is to examine how the relationship between central bank rates and corresponding interbank rates has developed before, during and after the crisis period of 2007-2009 in five developed countries and five emerging market countries. The results indicate that during the before-crisis period the interest rate markets reacted diversely but the joint recovery attempts of global economies seem to have stabilized the reactions during and especially after the crisis. The crisis also seems to have highlighted the characteristics of each country's survival strategy as the role of other policy instruments arose.

TIIVISTELMÄ

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Keskuspankkien rooli maailmanlaajuisilla rahoitusmarkkinoilla on finanssikriisin jälkeen korostunut. Ylimpinä rahapolitiikan määräävinä eliminä keskuspankit määräävät ohjauskoron avulla rahapolitiikan ja korkomarkkinoiden tulevaa suuntaa. Ohjauskoron käyttö rahapolitiikassa on muodostunut entistä tärkeämmäksi rahapoliittiseksi välineeksi monissa kehittyneissä ja kehittyvissä maissa.

Tämän työn tarkoituksena on tutkia keskuspankkien ohjauskorkomuutosten vaikutusta interbank-korkoihin ennen finanssikriisiä, sen aikana, sekä kriisin jälkeen viidessä kehittyneessä ja viidessä kehittyvässä maassa. Tulosten mukaan markkinat reagoivat hyvin moniulotteisesti ennen finanssikriisiä, mutta maailmanlaajuisten rahapoliittisten toimenpiteiden ansiosta korkomarkkinoiden reagointi tasoittui finanssikriisin aikana ja etenkin sen jälkeen. Finanssikriisi myös korosti maakohtaisia talouden ominaispiirteitä kriisin hoidossa, sillä myös muiden rahapoliittisten välineiden merkitys alkoi korostua.

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LIST OF TABLES AND FIGURES

LIST OF APPENDICES

Contents

1. Introduction

1.1 Background

During these volatile times in global markets the role and importance of financial and economic stability cannot be emphasized enough. As the recent global financial crisis clearly demonstrated, a growing amount of various financial institutions delivering new kinds of complex instruments put even more pressure on worldwide stability of the financial system during difficult times. As economic growth began to stall, the risks related to creditworthiness, market conditions, asset pricing, liquidity and operational aspects arose rapidly.

In order to maintain a competitive and vital position in the markets each financial institution should naturally be responsible for assessing comprehensive risk management procedures for themselves. Nevertheless, many financial institutions severely failed in external and internal risk hedging procedures during mid to late 2000s. That said a crucial role in maintaining financial stability fell to central banks as they monitor and oversee the whole financial system due to their legal authorization. Interest rate level development plays a major role in these stability procedures.

As we all know, interest rates move up and down in global financial markets. These movements have a direct impact on debt securities' values as well as an indirect impact on equity securities' values. Therefore, financial markets have always been trying to anticipate the interest rate movements as the interest rate levels affect every organizations' day-to-day business, cost of capital, loan interest payments and market values of various securities. Properly handled

interest rate risk management can help financial institutions and companies benefit during favorable market conditions and also reduce the risk of unfavorable events as the economic downturn occasionally begins. As markets attempt to predict the future trend of market interest rates they closely follow announcements and information provided by central banks.

Central banks are monetary institutions that are responsible for managing the monetary policy and price stability as their primary functions. Moreover, central banks focus on sustainable financial stability by monitoring national financial system as well as governing currency policy, money supply and interest rate levels. One of the main monetary supply vehicles of the monetary authorities is discount rate, which further affects all the other market interest rates provided by other financial institutions. Discount rate is the lending interest rate which is charged to depository institutions borrowing funds from central bank. By increasing (decreasing) these lending rates, central banks are able to decrease (increase) economic activity as not only investments become less (more) attractive but also debt costs rise (lower) and vice versa. However the problem is that interest rate markets do not react in discount rate changes similarly, simultaneously or even with the same magnitude since there are differences in market volatility, timing of the changes and monetary policy intentions.

Literature regarding central banks' discount rate effects on market interest rates is fairly extensive. Systematic research of discount rate changes' effect on market interest rates dates back to 1970 when Roger N. Waud conducted his study. Waud (1970) was the first to differentiate an announcement effect linked to discount rate change. He found out that discount rate changes convey information of upcoming condition of the economy resulting eventually in equity price changes. Lombra and Torto (1977) later extended the analysis by introducing the distinction of endogenous and exogenous factors in discount rate movements. These research papers were the earliest studies to demonstrate and observe market reaction effects on discount rate changes.

Nevertheless, vast majority of the papers are focusing primarily on central bank of the United States, Federal Reserve, and its discount rate. Baker and Meyer (1980) studied the impact of Federal Reserve's discount rate changes on Treasury bill rates during the period of 1953-1978 while Thornton (1982) construed the connection between discount rate and market interest rates by utilizing loanable funds theory that explains the interest rate levels with supply and demand of credit availability. Later on Roley and Troll (1984) provided a "before-after" analysis on how the discount rate announcements affected market interest rates in the US around the Federal Reserve's policy change of 1979. A year later Smirlock and Yawitz (1985) published their findings regarding discount rate endogeneity and announcement effects on market rates.

Common factor for these early and mid-1980s studies was that majority of the studies found evidence of significant change in discount rate-market interest rate-relationship right after Federal Reserve adjusted its monetary control procedures to reserves-based implementation in October 1979. This creates an interesting background for investigating effects of other remarkable events of the markets on interest rate relationships. Another important discovery introduced in the earlier studies was the twofold conceptual classification of discount rate changes. In this distinction technical changes in discount rates are the ones conducted in order to match discount rates with market interest rates including no standpoint of central banks' monetary policy (endogenous change) whereas non-technical changes are the ones based on unexpected and therefore exogenous future discount rate policy changes by central bank (Smirlock et al. 1985).

Discount rate change effects have been studied also with more geographically spread data, although the amount of research papers is distinctly smaller. Hardy (1993) examined how Lombard rate, a German central bank rate used by financial institutions for short term liquidity needs, and discount rate changes signal information to markets and further have an effect on market interest rates

in Germany during 1975-1995. Also Neumann and Weidmann (1998) investigated the impact of former national central bank of Germany's, Bundesbank's, credit rationing policy change of 1979 on German money market rates. Various major financial markets have been studied since. Dale (1993) investigated the discount rate changes of Bank of England, Muller and Zelmer (1999) examined Bank of Canada's monetary policy's impact on interest rate markets and Rai, Seth and Mohanty (2007) conducted a study where discount rate data was collected from Germany, Japan, UK and France.

Although the impact of discount rate changes has been rather comprehensively studied, most of the papers are investigating the effects during time period of 1970-2000 meaning that the need for more updated data and further research has arisen substantially. Field of research also lacks broader global studies in which the effects and characteristics of central banks could be more clearly presented and classified. Recent financial crisis of 2007-2008 will also add an interesting point of study as the impacts of regressive economy in interest rate markets as well as unusually low and relatively permanent market interest rate levels are not extensively examined in this field of literature.

1.2 Objectives and research questions

The main purpose of this thesis is to examine globally scattered markets' monetary policy impacts on market interest rates before, during and after the financial crisis of 2007-2009. It is obvious that the economic situation was not evenly unfold throughout the world either before the crisis or after the crisis. After many international debt crises prior to mid-2000s, the United States was at a "booming"-stage as foreign funds were flowing to the country whereas Asian countries and Russia were painfully, although rapidly, recovering from the 1997-1998 financial crises. Moreover, post-crisis recovery started unevenly on global scale. This creates an interesting setting for crisis-related study in interest rate markets as not only the central bank-specific policies can be compared but also the impact on discount rate-market rate relationship (i.e. market reactions) can be analyzed.

The research problem setting is threefold. The analysis attempts to classify the effects of the financial crisis of 2007-2009 on the relationship between central bank rates and market interest rates and how the market reactions distributed on global scale before, during and after the crisis. The empirical model of this study aims at capturing evidence of differences between central banks that make regular rate adjustments compared to those with irregular central bank rate changes as well as to identify different characteristics of developed and emerging markets' reactions. Thirdly, as many corresponding market rates have plunged to previously unseen levels after the crisis and have maintained such levels for years, it will be of interest to see how this kind of unusual market environment has affected the announcement reactions in these particular markets.

These issues are explored in the thesis by expanding the interest rate relationship study of Rai et al. (2007) by implementing broader scale of interest rate markets during time period of 2002-2014. Discount rates or other suitable refinancing rates are gathered from ThomsonReuters Eikon, ThomsonReuters Datastream and websites of central banks. Central banks included in this study are Federal Reserve of the United States, European Central Bank, Bank of England, Swiss National Bank, Bank of Canada, South African Reserve Bank, People's Bank of China, Central Bank of Russia, Banco Central do Brasil and Central Bank of India.

In order to comprehensively investigate the effect of discount rate changes to term structure of interest rates, corresponding market rates consist of various maturities including overnight-rate, 1-month rate, 3-month rate 6-month rate (which is also the standard rate maturity in derivatives markets) and 12-month rate. As Rai et al. (2007) proposed, announcement effects can be captured in this thesis by dividing the effects into three sections: anticipatory effect (5 business days *before* the announcement), announcement day effect (announcement day or the next day) and learning effect (5 business days *after* the announcement). Test method used in the analysis is ordinary least squares-method OLS modified with Newey-West estimator.

1.3 Limitations

The focus of the thesis is on major central banks and corresponding interest rate markets from large and financially significant economies. Due to extent of master's thesis, some of the major global economies were left out of the analysis. Also some central banks' discount rate data were not consistently available. This is why the data is constructed in a way that both developed and emerging markets' characteristics could be captured to reasonable extent. As the analysis is concentrating on financial crisis of 2007-2009 and its impacts, other specific financial market events occurred during the analysis period will be overlooked.

As the analysis is focusing on time periods around the financial crisis, it has to be kept in mind that the impact of the crisis can be evaluated on several dimensions. Academic literature is somewhat divided between real economy-effect analysis that investigate GDP's and other macroeconomic variables' impact on interest rates and financial market-effect analysis which concentrate on stock indices, credit development and interest rate reactions more specifically. For the purpose of the thesis, analysis is strictly related to financial market-effects.

It also has to be recognized that there are various amount of other factors that affect market interest rates such as changes in financial institutions' risk premiums. Therefore, thorough analysis of other factors linked to the discount rate-market rate relationship will be disregarded since the aim is strongly at the behavior of market interest rates before and after discount rate announcements. At the same time, when comparing central banks it has to be kept in mind that each economy has its unique social structure and political system which naturally have influence on interest rate environment.

1.4 Thesis structure

After the introduction section the thesis is divided into two main parts. Theoretical part which consists of sections 2 and 3 begins with discussion of purpose and structural forms of central banks and introduces relevant monetary policy actions conducted in global terms. Then, the impact of central bank's monetary policy operations on other interest rates are considered in respect to other duties administrated by the monetary authorities. This brings a natural way of further introducing key concepts of discount rate-market interest rate relationship by reviewing the most relevant academic literature. The literature review section has been formed in a way that it introduces historical timeline of studies on relevant central bank rate-market interest rate analysis covering announcement effects, technical and non-technical changes in discount rates, literature on change frequency and magnitude, discussion of interest rate term structure formulation as well as interest rate markets' linkage to financial crisis of 2007-2009.

The empirical part is structured as follows: The fourth section defines the data-related concepts and introduces the research methodology, as well as presents the econometric models and tests used in this thesis in detail. The fifth section covers the discussion of empirical findings and has also two sub-sections due to categorization of central banks: developed countries including United States, Euro-zone, United Kingdom, Canada, Switzerland and emerging countries including South Africa, China, Russia, Brazil and India. The results are also divided into pre-crisis (2002-2006) and post-crisis (2007-2014) periods in order to analyze the behavioral change effects among countries.

2. Theory

2.1 The purpose and functions of central banks; introduction to central bank rates

Central banks are national or currency-union based monetary institutions which ensure nations' or unions' financial and monetary stability in long-run. As a banking authority, central bank administrates other financial institutions' and commercial banks' procedures in national scale and forms the bank-related legislation framework. Central banks are also responsible for proactively maintaining and fine-tuning nations' money base since they are monopolists in economies' money supply. Especially after the financial crisis of 2007-2009 central banks' role in mitigation of uncontrollable risk spreading as well as other supervisory actions have significantly increased because the interbank markets became severely disturbed. Reasons for interbank market's turmoil are discussed further on in sub-section 2.3.

Central banks take care of various monetary functions to affect economy's financial condition. As previously mentioned central banks are autocratically responsible for monitoring economy's money base which will be conducted by monetary policy instruments. Open market operations are primary policy instruments in which central bank intends to impact the amount of money base by purchasing or selling government bond securities. This kind of quantitative easing was widely conducted by Federal Reserve, Bank of Japan and Bank of England during the volatile times of the recent crisis. By utilizing open market operations central bank attempts to eventually affect short term interest rates. Therefore central banks tend to set a certain target or boundaries for short-term interest levels and their development. Common explanation for this in the literature is expectations theory of interest rates stating that long-term interest rate levels are affected by short-term interest rate changes as long-term interest

rates are composed of an average of current short-term and expected future short-term interest rates.

Both ends of the term structure of the interest rates are important. As long-term interest rates are constructed on expectations of future short-term interest rate levels meaning that whenever short-term end of the term structure changes, it will automatically affect longer end of the curve. Long-term interest rate are meaningful because they are closely linked to real economy's actions (Ang & Piazzesi, 2003). Long-term interest rate have a direct impact on investment decisions of public and firms, policy implications and asset valuation. However these particular linkages between central bank rate and longer end of interest rate yield curve will be left out of the analysis in this thesis for two reasons. Firstly, interest rate data for longer maturities, for example 5-year and 10-year swap rates, is weakly available for the analysis period, especially for developing countries and markets. Secondly, previous studies (Roley et al.1984, Cook et al. 1988 etc.) have shown that the relationship pattern between central bank rates and interbank rates can be captured even in shorter maturities.

Monetary policy actions conducted by central banks can be either expansionary or contractionary. Expansionary policy (lowering central bank rates) attempts to affect unemployment and credit availability problems during difficult times in economy by increasing money supply. Eventually this will target to economic situation in which businesses' investment willingness increases (bank rates decrease) and economy's general growth perks up as goods and labour markets stabilize. During contractionary policy actions (raising central bank rates) central bank focuses on restraining inflation by slackening or reducing money supply and further public and private spending. This will typically lead to increased market interest rates as well as increased reserve requirements for commercial banks. It can be considered that central banks are constantly balancing between stable economic growth and inflation-related factors. Chart

1 clarifies the transmission mechanism of how central bank rate affects economy in detail:

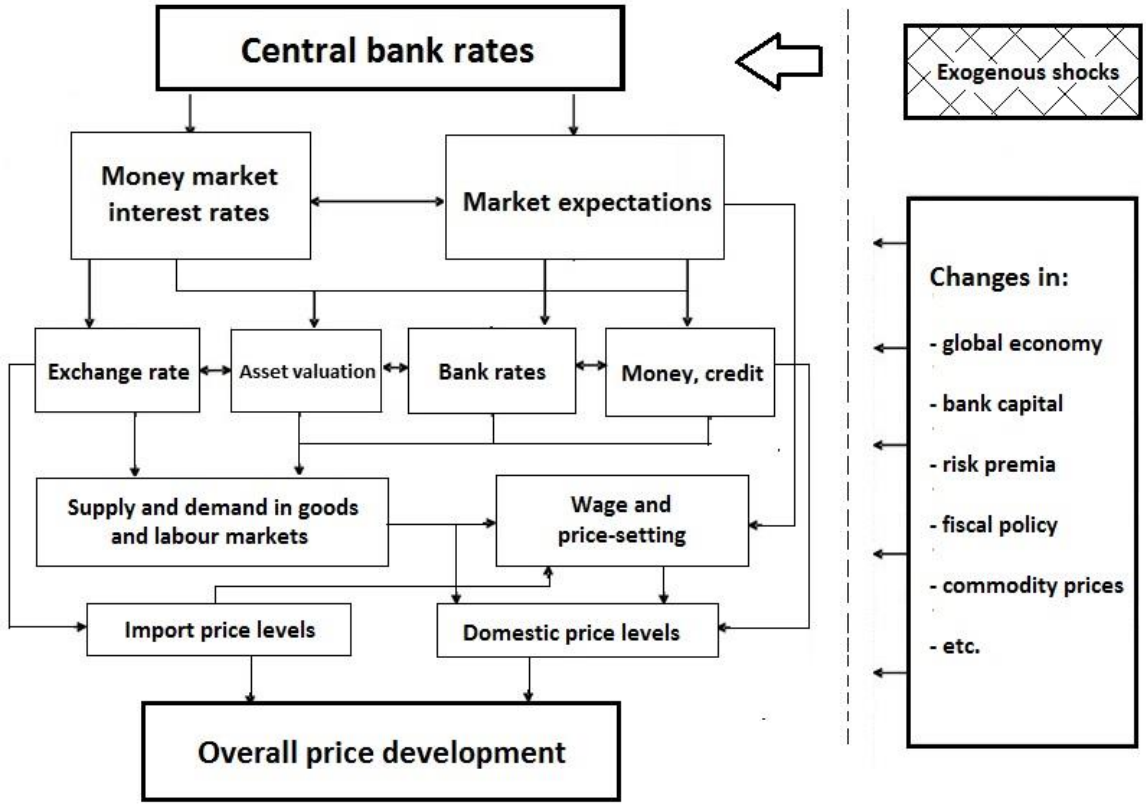

Chart 1. Transmission mechanism of central banks' monetary policy (European Central Bank 2014)

Transmission mechanism can be further opened up by explaining how interest rates fluctuate. Academic literature typically explains the interest rate movements by utilizing the loanable funds theory. According to the theory interest rate levels are closely linked to supply and demand of loanable funds. Demand-side refers to households, organizations, and governments (net-demand) whereas supply side consists largely of household and other savings (net-supply) provided in the markets. A key factor to notice is that central banks are also suppliers of loanable funds as the monetary policy actions of money

supply directly affect borrowing and spending willingness, as well as indirectly economic growth, inflation, budget deficit and foreign interest rate markets. This will further have an impact on demand environment of capital. As the money supply changes the level of aggregate borrowing and spending shift. This means that as the spending levels change it will further have an impact on supply and demand in goods and labor markets.

Before-mentioned reserve requirements for financial institutions are also one of the main instruments of monetary policy settings. By implementing a regulation of certain reserve level for banks to target, central banks are able to influence commercial banks' willingness of lending funds further. If the interbank market is somehow temporarily disrupted as is typically the case in crisis situations, financial institutions might not be willing to lend to each other in a fear of increased counterparty risk which will further lead to decelerated economic activity. Harmful consequences of these kind of situations are attempted to mitigate by lowering the central bank rate because it will automatically increase lending willingness. Central bank will therefore act as the so-called "lender of last resort" by maintaining a balance on financial institutions' reserve needs and therefore guaranteeing the vitality in interbank markets.

Alternatively, central banks can set a target for a nation's exchange rate in terms of other currencies or gold. This policy actions aims at maintaining exchange rate stability. The ways how open market operations are conducted vary among central banks since the volume and amount of capital flows are obviously diverse in different markets. Moreover, the main objectives of central banks may differ. For instance, Bank of England has set its main objective to maintain price stability with inflation target of 2% and confidence in national currency whereas Federal Reserve focuses more on employment maximization and composed interest rate development in the long run (Bank of England 2014, Federal Reserve 2013).

Central bank rates presented and analyzed should be precisely categorized as various central bank rates appear in the literature depending on the academic study or article. Central bank rates that are mainly focused on in this thesis are *discount* rates (sometimes referred as *official or key* interest rates). Discount rate further refers to central bank's lending rate that demonstrate the price at which a financial institution borrows funds from the central bank to meet required reserve level. This rate has to be distinguished from other central bank related rates presented in the literature. Typical example of other central bank rates is Federal Funds rate that represents the overnight rate at which the most creditworthy financial institutions in the United States borrow and lend reserves held by central bank to other financial institutions. As will be noticed, all central bank related rates have distinct characteristics in connection with market interest rates depending on the ongoing monetary policy and economy circumstances.

2.2 Relationship between central bank rate and market interest rates

Transmission mechanism presented in chart 1 clearly shows that central bank rate changes affect market interest rates in many ways. As central bank set discount interest rate as a monopoly banking authority, these changes will directly impact on money-market interest rates since central bank rates act as rate determinants in lending between commercial banks and central bank. Also the interbank markets are affected since the environment of funding between financial institutions change; As short-term interbank market rates are directly affected and commercial banks further provide financing to their customers, deposit and lending rates are indirectly adjusted by banks themselves.

The channel that impacts on commercial banks' lending and deposit rates by monetary policy actions is commonly referred as interest rate channel. According to European Central Bank (2010) interest rate channel, especially in the Euro area, has been evidenced to have the largest impact on the economy and price development which makes it most intriguing to analyze in the financial crisis context. In normal circumstances, every part of interest rate channel is connected with each other. Central bank rates affect money market interest rates and interbank markets, as well as further indirectly financial institutions' refinancing environment. This will eventually have an impact on retail interest rates for regular retail and wholesale banking customers, as stated before. During times of the transmission mechanism not working properly, problems regarding monetary policy intentions may arise. These problems are discussed in detail in sub-section 2.3.

Medium- and long-term market interest rates are also based on expectations concerning central bank rates. It can be stated that short term interest rates' development and expectations are built in long-term interest rates since long-term rates are determined by utilizing current and expected short-term rates in the future, as well as risk premium of future's uncertainty. Risk premium has a balancing effect on asset pricing and overall price development. Increased credibility of central bank will calm down the markets as the risk premium decreases and concern about both inflation and deflation mitigates. This way central bank is able to improve price stability efficiently.

Two other channels are straightforward as well. When the monetary conditions change in economy, central bank actions tend to impact on asset prices (asset price channel) and exchange rates (exchange rate channel). This was distinctly seen during the financial crisis of 2007-2009 and can be witnessed even today as housing, interest rate, equity and foreign exchange markets are greatly shaken leading to long periods of economic volatility. Although it cannot be said for sure that only unfavorable development of asset markets has caused the

spark of recent financial crisis, most of the major asset market transformations have led to economic imbalances throughout the world. Factors that led to ignition of economic turmoil after mid 2000's are also discussed in the next sub-section.

2.3 Evolution of financial crisis of 2007-2009

Ever since the Great Depression of the 1930s, financial crises have played important role in academic literature. Both the crisis of 1930s and recent financial turmoil of late 2000s have occurred after a period of very unstable economic development. The aftermath of global financial crisis can still be witnessed all around the world. Since the beginning of the crisis in the summer of 2007, governments and monetary authorities have put a vast amount of effort in risk management and the stabilization of financial markets.

As was also the case for the crisis of 1930s, the beginning of financial crisis of 2007-2009 was characterized by industry expansions and rapid economic growth. However, the global economy was not expanding evenly as several regulative barriers were removed to support favorable development of the national markets in few countries. Financial imbalance was initiated in the United States, where also the deregulative actions firstly took place. These actions were related to rapid rise of credit amounts in United States' mortgage market as well as subprime mortgage securitization.

When digging deeper, the key factor linked to initiation of the vast economic downturn was the maturity mismatch of banking procedures that were linked to short-term financing for wholesale customers. Financial institutions were distributing loans to customers in a way that the cash-flows of the loans were wrapped together resulting in formulation of *asset* backed securities (ABS) and *mortgage* backed securities (MBS). Main selling channels were Special Purpose Vehicles (SPV) that allowed the securities to be shown as off-balance sheet liabilities. This eventually led to situation in which SPVs issued short-term commercial papers to fund more illiquid long-term products.

As one might predict, the market liquidity eventually started to vanish. Starting from the US and quickly contaminating UK, the credit quality of these complex products collapsed as well as major rating downgrades and inadequate risk management procedures took place leading to extreme cautiousness in the markets (Borio 2009). Issuances rapidly freezed and customers were reluctant to roll-over maturing asset-backed commercial papers. Vast amount of asset-backed securities in the system led to funding to fade from the financial markets. Interbank lending problems spread all over the world as several financial institutions got in trouble. Central banks' liquidity actions were in crucial role during the times when key players (Bear & Stearns, Lehman Brothers, Citigroup, Fannie Mae, Freddie Mac etc.) faced tough times.

Financial crisis events and reasons for them have been extensively investigated. Đurašković (2014) summarized several structural weaknesses that led to unstable phase of global financial system. Due to the wave of deregulative actions, many extremely complex products were created in the financial markets. Products were innovative in a way that the regulators were lagging behind as trying to monitor and administrate all the new, risky products. Especially in the United States the shadow banking system, which consisted of non-financial credit-providers, was pooling various debt instruments thereby trying to allure investors with more tempting investment opportunities with

practically no transparency. Risky innovations spread also to derivatives markets making commercial banks taking too risky assets in their portfolios. Mainly because of the fact that the financial products had become more complex, risk evaluation of the products became even harder.

In addition to these weaknesses, markets had a handful of other problematic functionalities. Banks and other credit providers gave cheap financing without a proper risk evaluation leading to a situation in which the capital allocation ended up troublesome. Innovative product setup enabled investors to sell asset- and mortgage-backed securities, normally houses and properties, in short-term and then utilize temping long-term investment opportunities with selling returns. Also as the economic activity started to boom, company management's incentives were also reorganized in a way that bonuses and other compensation forms began to flow even during the unprofitable fiscal years. This was apt to cause catastrophic interest conflicts between top management and shareholders.

2.4 Impact of the financial crisis on central banks and interbank markets

It is obvious that while having the worldwide nature of the crisis, central banks were facing both global challenges as well as nation-specific issues as the recovery process had been eventually established. As was also the case during 1930s, the recent crisis began with massive expansion of credit and money base, constantly fluctuating volatile asset prices, growing weight of housing sector in the markets and favoring of combination of risk-taking and high confidence among the investors. Unexpectedly the recent crisis seem to have damaged economies with high dependency on foreign capital inflows, typically emerging economies, more than the countries of crisis origination (European Commission 2009). This increases the relevancy of deeper analysis on the relationship of central bank rate and corresponding market interest rates.

In order to understand policy response actions of central banks in crisis situation, it is crucial to understand historical development of global monetary system. Before the First World War the gold reserves were ruling the monetary system. Gold-exchange system was temporarily abandoned during the war but quickly taken back afterwards. However, the problems arose while the war had affected economies unevenly. Overall, especially in Europe, central banks were strictly focusing on protecting gold-linked interest rate. This meant that as being a part of the system, each economy had to follow certain budget and interest rate regulations. Obviously this meant that the economic environment and central bank setting was unique for each nation.

During the crisis of 1930s Federal Reserve had problems with execution of expansionary actions in the United States, making the crisis last longer and also making global economy’s decline even deeper. As gold-standard system made major economies vulnerably linked to each other, the crisis rapidly spread.

Financial situation weakened in Europe and markets were suffering from price decline, demand reduction and risen unemployment. In the beginning of 1930s, many countries decided to secede from the gold-standard system which turned out to be a major turning point in modern central bank system. The same kind of symptoms were also witnessed nearly 70 years later as well although the central bank actions were somewhat different. Linkages and dependencies between markets are still crucial when analyzing which interest rate markets suffered more than others during the recent crisis.

Times for cheap short-term financing were over in the interbank markets as the summer 2007 hit in. Before the credit and liquidity spreads skyrocketed, financial institutions were able to acquire unsecured short-term funds with significantly lower premiums than charged on secured borrowings. Wider spreads were obviously disastrous for many banks in need for funding. Financial innovations that were based on pooling and asset-backing started to collapse in 2007. Many international rating agencies re-evaluated a vast amount of bonds linked to subprime mortgages leading to wave of liquidation of these funds. Notable amount of investment funds began to tumble down and interbank rates started to rise.

Libor-OIS spread, which represents the spread between Libor-rates (act as benchmark interbank rates) and overnight indexed swap rate, is typically used to describe the risk and liquidity of the banking system. An overnight indexed swap is a swap contract between two counterparties in which fixed interest rate is swapped for the average overnight interest rate. This spread represents a valid tool for risk premia analysis as the credit and funding risk premia for overnight transactions has been only trivial even during the economic turmoil of 2007-2009 (European Central Bank, 2009).

As can be seen in figure 1, for instance the US 3-month Libor-OIS spread had maintained at the level of 10 basis points for months before the collapse but eventually burst to almost 350 basis point after Lehman Brothers, a major American investment bank, was left out of bail out aid in fall 2008. Funding became difficult as banks were extremely reluctant to lend funds.

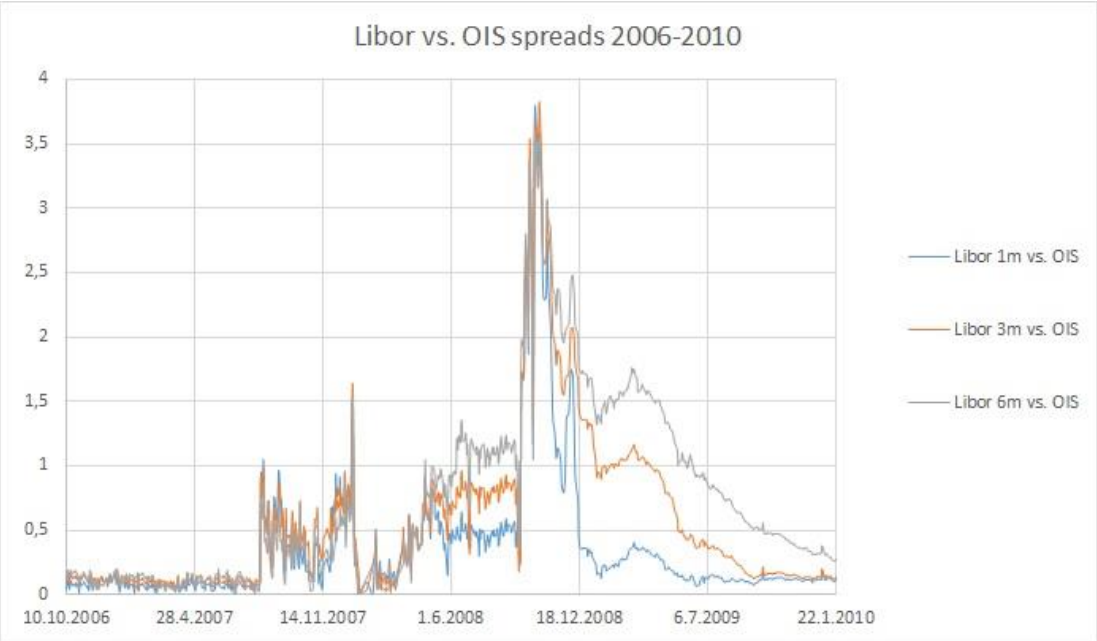

Figure 1. Libor-OIS spreads 2006-2010 (in percentage points)

After the interbank market collapse in late 2007, it was obvious that central banks focused on maintaining the financial system running. In practice, this meant that fragile financial markets had to be provided with liquidity aid which ensured that banks would not collapse and stability could be recovered. Financial institutions faced significant liquidity buffer requirements in order to be prepared for possible upcoming shocks. Many central banks also readjusted counterparty and collateral terms. Several improvement programs were also established to improve market functioning. Central banks' aid was also needed in money markets as the volumes dropped in major markets and banks had difficulties in meeting the adjusted reserve requirements. Therefore, the role of

the central banks in funding actions significantly rose and before-mentioned transmission mechanism of monetary system practically collapsed.

Central banks have learned a couple of important lessons from previous turmoils during the recovery process of the financial crisis of 2007-2009. The nature of the crisis was abnormal and severe so it is obvious that central banks have used various measures in order to balance markets. Federal Reserve and Bank of England relied mainly on quantitative easing policy which was conducted by vast government, corporate and other debt instruments' purchase programs whereas European Central Bank focused on providing ample reserves with tempting terms. Although the target of policy responses were somewhat common throughout the globe, the mechanism behind these approaches were obviously varying significantly.

Policy responses in the United States and United Kingdom were rather drastic. Large-scale purchase programs were implemented by central banks rapidly after the crisis took place. Programs were as significant as grossly equivalent to nearly one fourth of the GDP which meant that the central banks aimed at unconditionally quick changes in financial markets. This led to outstanding expansions in balance sheets of central banks. Federal Reserve started the quantitative easing programs immediately in 2008 by introducing liquidity measures in short-term needs: the Commercial Paper Funding Facility (CPFF) was firstly established and Term Asset-Backed Securities Programme (TALF) and Troubled Asset Relief Programme (TARP) later on. (Federal Reserve 2014, 2010)

European Central Bank clearly acted in a way that the integrity of monetary union could be maintained. In addition to liquidity provision by implementing main refinancing operations (MRO) and long-term refinancing operations (LTRO), as well as comprehensive fixing actions on interbank-markets, ECB

implemented the Securities Markets Programme in 2010 and two Covered Bond Purchase Programmes in 2010 and 2012 to heal transmission channel interruptions with asset purchase programmes. This was mainly conducted by purchasing troubled economies government instruments and backed securities. The ECB also introduced the Outright Monetary Transactions Programme in 2012 to support European Stability Mechanism (ESM). This announcement had a significant signaling effect regarding financial stability which later on had an impact on government bond yields in many EMU-economies. (European Central Bank 2015, 2012)

As we have seen, monetary authorities throughout the world have aimed at rapid expansionary actions which is clearly reflected in central bank rates. All the major central banks have significantly lowered the central bank rates in order to mitigate the risk of harmful effects spreading uncontrollably (see figure 2). Another crucial part of efficient recovery is the co-operation of global financial institutions. Authorities and financial institutions have made agreements concerning common monitoring and reporting procedures to help counterparties to compare and analyze financial data and risks.

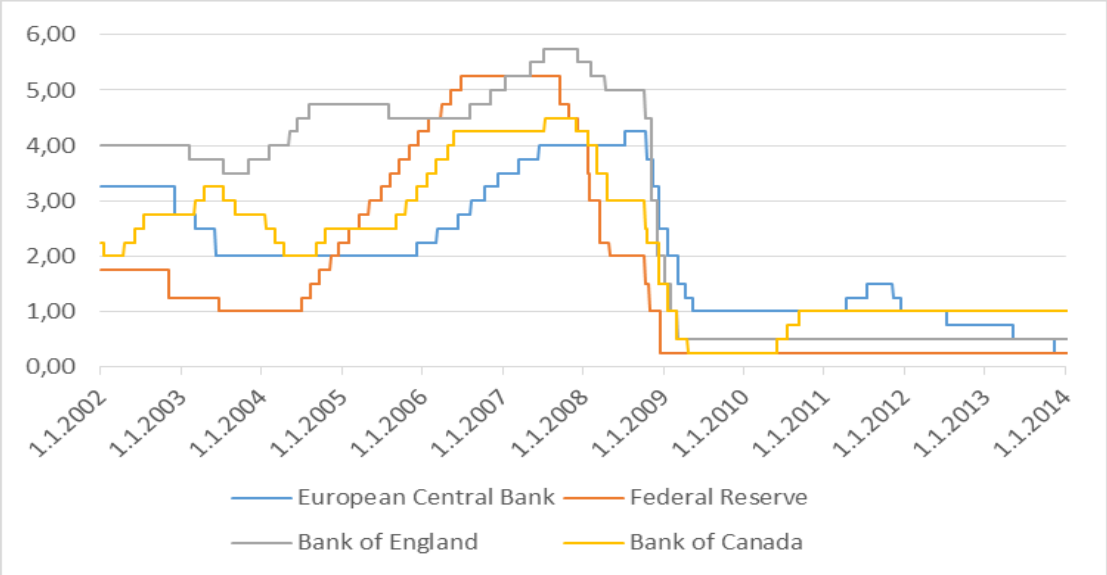

Figure 2. Central bank rate levels in 2002-2014 (in percentages)

Overall the recovery process has been sluggish and the effects can still be seen in money markets. European Commission (2009) stated that banks are maintaining long-term cautiousness in order to prevent such credit volatility impacts in the future and also risk management and valuation has drastically changed. Especially long-term funding procedures tied with mortgage and asset collaterals have been thoroughly re-evaluated. If volatile and insecure times in money markets prolongs, 10 basis point spreads might not be seen for few years ahead.

3. Literature review

Section 2 enlightened the relationship of central bank rates and market interest rates. Central bank rate changes have also been analyzed in academic literature with their impact on stock markets and foreign exchange rate markets but these aspects will be not evaluated due to limitations of the extent of the thesis. As this thesis is focusing exclusively on interest rate markets, it is crucial to mention at this point that the history of related academic literature is mainly connected to Federal Reserve's policy adjustments. Other central banks' actions have gradually started to gain more attention among the researchers and a review of these studies will be presented later on.

Waud's (1970) study is a valid starting point for discount rate research as he was the first to investigate central bank rate changes' impact on economic activity and market expectations. Waud argued that monetary policy changes has to affect businesses' and financial institutions' expectations on economy's movements. The point was that as there is a relationship between discount rate changes and financial institutions' expectations about the future to be found, this will have an impact on financial institutions' future net cash flows and further, on equity pricing. He also found evidence that as discount rate decreases, the movement tends to be anticipated beforehand by the financial actors. A possible explanation for this is that especially some market actors that are very close to money and interest rate markets have a close relationship and understanding of Federal Reserve's policy framework.

The angle from which the researchers have approached the topic is rather fragile and research methods obviously vary between decades. However, a common factor for most of the recent studies is that they aim to find a statistically significant explanatory, typically macroeconomic variable/variables that render the central bank policy actions. Examples of these variables are

presented in this section later on. The purpose of the section is to introduce relevant trend among the literature and demonstrate different research methods. That is why the third section is formed as follows: The first sub-section will bring relevant background to central bank rate studies whereas the next sub-section will proceed with historical timeframe in which all the notable studies from each century are accessed.

3.1 Background

After Waud's (1970) input, the central bank rate analysis began to gain more attention. Lombra and Torto (1977) analyzed Waud's findings and analyzed the relationship between Federal Funds rate and discount rate with later time period from 1968 to 1974. According to them, the announcement effect introduced by Waud could be recognized prior 1968 but after that there is no such effect to be observed. This is mainly because the role of monetary authorities and central banks was changing at the time and financial institutions' liability management was evolving rapidly. In late 1960's Federal Reserve's strategic policy changes led to a situation where Federal funds rate level (rate at which commercial banks lend money to each other overnight, see sub-section 2.1) rose over the discount rate (rate at which Federal Reserve lends bank money to financial institutions, see sub-section 2.1). Lombra and Torto (1977) also emphasized that in order to receive appropriate results, discount rate should be treated as endogenous factor since otherwise it could lead to severe misspecification and bias problems.

3.2 1980's - The beginning of systematic central bank rate research

In the beginning of 1980's the categorization of central bank's interest rate changes was brought to light by Thornton (1982). He argued that discount rate changes could be either technical or non-technical adjustments. Technical adjustments refer to interest rate actions by central bank in which discount rate adjustments are intended only to match market interest rates' development. Therefore these adjustments are not linked to central bank's policy regarding new economic information or market conditions. Conversely non-technical changes are adjustments that attempt to drive markets to desired direction by reflecting central bank's outlook of economy's future development.

As Lombra and Torto (1977) had done before, Roley and Troll (1984) also put the focus of their research on Federal Reserve's policy changes. In 1979 the US central bank was going through a three-year monetary control makeover as the targeting of short-term interest rate objectives were left behind. By the beginning of 1980, Federal Reserve had implemented a strategy in which it mainly concentrated on reserve availability of financial institutions. This strategy adjustment strengthened the role of discount rate as the central bank lending started to increase. Despite the earlier research evolution, Roley et al. (1984) were the first ones to analyze monetary policy effects on whole market interest rate term structure.

Interestingly, Roley et al. (1984) made very similar observation as Lombra and Torto (1977) stating that during times of strategic monetary policy changes the relationship of central bank rates and market interest rates also changes. They realized that before the Federal Reserve's policy change, various maturities of market yields did not vary significantly with respect to discount rate changes. However, during the period of monetary control makeover that lasted till 1982, the central bank's discount rate announcements had statistically significant

effect on market yields. This supports the expectation that monetary policy changes in terms of discount rate will have various consequences on market interest rates over the time of the recent financial crisis.

A year later Smirlock and Yawitz (1985) expressed their concern regarding discount rate's endogeneity and exogeneity issues. Majority of the previous studies had assumed that discount rate announcements by central banks can be either completely endogenous or exogenous. Smirlock et al. (1985) found this problematic since according to their empirical findings non-technical discount rate adjustments can be at least partially endogenous. However, the results supported the findings of Roley et al. (1984) that the period of Federal Reserve's policy change in 1979 to 1982 had significant announcement effects in market interest rates. Evidence clearly emphasized that markets tend to react (meaning the announcement effects should be witnessed) solely when the policy adjustment is unexpected and carries new information about central bank's intentions.

Federal Reserve's policy was reformed and operating procedures were adjusted again in 1982. Since then the central bank set a strategic framework to maintain predetermined level of average borrowed reserves for financial institutions instead of non-borrowed reserve level target that was used before. Thornton (1986) was interested to investigate this policy change in terms of interest rate relationships. He stated that previously presented view according to which the relationship of discount rate and market interest rate stems from supply and demand of credit is correct, though the effect on market interest rate can be threefold.

Direct effect represents the movement in which discount rate change directly impacts on supply of credit and further market interest rates. If discount rate is cut, financial institutions increase borrowing and therefore, the money base

expands leading to market rates to decline. *Announcement effect* refers to signaling effect of markets' expectations linked to central bank's policy on market interest rates. It conveys possible scenarios of central bank's actions regarding future path of the markets whereas *policy effect* defines the actual policy adjustment of central bank. Empirical results indicated that announcement effect exclusively has the strongest explanatory power on market rate reactions disregarding the significance of other two effects.

Announcement effects were investigated closer by Cook and Hahn (1988). They pointed out that discount rate changes signal information to markets in various ways which is why market participants' reaction to announcements varies. According to them, markets can learn central bank's announcement ideology concerning funds rate development and therefore forecast upcoming movements in funds rate levels. Cook et al. (1988) argued that this is why especially short-term market interest rates might be affected purely by learning effect and not by central bank's implemented policy itself. Interestingly, they found that right before the Federal Reserve's policy change of 1979, discount rate announcements had significant explanatory power on market interest rate, unlike previous literature presented before.

In general, years in 1980's were rather fragile in central bank rate related literature. As the field was gaining more interest among the academics, many researchers introduced their own categorizations regarding discount rates and research periods on focus varied substantially mainly because of several strategic changes in monetary policy during the decade. However, common factor for these studies was that the vast majority of the remarkable studies were conducted in the United States and they examined the impact of Federal Reserve's actions on market interest rates. Other central banks' key rate analysis was not widely of interest to academics until 1990's when research field began to expand.

3.3 1990's and 2000's – Research field starts to expand

Central bank rate analysis began to diverge in the beginning of 1990's. Dueker (1992) expressed his concern linked to previously presented categorization of technical and non-technical discount rate changes. He stated that there can be found a more precise way to present factors behind market interest rate reactions than previously considered. By utilizing individual macroeconomic factors to explain the response of market interest rate, Dueker created the *mixture model* that performed mainly better in estimating and forecasting future market reactions in the period from 1973 to 1989 compared to models relying on technical and non-technical differentiation.

Dale (1993) conducted his study by using Bank of England's official rate announcement data to analyze central bank rate's influence on overall market interest rate term structure. In 1980's academic literature concentrated on explaining the importance of short-term interest rates and how the central bank's announcements affected the monetary transmission mechanism. This is why the key focus regarding the market interest rate impact was on short-term interest rates. Dale believed that the effectiveness of transmission mechanism could be better understood if long-term interest rates were added to analysis. Cook and Hahn (1989) shared same kind of insights as they were examining the relationship between Federal Funds rate and the corresponding US market rates.

Dale (1993) found statistically significant evidence that market rates responded to central bank rate changes along market interest rate's term structure and there is reason to suppose that long-term interest rates are formed from forecasts of upcoming short-term interest rate levels in the future. Not surprisingly, Dale also found support for parallel movement in central bank rate-market interest rate relationship, especially for maturities from three to twelve

months. Nevertheless, probably the most interesting finding of the study was related to possible market efficiency problems. Dale stated that systematic shifts in market interest rates were witnessed both in days before central bank rate change and also right after the official rate adjustment. This is why it is interesting to see how globally dispersed central banks with different policy adjustment methods and more importantly, corresponding market interest rates reacted at the time of announcements before, during and after the financial crisis of 2007-2009.

In the same year Dale had published his findings, Wagster (1993) attempted to conclude main findings of controversial study field of 1980's. As mentioned before Cook et al. (1988) had different conception about Federal Reserve's announcement intentions during Federal Funds rate targeting period of 1973-1979 than Roley et al. (1984) and Smirlock et al. (1985). Wagster (1993) created a model that mitigated the differences of central bank rate announcement classifications and divergent analysis periods of each of the three studies and found out that by eliminating the impact of years 1973-1974, Cook et al.'s (1988) results would have conformed with Roley et al. (1984) and Smirlock et al. (1985) who stated that during the period of 1973-1979, market interest rates did not statistically respond to Federal Reserve's announcements.

Thornton (1994) was skeptical about the insight that there should be unequal market responses to be witnessed during monetary policy changes. He examined Federal Funds and T-bill rates' movements after central bank's non-technical discount rate announcements and concluded that typically market rate responses were both immediate and simultaneous with discount rate changes. This encouraged to sum up that level or magnitude of discount rate adjustments do not reflect to market interest rates per se; new information conveyed to the markets during announcement is far more important. The magnitude of market interest rate reaction obviously depends on the nature and information content of each individual announcement.

Theory concerning central bank's actions and monetary policy's transmission mechanism to economy has had a tendency of being explained by a connection between monetary policy adjustment and corresponding market interest rate responses. The standard view in many earlier studies introduced before had been that central bank rate changes have a significant impact on short-term market rates whereas long-term market rate relationship is weak and seldom reliable. This problematic setup started to interest academics even more.

Consistent with Dale (1993), Roley and Sellon (1995) were confident that the effectiveness of monetary policy and transmission mechanism can be more thoroughly understood by examining the relationship between central bank's monetary policy actions and long-term market interest rates. Roley et al. (1995) found out that the connection between these interest rates seemed to be linked to market participants' stance of stability of central bank actions. Cyclical changes in economic outlooks might therefore be much more important factors in understanding the connection between monetary policy and market responses than previously known.

Research field spread further in Europe in mid-1990s. Hardy (1995) was the first to examine market interest rate's reaction to German central bank's, the Deutsche Bundesbank's, official interest rate announcements. His study comprehensively categorized various interest rates', exchange rates' and stock prices' impacts linked to announcements, as well as attempted to identify and separate anticipated and unanticipated effects. Hardy (1995) found out that the central bank was able to use strong signals of its policy implications as an instrument to convey information to the markets. This was clearly observable in whole term structure during the test period of 1985-1995. Hardy also highlighted that signaling effects could be found in both anticipated and unanticipated announcements implying that the change of central bank rate provides additional information along with public announcement alone.

Even more interesting findings can be found from Hardy's (1995) study as the results are compared with prior studies from the US (Roley et al. (1984), Smirlock et al. (1985) etc.) and that of Dale (1993) from the UK. It seems that Federal Reserve and Bank of England have had slightly larger impact on market interest rates on the day of discount rate change, especially in shorter maturities. Hardy suspects that the reason for this is twofold. Firstly, not only the Deutsche Bundesbank had given clearer warnings of official rate change in advance compared to the US and UK central banks, but also Anglo-American economies tend to have a history of more volatile inflation and interest rate markets.

Neumann and Weidmann (1998) concluded comparable results as Hardy (1995) before; German central bank's discount rate changes were exclusively related to announcement effects after 1979. They also shared a view that discount rate has a solid state as a policy instrument regardless the availability of instruments like repo rate changes and public announcements that typically offer much more flexibility. Nevertheless, German market interest rates had only responded to unanticipated discount rate adjustments. The authors found evidence that the market interest rates' response declined along the market rates' term structure as presented by Lombra and Torto (1977), Roley et al. (1984), Thornton (1986, 1994) and Hardy (1995) for example.

Thornton's (1998) research was probably the last noteworthy study from the 1990's. He conducted tests that varied from previously introduced hypotheses related to Federal Reserve's discount rate changes as he wanted to distinguish pros and cons from them. Like Neumann et al. (1998), Thornton stated that market interest rate connection is solely because of announcement-related effects. Nevertheless, it is difficult to differentiate between technical and non-technical discount rate adjustments since the central bank acts as monopolistic monetary authority and has therefore power to make decisions concerning the nature of change (technical vs. non-technical), magnitude and timing of change.

This creates challenges for market participants to anticipate characteristics of discount rate adjustments.

Overall, the majority of research papers conducted during the late 1980's and 1990's are linked to monetary policy related discount rate adjustment's market reactions which are further explained by various hypotheses. Research field got many new insights as the spectrum of central banks examined become broader, as well as differentiation between monetary policies and interest rate market gained more interest.

One of the few notable researches during 2000's emerged right after the financial crisis had begun. Rai, Seth and Mohanty (2007) were the first to examine official discount rate adjustments effect on market interest rates in global scale. They analyzed Germany's, France's, the UK's and Japan's central bank rates against corresponding market rates in whole term structure. The key findings were that there were country-specific changes to be observed and that the frequency of central bank rate adjustments have impact on market rate responses. This is why it is appropriate to assume that various central bank rate-market interest rate relationships did not act similarly during financial crisis either. Therefore Rai et al.'s (2007) study will be used methodology-wise as a background study in this thesis.

By this point it is extremely important to mention that many previous studies applied linear regression methods with various modifications like also done in this thesis. Methods used in the literature are attempting to explicate how market interest rates react in discount rate announcements and money supply changes. Roley et al. (1984) found out that even with occasional problems with low explanatory power, linear regression is still most suitable method for capturing relevant announcement effects on central bank rate and market interest rate relationship. In addition to Rai et al.'s (2007) study, Urich and

Wachtel (1981) did linear regression-based event-time approach to explain market's reaction to changes in national money supply. Ruoppa (2008) investigated central bank rate announcement's impact on market interest rates before and after the establishment of joint monetary union in Europe by exploiting OLS linear regression model. Utilizing OLS-model in this thesis is therefore valid and suitable analysis method.

Later studies regarding the environment of financial crisis in 2007-2009 can also be found: León and Sebestyén (2012) analyzed monetary policy surprises' effect on interest rate markets in Europe concluding that the importance of information distribution between market participants plays even greater role during and after volatile times and afterwards. They pointed that even though the predictability of monetary authorities' actions has enhanced in recent years, central banks have to focus more on the way they convey information to the markets as the stability and further market reactions are highly dependent on the information content of the announcement. Another interesting finding was that as ECB was having more frequent meeting schedule it tended to cause more volatile market reactions. As markets started to learn the announcement procedures and the central bank held meetings less frequently, surprise reactions substantially decreased.

Fiordelisi, Galloppo and Ricci (2014) conducted an event-study concerning the effects of monetary policy intervention on market interest rates and liquidity and credit risk premia. They found that in recent financial crisis periods, LIBOR-OIS spreads reduced during central bank rate cuts and increased during central bank rate increases. Interest rate adjustments are therefore extremely important in reducing credit and liquidity risks, especially in crisis periods. This insight was also supported by Aït-Sahlia, Andritzky, Jobst, Nowak and Tamirisa (2012).

Naturally right after the global crisis had begun, the interest for anatomy of the crisis, as well as the key consequences for world economy started to gain more attention. Articles, publications and discussion to be presented are not strictly related to central bank rate-market interest rate relationship itself but contain and conclude reasons and linkages that are of interest in this thesis. Therefore the factors regarding interest rate market effects, as well as monetary policy implications during the crisis of 2007-2009 are discussed. It will further help to make assumptions how market interest rate might have reacted to changes. So far the analysis has been linked to events of developed economies and their central banks. It is fair to assume that emerging markets have reacted to financial crisis of 2007-2009 differently because of the political, environmental and financial divergences. The nature of the crisis in couple of emerging economies will be discussed next.

Russia belongs to the list of major emerging economies and is a part of BRIC-categorization along with Brazil, India and China. Before the vast global collapse, the economy was domestically booming in Russia. Looking back five to ten years, Russia was outperforming other fast-growing BRIC-economies by various measures, especially in GDP growth-rate (Gaddy & Ickes 2010). However, the problems with Russia were very similar as they had been a decade earlier. Oil prices sunk in the markets which was then directly linked to Russia as its economy is highly dependent on oil and gas business, as well as on the oil price. This led to the situation where Russia’s stock markets and industrial production dropped heavily. In addition, the interest rate markets were obviously shaken in Russian markets. Figure 3 represents a drastic example of the development of Russian market interest rates and oil market price levels during the recent crisis.

Figure 3. Oil Brent Price Levels vs. 3-month Moscow Prime 2005-2010 (in US-dollars and percentages)

The importance of oil and gas cannot be underestimated in Russia's case; administrating vast oil and gas resources is the base for the whole political, environmental and financial system in the country. As in many other natural resource-dependent economies, Russia has implemented a resource rent system based on structures inherited from the times of Soviet Union. Rents represent not only the income from national oil production but they also excess extraction costs and other informal rent distribution impacts. In order to understand the linkage between interest rate markets and oil dependency as well as the state of Russian economy during the economic turmoil, it is crucial to take a look at the rent levels. Since 2002, Russian oil and gas rent levels soaked significantly but in the mid-2008, the levels went into a tailspin. (Gaddy et al. 2010) This was extremely problematic since the oil companies' success is greatly tied to economy's condition and further to investment environment and interest rate levels.

China has gone through some notable changes regarding its structural and institutional systems during the last 20 years. Central bank of China, officially People's Bank of China, is nowadays only partially responsible of implementing the economy's monetary policy as it has to negotiate the final rate targets with the governmental authority, the State Council. Moreover, there are other non-central bank dependent instruments that are used by authorities to affect monetary policy's effectiveness. This is why central bank's role as an independent monetary authority is slightly different in China than it is in other large economies.

What comes to interest rate markets, China's interest rates are still largely controlled by authorities despite the transformation attempts to liberalize interest rate markets. Due to the lack of full liberalization, the interest rate channel linked to transmission mechanism is twofold. Part of the instruments, such as minimum reserve requirements are acting directly with the central banks' intentions. However, there are also instruments that are not fully liberalized and therefore act connected with central bank's lending and deposit rates. This means that that under the case of administrative changes in rates, financial institutions have to modify the interest rate for money already at their disposal. (Fernald, Hsu & Spiegel 2014) This put even more pressure on China's economy during the financial crisis and recovery process.

Nevertheless, China reacted with vast intervention actions compounded with accommodative monetary policy which started the economic aid rapidly. This was also a strategic choice as China's role as investment-driven nation emphasized; China had been mainly an export-based economy for years. Countercyclical policy change was crucial to avoid China's own economic recession but side effects arose. Many companies that were not owned by the government got in trouble as their situation had weakened because of the global decline of demand and they had to seek for financing elsewhere. This was the initiation of famous shadow banking system of China. Boost in China's economy

had an indirect impact on other countries as well because the imports eventually began to blossom. Not only many neighbor markets but also Australia and Brazil gained benefit from China’s recovery actions. (Risager 2013)

4. Data description and methodology

4.1 Reseach questions

Although the empirical research field regarding the relationship between central bank rates and market interest rate is rather extensive, there are issues that have not gained much of attention among the academics. Many earlier studies have focused on single central bank's monetary policy implementations as well as disregarded the analysis of anticipatory, announcement and learning effect together except for Rai et al. (2007) and Ruoppa (2008). Also the impacts of financial crisis on interest rate markets and central banks' monetary policy implementation have not been investigated properly on global scale. This thesis will attempt to enlighten these issues.

The purpose of this thesis is to give answers to following issues. Firstly, what kind of impact has the financial crisis of 2007-2009 brought to the relationship between central bank rates and market interest rates and how the market reactions scattered globally before, during and after the crisis. Secondly, the analysis will attempt to capture evidence of variation between central banks that make regular adjustments compared to those with irregular central bank rate changes as well as to identify different characteristics of developed and emerging markets' reactions. Thirdly, as the many corresponding market rates have plunged to levels close to zero after the crisis and have maintained such levels for years, it will be of interest to see how this kind of unusual market environment has affected the announcement reactions in those particular markets.

Research questions are strictly linked to impact of the recent financial crisis of 2007-2009. Purpose of the empirical model is to figure out how the relationship, more specifically the announcement effect of central bank rate change on corresponding market interest rate has developed pre- and post-periods of the financial crisis. Pre-crisis period contains data of central bank rates and market interest rates in 2002-2006 and post-crisis period contains years 2007-2014. As Rai et al. (2007) proposed in their study, announcement effects will be captured by dividing the effects into three sections: anticipatory effect (5 business days *before* the announcement), announcement day effect (announcement day or the next day) and learning effect (5 business days *after* the announcement).

There are couple of important reasons for this division. Anticipatory effects will capture the possible forecast impact of monetary authorities' actions which is extremely important as correct speculative actions are vital for financial institutions' long-term success. Announcement day effect analysis will include next day of the announcement because there is a possibility that the news regarding the central bank's announcement might lag between markets meaning that some participants would be able to get the information earlier than others. Learning effect can be identified by investigating delayed market interest rate responses. The lag between the announcement and market reaction will enlighten markets conception of nature of the change (temporary or permanent).

The common separation approach between technical and non-technical central bank rate adjustments will be left out of analysis for few reasons. Firstly, markets have no possibility to anticipate the nature of the adjustment accurately. Prior literature have identified both technical and non-technical changes during various periods but the conception of the type of the changes is still rather fragile as it cannot be said for sure if technical adjustments contain information about central bank's future actions or not. Starting from the study of

Neumann et al. (1996), academics have also found it difficult to predict the nature of the changes with statistical models. Main reason for this is that as a monetary authority, central bank has a power to decide between technical and non-technical change as well as to control the announcement timing and magnitude of central bank rate change. Another related issue is that there has also been found evidence regarding market reactions during times of central bank announcement with no rate adjustment intentions (Roley et al. 1998).

4.2 Description of interest rate data

Central bank rate data will include fundamental central banks' official lending rates that represents each economy's monetary authority's rate adjustment intentions (see sub-section 2.1 for central bank rate categorization). Data is gathered from ThomsonReuters Eikon and ThomsonReuters Datastream and sorting of the data is done by utilizing Microsoft Excel. Rate data will start from the beginning of 2002 and end in the end of 2014. Some central bank rates could not be captured for the entire analysis period indicating that few markets' reactions had to be left out of analysis during pre-crisis period.

Central bank rate data includes following countries for entire analysis period of 2002-2014 (name of the central bank in parenthesis, D stands for developed economy, E stands for emerging economy): *United States of America* (Federal Reserve, D), *Euro-zone* (European Central Bank, D), *United Kingdom* (Bank of England, D), *Switzerland* (Swiss National Bank, D), *Canada* (Bank of Canada, D) and *South Africa* (South African Reserve Bank, E). Bank of Japan was originally planned to be included in the analysis, but the extremely flat interest rate environment combined with infrequent central bank rate announcement

phase during 2002-2014 confirmed Japan data's unsuitability for this study method. Table 1 shows the central bank rate data availability for analysis periods as well as the number of rate adjustments for the period:

Market	CBR changes	Data available	Data source
United States of America	**29**	2002-2014	Thomson Datastream
Euro-zone	**23**	2002-2014	Thomson Datastream
United Kingom	**22**	2002-2014	Thomson Datastream
Switzerland	**19**	2002-2014	Thomson Datastream
Canada	**34**	2002-2014	Thomson Datastream
Russia	**25**	2007-2014*	Thomson Datastream/Eikon
China	**20**	2007-2014*	Thomson Datastream/Eikon
Brazil	**64**	2002-2014*	Thomson Datastream/Eikon
South Africa	**30**	2002-2014*	Thomson Datastream/Eikon
India	**36**	2002-2014*	Thomson Datastream/Eikon

Table 1. Central bank rate change data in 2002-2014 for developed and emerging countries (= partial data availability for maturities)*

Central banks included in the analysis with only partial data availability are *China* (People's Bank of China, E), *Russia* (Central Bank of Russia, E), *Brazil* (Banco Central do Brasil, E) and *India* (Central Bank of India, E). For the purposes of distinguishing the effects of the differences of developed and emerging economies' central banks, D stands for category of developed countries and E for emerging countries (in parenthesis). Table 1 represents the central bank rate data used in both analysis periods for developed and emerging countries and the number of rate adjustments for the markets. Market interest rate data (interbank rates) consists of short end of the yield curve including overnight rate, 1-month rate, 3-month rate 6-month rate and 12-month rate. Table 2 enlightens the data availability for interbank rates during the entire analysis period:

Data availability	Overnight		1-month		3-month		6-month		12-month	
Period	2002-2006	2007-2014	2002-2006	2007-2014	2002-2006	2007-2014	2002-2006	2007-2014	2002-2006	2007-2014
United States of America	*	*	*	*	*	*	*	*	*	*
Euro-zone	*	*	*	*	*	*	*	*	*	*
United Kigndom	*	*	*	*	*	*	*	*	*	*
Switzerland	*	*	*	*	*	*	*	*	*	*
Canada	*	*	*	*	*	*	*	*	*	*
Russia				*		*		*		*
China		*		*		*		*		*
Brazil			*	*	*	*	*	*	*	*
South Africa	*	*	*	*	*	*	*	*	*	*
India	*	*	*	*	*	*				

Table 2. Interbank rate availability in 2002-2014 for developed and emerging countries (= data available)*

4.3 Methodology

In order to describe data variation properly as well as to identify the relationship between central bank rates and market interest rates, both analysis periods' complete time series data was sorted and natural logarithmic changes were calculated for daily observations. This was conducted by utilizing Microsoft Excel-program. The formula (1) used for time series data's logarithmic change transformation was:

$$\Delta r_t = ln\left(\frac{r_t}{r_{t-1}}\right) \quad (1)$$

Empirical tests were conducted by using ordinary least squares, OLS, method and data was analyzed by using EViews 8.1. According to the previous literature presented in sub-section 3.3, OLS-based method is the most suitable model to capture announcement effects in this interest rate relationship framework. Linear regression was formed for each market in order to capture the relationship between the central bank rates and market interest rates. Dependent variable used in the model was the logarithmic change for daily market interest rate data and independent variable was formed by using central bank rate's logarithmic change. Formula 2 represents the relationship between variables:

$$\Delta MR_{t-n,t+m} = \alpha + \beta\Delta\left(CBR_{t-1,t}\right) + \varepsilon_t \quad (2)$$

$\Delta MR_{t-n,t+m} = logarithmic\ change\ of\ market\ interest\ rates\ between\ t-n\ and\ t+m$

$\Delta\left(CBR_{t-1,t}\right) = logarithmic\ change\ of\ central\ bank\ rates\ between\ t-1\ and\ t$

$\varepsilon_t = error\ term$

The values of n and m will vary depending on which effect is of interest at different stages of the analysis. Anticipatory effects will be captured with -5 days to announcement day setting whereas learning effects derive from announcement day to +5 days setting. Announcement day effects are analyzed with announcement day change (0), a day after the announcement setting (+1) and with overall announcement day and the next day change taken into account any possible information delay among the markets (0 - +1).

OLS-model used in this thesis will be updated by using the Newey-West estimator of standard error for two particular reasons. Firstly, daily interest rate data is extremely exposed to autocorrelation and heteroskedasticity and therefore, the estimators will provide more accurate results for the time series data when the error terms are correlated over time. This means that however the beta estimator is statistically suitable and accurate for the model, the efficiency of the model will be disrupted as error terms are correlated over time. The Newey-West estimator will be therefore used to alleviate effects of autocorrelation and heteroskedasticity of error terms, as well as to improve the accuracy of t-values.

Secondly, one of the key advantages of the Newey-West estimator is that the beta estimators in the modified OLS-model are suitable even though the form or magnitude of heteroskedasticity are not to be seen. Also the estimator tends to have barely a marginal impact on the efficiency and accuracy of the analysis model. Supportive approach for Newey-West estimator can be found in the academic literature: Long and Ervin (2000) proposed that generally if there is a priori reason to suspect that the heteroskedasticity issues could arise in time series data analysis, the Newey-West estimator should be utilized.

4.4 Descriptive statistics

As presented earlier, the interest rate data used in this thesis is based on five developed countries'/currency union's (Euro-zone, the United States, the United Kingdom, Switzerland and Canada) central bank's discount rates and corresponding interbank rates, as well as five emerging countries' (Brazil, South Africa, Russia, China and India) central bank's discount rates and corresponding interbank rates. In this sub-section the descriptive statistics for the United States' interbank rate data during the period of 2002-2014 will be analyzed and descriptive statistics for other interbank rates are shown in Appendix 1.

USD Libor					
2002-2014	O/N	1-month	3-month	6-month	12-month
Mean	1,622	1,714	1,838	1,986	2,216
Maximum	6,875	5,824	5,725	5,640	5,766
Minimum	0,080	0,148	0,223	0,319	0,534
Std. Dev.	1,804	1,808	1,796	1,748	1,635
Skewness	0,997	0,960	0,928	0,890	0,850
Kurtosis	2,583	2,494	2,429	2,357	2,302
Probability (p-value)	<0,001	<0,001	<0,001	<0,001	<0,001
Observations	3392	3392	3392	3392	3392

Table 3. Descriptive statistics for USD Libor daily rate data in period 2002-2014 (in percentages)

Couple of important observations can be noticed from the interbank rate statistics. Firstly, "Mean"-values are positive in all the markets and systematically increase as the interbank rate's maturity increases. As anticipated, "Mean"-values are higher in emerging markets. Russia, Brazil, South Africa and India have highly positive "Mean"-values whereas China's interest rates are significantly lower. This can be explained with the shaken market conditions in Brazil, South Africa and India, as well as with the restricted data periods: Data

of Russia covers 2005-2014 including two notable interest rate “hikes” in Russian markets whereas the interest rate data of China has been rather stable during 2007-2014. Overall this is consistent with the fact that interest rate markets reacted extremely intensely to the events of the financial crisis but afterwards, the interbank rate downturn was long and significant. “Maximum”-values vary from market to market mainly because generally all the interest rate markets had a random short-term hikes during the financial crisis. This was the case especially for the overnight rates which supports the tendency of shorter maturity interbank rates to react more vibrantly also during central bank rate announcements compared to those for longer maturities. “Minimum”-values increase modestly over maturities in all the markets. Interestingly though, only Euro-zone and Switzerland have negative “Minimum”-values to be evidenced.

Standard deviation implies the frequency of how much in value have the interbank rate data points differed from the “Mean”-value in longer analysis horizons. As expected, “Std. Dev.”-values are likewise rather flat and constant over the maturities. In general, longer maturity rates vary on smaller scale than shorter maturities. However, Russia has a noticeable increasing tendency in “Std. Dev.”-values indicating that shorter maturities, particularly Mosprime overnight rate vary in slightly smaller scale compared to longer maturities. A probable reason for this is that Central Bank of Russia’s monetary policy had significant transparency issues in the data period making the longer term maturities more difficult for interest rate markets to anticipate.

What comes to kurtosis and skewness values, the results are as expected in all the analyzed markets. Majority of the interest rates are slightly positively skewed, as well as “Kurtosis”-values are mostly smaller than the kurtosis value of normal distribution meaning that in general, the analysis distributions include substantial amount of volatility. This is an anticipated result since even though the future time series data values in interbank markets have a tendency to be linked to previous values and, therefore decreasing the risk of volatile outcomes, the

vastly changing and drastic market environment during the financial crisis had a noticeable impact on the analyzed daily data. Jarque-Bera-test was also utilized in order to analyze the degree of normal distribution related factors in the data. As normally distributed data has the Jarbue-Bera-statistic that consists of chi-squared distribution with two degrees of freedom and the statistic value will be compared to p-value of 0.05, statistics for all the markets show that the null hypothesis of expected skewness = 0 and expected kurtosis = 0 will be rejected. This is the main reason why the anticipation of the null hypothesis rejection is valid for this data and it also supports the fact that Newey-West estimator will be useful for better OLS-results. P-values for the Jarque-Bera-tests can be found in statistic tables for each market.

5. Empirical findings

As the financial crisis hit in during 2007 the interbank markets were severely shaken worldwide. Credit and liquidity spreads drastically increased and the uncertainty of future actions did not leave central banks as passive bystanders. After the intensification of the credit problems in 2008, central banks quickly increased the amount of money supply in order to verify fund availability and further stability of wounded financial system. According to the loanable funds theory presented in sub-section 2.1, these actions put a pressure on lower interest rate levels. However, interest rates lowered for months and reached historically low levels for years. Obviously one of the main reason for that was the decreased demand for extra funds in the market in volatile market environment. Economic conditions in one country as well as central bank's response to arisen interbank market problems were evidently linked to other markets' interest rate development.

The analysis data for the study consists of short end of the interbank rate yield curves. It is logical to assume that short term interest rates adjust similarly and in the same magnitude to central bank rate changes if the markets do not anticipate any new monetary policy information. This means that if the market interest rates react to central bank rate changes, new information of central bank's future path of managing monetary policy has been contributed. Sub-sections 5.1 and 5.2 analyze these potential announcement effects as well as anticipatory effects before the central bank rate announcement and learning effects after the announcement has been witnessed.

It can be said that different interest rate maturities do not necessarily react to monetary policy announcements similarly. Thornton (1998) emphasized that especially for longer maturities the degree and magnitude of interbank rate level change is closely linked to markets' conception of the central bank's intentions.

If the discount rate change was considered a short-term repair for macroeconomic issues only minor adjustment should appear. However if the markets sense signals of central bank's intentions of correcting long-term policy implications unexpectedly, the interbank market rates react throughout the yield curve. Overall the degree of expectancy and magnitude of the change are the main contingencies linked to interest rate market reactions. It is obvious that markets do not react simultaneously to central bank rate announcements. The reason for this is that monetary policies vary from country to country and the linkages between monetary policy and real economy can be substantially different. Therefore the frequency and magnitude of the change are not constant between the markets.

During the financial crisis of 2007-2009, the markets were insecure and cautious of the future guidelines of monetary policy. Therefore, it is logical to expect that during the analysis period starting from 2007 the market reactions are stronger and more centered around the central bank rate announcements compared to the period before the crisis. Another scenario to be looked for is whether there are certain markets that anticipate the changes beforehand and adjust the rates after the certainty of central bank rate level has been notified. These markets would therefore have only partial interbank rate adjustment in the announcement day.

As presented before, financial markets have globally soothed regulative barriers. These actions combined with faster and more advanced trading systems and services have provided much easier accessibility for market information. This has to be kept in mind especially when analyzing the results of emerging economies in which the regulative actions as well as information channels are not as developed as in developed economies. Due to more stable information systems and more comprehensive information flow it is expected that developed markets' rates react more modestly to central bank rate announcements and even before the announcement. Also resulting from mutual attempts to stabilize

international interbank markets, information flow between monetary authorities and markets should have been at least partially enhanced after the financial crisis which would lead to smaller interbank rate adjustments, especially in emerging markets.

The following sub-section 5.1 will concentrate on developed countries' interbank market reactions by analyzing each country individually and finally, by summarizing relevant observations. Sub-section 5.2 will be constructed in similar way for emerging markets' data. Each country-specific section will also provide a pre-analysis part in order to form an outlook of the market-related factors and enlighten pre-assumptions of outcomes that can be expected to result from the model and previous academic literature. The tables are formed in a way that they represent exclusively beta-values, t-values and confidence levels of each period and maturity respectively. Consistent with Roley et al. (1998), constant term of the regression model will be left out of the result tables as the values were consistently insignificant with all maturities and periods.

Row "0" of the tables shows the changes in market interest rates at the announcement day. Row "+1" indicates the next day effect whereas "0…+1" captures the combined effect of the previously mentioned two days. There are also rows for anticipatory effects and learning effects, named "-5" and "+5" respectively. Anticipatory effects consist of the impact of the announcement day combined with the interest rate market reaction four market days before the announcement. Conversely, the learning effect row includes the impact of announcement day plus the next four market days. Finally, the overall impact is presented on row "-5...+5".

5.1 Developed countries

5.1.1 The United States

The analysis of results is logical to start from the United States, from which the financial crisis of 2007-2009 originated. In the beginning of 2000's the United States was recovering from the short recession period of 2001 which forced Federal Reserve to maintain central bank rates at low levels. Price levels in the United States slowly began to rise and by the end of June 2006, the discount rate had been cyclically increased to 5,25%. The long period of low interest rates can be argued to have caused the ignition of the crisis along with modified regulations and savings surplus in the global economy.

Interbank rates sunk from 2002 to mid-2003 to a level near 1,00% and then steadily increased after the mid-2004 in all maturities. This rise was the starting point for the liquidity loss spiral and capital losses in asset markets. The impacts on production and aggregate demand of the nation were soon to be noticed resulting in a recession period during late 2007. As the spillover effects of housing markets became apparent and the consequences of the untypical market conditions spread internationally, both the discount rate and interbank rates in all maturities began to slump: in the period of mid-2007 to end of 2008 central bank rates and market interest rates had dropped to near 0,25%.

Table 4 represents the results for market interest rates for all the maturities up to 12 months and for both periods. The similar approach will be used for all the other markets in the analysis scope. The results of the US market indicate that the change of the overnight rate is positive and statistically significant on the announcement day with the change of nearly half of the central bank rate adjustment. Overall effect of the announcement day combined with the next day

rises up the 55% of the adjustment. Interestingly, the effect on overnight rate turns to slightly negative on the latter period indicating an elevated volatility impact on the market. This is also supported by the higher next day effect of 0,25. It is quite logical to assume that as interbank markets were suffering severely from the illiquidity and the uncertainty of the upcoming central bank policy changes was increasing, the markets reacted with more modestly to central bank rate changes and the anticipatory power was weaker as well.

The United States														
2002-2006	**O/N**	t-value	sign.	**1m**	t-value	sign.	**3m**	t-value	sign.	**6m**	t-value	sign.	**12m**	t-value	sign.
0	**0,44**	3,45	***	**0,02**	4,12	***	**0,02**	7,35	***	**0,02**	2,49	**	**0,01**	0,63	
+1	**0,10**	0,60		**0,10**	0,74		**0,09**	0,70		**0,03**	0,29		**-0,03**	-0,26	
0…+1	**0,55**	5,88	***	**0,12**	0,86		**0,11**	0,90		**0,05**	0,49		**-0,02**	-0,19	
-5	**0,82**	4,27	***	**0,19**	6,84	***	**0,15**	4,19	***	**0,12**	3,05	***	**0,08**	1,44	
+5	**0,04**	0,22		**0,09**	0,63		**0,10**	0,75		**0,04**	0,34		**-0,03**	-0,21	
-5…+5	**0,86**	22,59	***	**0,29**	1,96	**	**0,24**	1,79	*	**0,17**	1,37		**0,05**	0,42	
2007-2014	**O/N**	t-value	sign.	**1m**	t-value	sign.	**3m**	t-value	sign.	**6m**	t-value	sign.	**12m**	t-value	sign.
0	**-0,18**	-3,37	***	**0,05**	5,40	***	**0,01**	1,12		**0,02**	2,77	*	**0,02**	2,76	***
+1	**0,25**	2,17	**	**0,27**	8,02	***	**0,11**	7,37	***	**0,09**	5,04	***	**0,08**	4,39	***
0…+1	**0,07**	0,43		**0,32**	7,53	***	**0,12**	5,76	***	**0,10**	4,66	***	**0,10**	4,10	***
-5	**-0,14**	-2,74	***	**0,38**	7,17	***	**0,11**	5,63	***	**0,11**	6,55	***	**0,10**	5,17	***
+5	**0,55**	1,62		**0,47**	8,22	***	**0,19**	3,88	***	**0,12**	3,72	***	**0,08**	2,86	***
-5…+5	**0,41**	1,33		**0,84**	13,11	***	**0,30**	5,94	***	**0,23**	8,09	***	**0,18**	10,35	***

Table 4. Regression betas and t-values for period 2002-2014 (The United States), (, **, ***, 10%, 5%, 1% significant, respectively)*

The interest rate markets in the United States show anticipatory effects on both analysis periods. However, as the markets reacted with 82% change of the adjustment before the crisis, the latter period has negative, although statistically significant anticipatory effect. This denotes that the overall effect of the market reaction is over double as high on the before crisis-period as it is for the latter period. Further there are no significant learning effects to be observed in the pre-crisis period. This predicts and enforces the nature of infrequent adjustment schedule of Federal Reserve as well as that the markets in this kind of environment have a higher tendency of predicting the central bank rate change.

Both periods provide significant results on the announcement day in all maturities except on the 2002-2006 period for 12-month Libor-rate. The changes are the largest for overnight-rates and decrease as the maturity rises. This is consistent with the findings of Thornton (1982), Cook et al. (1989) and Dale (1993). However, it has to be pointed out that there are modest learning effect to be observed in the latter analysis period. This indicates that even though there are anticipatory effects on both periods, markets have re-adjusted the rate levels more eagerly on the 2007-2014 period. A probable motive for this is that Federal Reserve has not been as efficient and transparent when it comes to informing markets of new policy implications as for example the ECB.

5.1.2 Euro-zone

When comparing European Central Bank and Federal Reserve, several differences can be found in their monetary policy implementations. European Central Bank conducted slightly different approach in stabilization attempts compared to Federal Reserve after the financial market turmoil hit in since it mainly had to concentrate on fine-tuning markets whereas Federal Reserve put more effort on market stabilization combined with action related to boosting economy simultaneously. Price stability being the main target of the European Central Bank, Federal Reserve's actions are characterized more by the mixture of stabilized price level development and stronger emphasis on the unemployment rate. Table 5 provides the data results for the European Union.

Euro-zone														
2002-2006	**O/N**	t-value	sign.	**1m**	t-value	sign.	**3m**	t-value	sign.	**6m**	t-value	sign.	**12m**	t-value	sign.
0	**0,58**	2,02	**	**0,01**	0,31		**0,02**	0,85		**0,04**	1,64		**0,07**	2,27	**
+1	**0,01**	1,20		**0,00**	0,01		**0,01**	1,46		**0,01**	1,04		**0,02**	1,05	
0…+1	**0,59**	2,07	**	**0,01**	0,27		**0,03**	1,08		**0,05**	2,23	**	**0,09**	3,96	***
-5	**0,81**	5,36	***	**0,30**	3,86	***	**0,15**	2,94	***	**0,14**	2,67	***	**0,17**	3,16	***
+5	**0,15**	1,11		**0,00**	-0,27		**0,02**	0,88		**0,06**	2,60	***	**0,12**	2,56	**
-5…+5	**0,96**	21,94	***	**0,30**	4,01	***	**0,17**	2,95	***	**0,20**	3,12	***	**0,29**	4,14	***
2007-2014	**O/N**	t-value	sign.	**1m**	t-value	sign.	**3m**	t-value	sign.	**6m**	t-value	sign.	**12m**	t-value	sign.
0	**0,77**	2,56	**	**0,02**	1,44		**0,02**	3,75	***	**0,01**	1,64	*	**0,01**	3,09	***
+1	**0,21**	1,91	*	**0,18**	2,55	**	**0,04**	3,29	***	**0,02**	2,66	***	**0,02**	3,67	***
0…+1	**0,63**	3,15	***	**0,21**	3,12	***	**0,06**	3,63	***	**0,03**	2,39	**	**0,03**	3,75	***
-5	**0,02**	0,04		**0,94**	2,66	***	**0,33**	3,69	***	**0,20**	6,29	***	**0,14**	10,32	***
+5	**0,27**	0,56		**0,33**	3,22	***	**0,08**	2,26	**	**0,05**	1,77	*	**0,04**	2,61	***
-5…+5	**0,17**	0,22		**1,27**	2,93	***	**0,41**	4,35	***	**0,25**	6,14	***	**0,18**	6,91	***

Table 5. Regression betas and t-values for period 2002-2014 (Euro-zone), (, **, ***, 10%, 5%, 1% significant, respectively)*

The data results of the European market designate that overnight rate reactions are positive and statistically significant on the announcement day with the effect of over a half of the central bank rate adjustment. Combined effect of the announcement day and the next day reaches the 59% of the European Central bank's adjustment. This indicates that the overall announcement day effect was somewhat equal in Euro-zone and the United States. However, the effect on overnight rate strengthens modestly on the after-crisis period providing therefore a distinguishable deviation compared to the US markets.

Two probable reasons arise. Firstly, the European monetary system is more closely linked to banks whereas the Federal Reserve conducts the policy implementations with its primary dealers. This means that the money supply changes and their impacts on the economy were faster to take action. Also the European Central bank succeeded slightly better in information delivery to the markets since the effects of the total effect (-5…+5) are stronger in all the maturities.

Overall the European markets have a similar trend of the results with respect to entire yield curve than in the US since the effects are strongest for the overnight rates and become milder for longer maturities. The overall impact on the announcement and the next day rise in the latter period and is significant for all the maturities, except for the overnight rate. Stronger market reaction for the European market is expected since Federal Reserve has a more complex monetary policy structure and European financial market environment is highly dependent on the development of the US markets. This meant that Federal Reserve, as a part of its economy boosting target, had to cut its discount rate earlier and more intensely in order to stabilize harmful progress of the markets. It is therefore expectable that European markets reacted more powerfully as they had more time to anticipate the magnitude of the adjustment.

5.1.3 The United Kingdom

Bank of England responded to the symptoms of the crisis with both conventional and unconventional methods. As was the case with Federal Reserve's strategy, Bank of England relied on quantitative easing approach during the crisis period. This was seen as an efficient way to recover liquidity problems in corporate and banking sectors as well as to stimulate economy's development. However a distinguishable difference between the monetary policy conduction can be found since the English monetary authority sets the central bank rate relatively more frequently than in the US and Europe. The impact can be seen in Table 6.

The United Kingdom														
2002-2006	**O/N**	t-value	sign.	**1m**	t-value	sign.	**3m**	t-value	sign.	**6m**	t-value	sign.	**12m**	t-value	sign.
0	**1,48**	3,38	***	**0,05**	3,25	***	**0,02**	3,49	***	**0,02**	2,55	**	**0,01**	1,15	
+1	**1,01**	1,83	*	**0,30**	2,78	***	**0,24**	2,19	**	**0,24**	2,20	**	**0,25**	2,04	**
0…+1	**2,49**	4,88	***	**0,35**	3,60	***	**0,26**	2,32	**	**0,26**	2,48	**	**0,26**	2,20	**
-5	**-1,06**	-3,07	***	**0,18**	6,20	***	**0,10**	4,91	***	**0,07**	2,63	***	**0,02**	0,39	
+5	**1,32**	2,04	**	**0,37**	3,00	***	**0,28**	2,21	**	**0,26**	1,98	**	**0,22**	1,35	
-5…+5	**0,25**	0,55		**0,55**	5,37	***	**0,38**	3,07	***	**0,33**	2,44	**	**0,24**	1,34	
2007-2014	**O/N**	t-value	sign.	**1m**	t-value	sign.	**3m**	t-value	sign.	**6m**	t-value	sign.	**12m**	t-value	sign.
0	**0,50**	5,72	***	**0,06**	3,82	***	**0,03**	3,78	***	**0,03**	3,01	***	**0,03**	2,64	***
+1	**0,36**	6,00	***	**0,23**	2,53	**	**0,15**	1,80	*	**0,14**	1,70	*	**0,13**	1,57	
0…+1	**0,86**	12,19	***	**0,29**	2,78	***	**0,18**	2,02	**	**0,16**	1,86	*	**0,15**	1,71	*
-5	**0,44**	3,89	***	**0,11**	3,75	***	**0,09**	2,81	***	**0,08**	2,74	***	**0,07**	2,50	**
+5	**0,38**	4,77	***	**0,34**	2,90	***	**0,23**	2,29	**	**0,21**	2,18	**	**0,20**	2,05	**
-5…+5	**0,82**	6,48	***	**0,45**	3,23	***	**0,31**	2,55	**	**0,29**	2,41	**	**0,27**	2,22	**

Table 6. Regression betas and t-values for period 2002-2014 (The United Kingdom), (, **, ***, 10%, 5%, 1% significant, respectively)*

As also noted by Rai et al. (2007), the interest rate markets with frequent central bank rate adjustments have a tendency to perceive the changes as persistent and therefore, more volatility around the announcement days appear. This further indicates stronger learning effects, especially in shorter maturities. Despite the fact that 1-month Libor reacted more modestly in after-crisis period total effect-wise, 1-month to 12-month maturities' rates had similar trend compared to the US and European markets: the longer the maturity, the weaker the impact on the interbank rates.

Interestingly, overnight rates responded with extremely large magnitude on the pre-crisis period. With the total response of 2,49 the United Kingdom's market rates seem to have been uncertain about probable upcoming shocks in the markets as well as the unexpected policy implications. This can be seen from significant learning effect coefficients for overnight rates in the period. It can be concluded that Bank of England were conveying information not only about the desired interest rate level development but also the strategic policy implications. The same observation was also documented by Dale (1993) and Ruoppa (2008).

Overall the English markets reacted more powerfully to the central bank rate announcement than the US and European markets mainly because Bank of England have a history of rather frequent announcement schedule packed with intentions to convey information of its policy status in larger scale. Consistently lower responsiveness of the after-crisis period also indicates that the transparency in the interest rate market has increased along with the trend of slackening financial flows which further led to decreased foreign funding. This has formed a tighter relationship between the central bank rate and market interest rates in the United Kingdom.

5.1.4 Switzerland

Swiss National Bank's monetary policy implementations before and after the financial crisis of 2007-2009 should be approached by the central bank's balance sheet. In the 2000's, the Swiss franc under the rule of the central bank of Switzerland has had a safe haven position in the volatile circumstances of financial markets and this was also to be seen during the recent crisis. Major currencies like US dollar and euro significantly depreciated against franc and Swiss National Bank quickly reacted by purchasing massive reserves of foreign currencies from the markets in order to stop the franc's appreciating trend. After the financial crisis SNB introduced a floor value for franc to provide favorable development for the national currency. As a result, the central bank eventually hold reserves of nearly four fifth of the Swiss economic output of 2014 and therefore, carried a notable currency risk.

Although Switzerland has paid a price for the safe haven position, the fundamentals regarding economy's situation has remained stable and the crisis had relatively minor effect on its cantons' budgets. Monetary authorities have also succeeded in efficiently ensuring price stability targets. The monetary policy in Switzerland is conducted by regularly fixing a value for the three-month

maturity Swiss franc Libor. If the Swiss National Bank monitors situations in the markets that require adjustments more often, the adjustment meeting will be held also between the quarterly meetings. The data result table of Swiss National Bank and corresponding market rates can be seen in Table 7.

Switzerland														
2002-2006	**S/N**	t-value	sign.	**1m**	t-value	sign.	**3m**	t-value	sign.	**6m**	t-value	sign.	**12m**	t-value	sign.
0	**0,34**	2,11	**	**0,13**	1,61		**0,08**	2,49	***	**0,06**	2,51	**	**0,06**	2,91	***
+1	**0,30**	2,13	**	**0,32**	2,40	**	**0,28**	2,26	**	**0,24**	2,22	**	**0,16**	1,96	*
0…+1	**0,63**	6,67	***	**0,45**	5,63	***	**0,36**	3,55	***	**0,31**	3,16	***	**0,22**	3,15	***
-5	**0,31**	2,00	**	**0,15**	2,13	**	**0,10**	3,66	***	**0,11**	3,97	***	**0,11**	3,76	***
+5	**0,41**	3,73	***	**0,35**	2,50	**	**0,29**	2,40	***	**0,23**	2,22	**	**0,14**	1,99	**
-5…+5	**0,73**	9,56	***	**0,50**	6,94	***	**0,38**	3,16	**	**0,34**	3,35	***	**0,26**	2,99	***
2007-2014	**S/N**	t-value	sign.	**1m**	t-value	sign.	**3m**	t-value	sign.	**6m**	t-value	sign.	**12m**	t-value	sign.
0	**0,12**	1,46		**0,20**	1,48		**0,14**	1,42		**0,13**	1,59		**0,09**	1,54	
+1	**0,32**	1,51		**0,31**	1,86	*	**0,24**	1,97	**	**0,18**	1,50		**0,16**	1,62	
0…+1	**0,44**	2,29	**	**0,51**	3,35	***	**0,37**	3,83	***	**0,31**	2,89	***	**0,24**	2,90	***
-5	**0,27**	1,73	*	**0,36**	2,61	***	**0,21**	2,45	**	**0,20**	2,49	**	**0,14**	2,49	**
+5	**0,40**	2,49	**	**0,23**	3,64	***	**0,31**	2,79	***	**0,26**	2,41	**	**0,23**	2,29	**
-5…+5	**0,67**	3,50	***	**0,60**	3,09	***	**0,52**	4,40	***	**0,46**	4,11	***	**0,36**	3,43	***

Table 7. Regression betas and t-values for period 2002-2014 (Switzerland), (, **, ***, 10%, 5%, 1% significant, respectively)*

In case of Switzerland the spot-next rate will be used instead of overnight rate due to the weak data availability for the Swiss overnight rate in ThomsonReuters database. Spot-next rate derives from the overnight contract made two bank days prior obtaining funds between the participants. Therefore it will provide a close substitute for the overnight rate analysis. Starting from the spot-next rate over the maturities, it can be clearly seen that the beta values is relatively small. This further indicates that Swiss National Bank utilized more open market operations as a primary policy tool compared to other major central banks both before and after the financial crisis. Rai et al. (2007) also concluded that central banks with less open market operation-centered focus tend to have stronger effect to be noticed in terms of market interest rates and central bank rates.

Couple of mentionable issues arise from the results: Although the short term end has more modest reaction during the central bank rate announcement, there seems to be significant anticipatory and learning effects to be witnessed in both analysis periods. This will raise the combined effect to nearly 70% of the central bank's target rate change. It is rational since the Libor rates frequently fluctuate and are therefore absorbing and conveying information of the rate adjustment both before and after the meeting. Significant learning effect also signals rather frequent announcement policy of the central bank. Interestingly, the effect on interbank rates in all the maturities have stabilized after the crisis and the differences in impacts have narrowed. Especially the combined effect of -5 to +5 days have strengthened in longer maturities. This implies that central bank's target rate announcement have carried more information about the future policy implementations and the changes have therefore been slightly more expectable.

5.1.5 Canada

Canada handled the times of the financial crisis relatively efficiently. Although the liquidity issues were problematic also for Canadian institutions, mainly because of the proper risk management efforts conducted by Bank of Canada helped the financial system to avoid any central bank managed capital injections. Canadian markets faced very similar problems as the Federal Reserve had to face in the US. Even though the importance of the asset-backed securities market in the financial system is smaller, many asset-backed securities were traded in the Canadian markets as well and the harmful effects of these products had to be mitigated. Canadian monetary authorities provided comprehensively both short and long term financing for the Canadian markets and combined with strong balance sheets of the domestic companies, Canadian markets performed rather well during the volatile times. Data analysis results for Canadian markets are shown in Table 8.

Canada															
2002-2006	**O/N**	t-value	sign.	**1m**	t-value	sign.	**3m**	t-value	sign.	**6m**	t-value	sign.	**12m**	t-value	sign.
0	**0,73**	8,70	***	**0,03**	1,99	**	**0,02**	0,78		**0,02**	0,85		**0,01**	0,36	
+1	**0,14**	1,76	*	**0,07**	0,91		**0,07**	1,01		**0,05**	0,72		**0,03**	0,44	
0…+1	**0,87**	39,60	***	**0,10**	1,61		**0,08**	1,26		**0,07**	1,05		**0,04**	0,69	
-5	**0,75**	8,96	***	**0,25**	4,12	***	**0,17**	2,37	**	**0,09**	1,05		**0,04**	0,32	
+5	**0,16**	1,79	*	**0,07**	0,89		**0,08**	0,89		**0,05**	0,45		**0,00**	0,00	
-5…+5	**0,91**	23,19	***	**0,32**	7,11	***	**0,25**	4,01	***	**0,14**	1,52		**0,04**	0,32	
2007-2014	**O/N**	t-value	sign.	**1m**	t-value	sign.	**3m**	t-value	sign.	**6m**	t-value	sign.	**12m**	t-value	sign.
0	**0,27**	3,80	***	**0,08**	2,96	***	**0,05**	1,38		**0,03**	1,75	*	**0,02**	2,21	**
+1	**0,37**	4,53	***	**0,28**	2,99	***	**0,14**	7,92	***	**0,10**	4,98	***	**0,07**	3,17	***
0…+1	**0,63**	8,93	***	**0,36**	4,25	***	**0,19**	5,80	***	**0,13**	6,07	***	**0,09**	4,67	***
-5	**0,39**	5,82	***	**0,22**	5,51	***	**0,11**	2,98	***	**0,06**	1,70	*	**0,03**	1,26	
+5	**0,46**	13,06	***	**0,30**	5,91	***	**0,20**	6,26	***	**0,12**	4,32	***	**0,07**	2,91	***
-5…+5	**0,85**	13,28	***	**0,51**	9,86	***	**0,32**	6,73	***	**0,19**	4,74	***	**0,09**	4,35	***

Table 8. Regression betas and t-values for period 2002-2014 (Canada), (, **, ***, 10%, 5%, 1% significant, respectively)*

Canadian interest rate markets reacted the most intensively in overnight rate maturity. It is noteworthy that before the crisis, most of the reaction effect was centered on the announcement day but period after the crisis provides a significantly smaller announcement day effect. The combined effect from -5 to +5 days indicate rather equal effect on both periods. Also there are considerable learning effects to be observed in the latter analysis period. There are several reasons for this trend.

Canadian interest rate markets and more specifically monetary authorities' policy changes are closely linked to Federal Reserve's policy trends which is mainly because the economies are major trading partners. This further leads to somewhat similar trends in both markets. A probable reason for Canadian market's slightly stronger effect is due to economy's state and development after the crisis. While Federal Reserve's quantitative easing policy ended up reducing public debt levels and stabilizing longer term interest rates, low Canadian interest rates were still tempting for loan issuers in housing markets. Increased unemployment rates and export problems are also reasons for increased volatility in the markets.

5.2 Developing countries

Panic that evolved in the North American markets during 2007-2008 rapidly spread to emerging economies. Even before the year 2008 had ended, the market changes had also been evidenced in the developing markets. When thinking about monetary policy and corresponding interest rate markets in these countries, it has to be taken into consideration that majority of the emerging economies face various problems that are much more crucial for them compared to developed economies. Examples of the issues include strong commodity and nature resource dependency as well as currency policy's strict links to major global currencies. European Commission (2009) investigated that the crisis seem to have damaged economies with high dependency on foreign capital inflows more severely than others.

Overall the emerging economies tend to have less developed financial systems with difficulties in information flow and distribution. These factor put extra pressure on emerging economies' central banks as the flexibility is somewhat tenuous. Lastly, the majority of developing countries still faced painful recovery programs that were established after earlier crises as the financial turmoil of 2007-2009 hit in. This weakened the circumstances of the central banks to effectively strike against symptoms of the recent crisis.

5.2.1 Russia

Before the crisis of 2007-2009, Russia's domestic economy was performing well compared to other developing markets. However, as discussed in sub-section 3.3, the Russian markets drastically collapsed as the crisis spread globally. A major direct impact was realized when oil prices tumbled down. Rent system that was established during the times of Soviet Union combined with the resource dependency has naturally created inflexibility and extra risk for the Russian economy. Risk and reward go hand in hand in larger scale as well: as oil prices increased in mid-2000's, Russia recovered quickly but also collapsed much faster than other economies when oil became cheaper.

As for other developing countries, Russia has rather conservative fiscal policy and old governmental structures. These issues are anticipated to be evidenced in results in a way that learning effects will be emphasized as the uncertainty is higher and highly dependent on foreign markets, as well as because information flow is less transparent. Mosprime-reference rates were not launched until 2005 which means that the analysis period only covers the after crisis period. The analysis results can be seen in Table 9.

Russia												
2007-2014	**O/N**	t-value	sign.	**1m**	t-value	sign.	**3m**	t-value	sign.	**6m**	t-value	sign.
0	**1,31**	1,05		**0,18**	1,16		**0,24**	1,73	*	**0,30**	1,93	*
+1	**0,21**	0,26		**0,15**	3,29	***	**0,08**	1,65	*	**0,09**	1,58	
0…+1	**1,52**	2,06	**	**0,33**	1,93	**	**0,32**	1,79	*	**0,39**	1,91	*
-5	**-0,86**	-0,89		**0,18**	0,85		**0,45**	2,47	**	**0,49**	2,87	***
+5	**2,42**	1,64		**0,83**	2,53	**	**0,53**	2,64	***	**0,61**	3,71	***
-5…+5	**1,55**	1,01		**1,01**	2,49	**	**0,98**	2,83	***	**1,10**	3,60	***

Table 9. Regression betas and t-values for period 2007-2014 (Russia), (, **, ***, 10%, 5%, 1% significant, respectively)*

The results from the Russian market designate that overnight rate reactions are positive although only the combined effect of the announcement day and the next day is statistically significant. The combined effect of overnight rate has been 1½ times the central bank rate adjustment. This logically indicates that shorter maturities are more volatile in Russia than in major developed economies. As also in cases of developed countries, the impact on the market rates decreases as the maturity increases. Also as anticipated, the learning effects are stronger in 1-month to 6-month maturities compared to anticipatory effects. Combined effect of the -5 days to +5 days reaches the level of over 1,00 with all the maturities. Most of the impact is therefore not centered around the announcement day and is more scattered.

Exceptionally strong learning effect emphasis can be explained by before-mentioned structural inflexibility and relatively more volatile interest rate environment. Although the comparison between the two periods cannot be made between pre- and post-crisis periods for Russia, it still can be concluded that learning effects are relatively higher than in developed economies. Lack of information flow transparency can be seen as a partial reason for this interest rate behavior.

5.2.2 China

China’s economic performance has been rather interesting after the crisis. Although the financial system is slowly beginning with regulative actions and the monetary policy is strictly ruled by the political system, China performed relatively well during and after the financial crisis of 2007-2009. The reasons for this are huge foreign reserves and the country not being closely linked to the crisis origination problems. However, the situation was also problematic since the Asian economy is highly dependent of successful export business that turned downhill during the volatile years. Obviously this resulted in increased pressure

on GDP growth, trade balance, interest rates and housing prices. Market interest rate levels in China have constantly decreased after the crisis ignition.

The political stiffness has had pros and cons. Even though the constant inflexibility and lack of market force-driven environment has been present, China might have mitigated some harmful effects on the economy by restricting the utilization of complex derivatives products that increased risks in the US and Europe. In recent years, many international banks have set their foot on China and the regulative barriers have been reduced. These arrangements have increased transparency but also allowed more risky products to be traded in the conservative market environment. Shanghai interbank rate data available was starting from 2007 which is why the pre-crisis period had to be left out of the analysis. The results for China are shown in Table 10.

China														
2007-2014	**O/N**	t-value	sign.	**1m**	t-value	sign.	**3m**	t-value	sign.	**6m**	t-value	sign.	**12m**	t-value	sign.
0	**1,18**	2,48	**	**0,62**	2,19	**	**0,78**	3,54	***	**0,81**	3,48	***	**0,78**	3,80	***
+1	**-0,24**	-1,20		**0,12**	1,01		**0,12**	3,85	***	**0,17**	6,24	***	**0,16**	4,85	***
0…+1	**0,94**	1,79	*	**0,74**	2,19	**	**0,90**	3,91	***	**0,98**	4,22	***	**0,95**	5,10	***
-5	**2,05**	2,98	***	**0,91**	2,00	**	**0,31**	1,69	*	**1,02**	4,48	***	**0,97**	4,58	***
+5	**-0,34**	-0,70		**0,29**	0,80		**1,07**	4,49	***	**0,49**	5,89	***	**0,50**	5,85	***
-5…+5	**1,70**	1,95	**	**1,20**	1,58		**1,38**	4,05	***	**1,52**	6,37	***	**1,48**	7,68	***

Table 10. Regression betas and t-values for period 2007-2014 (China), (, **, ***, 10%, 5%, 1% significant, respectively)*

Chinese interest rate markets reacted the most intensively in overnight rate maturity of all the emerging economies in the after-crisis period with 1,18 times the central bank rate change. The combined effect of the announcement day and the next day nearly equals the central bank rate adjustment. Overnight rate had significant anticipatory effects which were twice the central bank rate change resulting in combined effect of 1,7 in -5 to +5 days period. All the emerging markets had similar kind of trend to be evidenced meaning that the overnight rate effects were inevitably stronger compared to the developed markets. An

interesting finding is that China has strongly positive and significant anticipatory effects for all the maturities and there are notably lower emphasis on learning effect except for 1-month rate when comparing to Russia. This trend can be explained by China's central bank's autonomy in the Chinese banking markets. People's Bank of China monitors the economy's financial system in a way that its policy functions are extremely closely linked to commercial banks' day-to-day business. Basically this means that the central bank sets the rates at which commercial banks can issue loans and at what levels should the savings rates maintain. The trend of both combined effects of 0..+1 days and -5 to +5 days being nearly equal of magnitude to central bank rate change in all maturities can be therefore explained by this procedure.

5.2.3 Brazil

Brazil had established national macroeconomic policies to maintain inflation expenditures sustainable a decade before the financial turmoil. Among with stronger fiscal policy adjustments Brazil also followed the example of many other emerging economies and tied its currency to flexible rate system in order to avoid shocks and heightened volatility environment. Much like in China, Brazil was reluctant and incapable of adopting deregulative adjustments which in some way also protected the Brazilian financial markets from unmanageable risks and extra capital market volatility. However, these policy adjustments seemed to have not gone as intended.

Before the beginning of global financial market downturn, foreign capital was flowing in to Brazilian markets because of tempting short term assets offering higher returns. Investors were speculating on Brazilian real's appreciation and even more external capital started to flow in domestic stock markets. The problem was that simultaneously the amount of liabilities denominated in US-dollars rapidly increased and it was only a matter of time when a financial market

shock could start the capital drastic outflow. The worst happened in the summer of 2008 and real significantly depreciated.

Banco Central do Brasil had difficulties in maintaining stability. Sterilization-process of central bank selling short-term government securities attempted to provide excess liquidity for the markets but both average maturities shortened and interest rates increased. This kind of development in the markets allowed domestic financial institutions to borrow even more foreign capital and increase their vulnerability against foreign exchange risk exposure. The central bank noticed the harmful effect later and began to provide massive programs of foreign liquidity. It can be argued that the policy change had to be done in order to prevent further depreciation of real but the negative impact was that the amount of short term assets began to increase which further added extra risk of potential and quick capital outflow. The data results of Brazil are presented in Table 11.

Brazil												
2002-2006	**1m**	t-value	sign.	**3m**	t-value	sign.	**6m**	t-value	sign.	**12m**	t-value	sign.
0	**0,17**	2,55	**	**0,19**	2,71	***	**0,20**	3,51	***	**0,19**	3,71	***
+1	**-0,07**	-1,04		**-0,05**	-0,66		**-0,04**	-0,57		**-0,03**	-0,40	
0…+1	**0,10**	4,19	***	**0,14**	4,78	***	**0,15**	3,30	***	**0,16**	3,72	***
-5	**0,69**	2,60	***	**0,59**	2,14	**	**0,46**	1,85	*	**0,25**	1,12	
+5	**-0,10**	-0,82		**-0,04**	-0,27		**-0,08**	-0,52		**-0,12**	-0,64	
-5…+5	**0,60**	3,87	***	**0,56**	3,47	***	**0,38**	2,80	***	**0,13**	0,77	
2007-2014	**1m**	t-value	sign.	**3m**	t-value	sign.	**6m**	t-value	sign.	**12m**	t-value	sign.
0	**0,08**	4,43	***	**0,08**	3,92	***	**0,07**	2,85	***	**0,05**	1,87	*
+1	**0,01**	1,60		**0,02**	2,01	**	**0,03**	1,52		**0,03**	1,31	
0…+1	**0,10**	5,17	***	**0,11**	4,44	***	**0,10**	2,89	***	**0,08**	1,96	*
-5	**0,29**	8,41	***	**0,23**	4,29	***	**0,20**	3,14	***	**0,14**	1,80	*
+5	**0,12**	3,31	***	**0,16**	4,12	***	**0,18**	3,62	***	**0,20**	3,63	***
-5…+5	**0,41**	13,89	***	**0,40**	7,58	***	**0,38**	5,63	***	**0,34**	4,34	***

Table 11. Regression betas and t-values for period 2002-2014 (Brazil), (, **, ***, 10%, 5%, 1% significant, respectively)*

The currency-focused policy can be clearly seen in the results as the market interest rates are reacting only marginally. On the before crisis period all the analyzed maturities have witnessed nearly equal, 20% change of central bank rate change on the announcement day. When looking at the anticipatory effects the central bank rates have significantly lower effects on longer maturities. However there are no statistically significant learning effects to be witnessed in before crisis-period. On the latter period the market rates have adjusted 10% to 20% of central bank rate change which is comparably higher reaction than in the US or Euro-zone. Rai et al. (2007) concluded that countries with more frequent central bank rate changes tend to have stronger market reactions. The increased emphasis of combined effect of -5 to +5 days as well as comparably low market rate reaction verify the assumption that Banco Central do Brasil clearly focused on exchange rate stability and the interest rate market adjustments were made primarily to match market interest rates. This finding was also supported by Rai et al. (2007).

5.2.4 South Africa

Compared to other emerging economies during the financial crisis, South Africa was mildly affected by the harmful financial market imbalances. Main reasons for this were South African financial institutions' relatively small exposure to foreign structured assets and rather conservative banking regulations and risk management related procedures. Therefore the pressure for any kind of major monetary policy adjustment was quite marginal. Also the liquidity offerings conducted by South African Reserve Bank's refinancing auctions were barely affected meaning that the central bank did not have to respond to any liquidity shortages.

When the global, as well as South Africa's domestic economic outlook started to weaken even before the crisis in 2006, South African Reserve Bank reacted to higher inflation expenditures by raising the repurchase rate. Two years later the central bank rate was cut as the central bank was anticipating better inflation numbers combined with attempts to stir up the jamming economic growth. South Africa has also followed the so-called non-intervention exchange rate policy indicating that the central bank rate adjustments were not intended to directly affect exchange rate levels, domestic banking sector or external shocks.

What comes to interest rate markets, the fluctuation of central bank rate and market interest rates remained stable. Unlike in many markets analyzed, the overnight market rate levels remained below the central bank rate both before and after the crisis period. This denotes that the upward pressure for shorter market rates was relatively small. Also the lending volumes barely increased in interbank markets during the crisis period indicating stable market condition in South African markets. The central bank's reserves obviously dropped temporarily but the fall was mainly due to drop in gold price and US dollar's appreciation. Even though South Africa seem to have avoided the worst effects of the financial turmoil, it does not mean that there are no economic risks. South Africa along with many other emerging economies is extremely nature resource dependent economy with developing financial flexibility. Obviously this increases the volatility for potential negative shocks in Sub-Saharan Africa. South African data analysis results are shown in Table 12.

South Africa															
2002-2006	**O/N**	t-value	sign.	**1m**	t-value	sign.	**3m**	t-value	sign.	**6m**	t-value	sign.	**12m**	t-value	sign.
0	**0,79**	8,28	***	**0,51**	6,44	***	**0,35**	4,60	***	**0,25**	3,75	***	**0,24**	2,92	***
+1	**0,06**	1,11		**0,08**	1,89	*	**0,05**	1,53		**0,03**	1,13		**0,01**	0,59	
0…+1	**0,85**	11,41	***	**0,60**	8,47	***	**0,40**	5,49	***	**0,28**	4,09	***	**0,25**	2,92	***
-5	**0,80**	8,94	***	**0,64**	8,84	***	**0,48**	6,16	***	**0,37**	4,57	***	**0,35**	4,27	***
+5	**0,05**	0,90		**0,12**	2,71	***	**0,09**	2,38	**	**0,13**	4,07	***	**0,14**	2,47	**
-5…+5	**0,85**	11,95	***	**0,77**	12,51	***	**0,57**	7,24	***	**0,49**	5,22	***	**0,49**	4,20	***
2007-2014	**O/N**	t-value	sign.	**1m**	t-value	sign.	**3m**	t-value	sign.	**6m**	t-value	sign.	**12m**	t-value	sign.
0	**1,01**	47,58	***	**0,54**	5,81	***	**0,44**	4,39	***	**0,36**	3,39	***	**0,29**	2,68	***
+1	**0,00**	0,07		**0,01**	1,14		**0,00**	-0,03		**0,03**	1,02		**0,05**	1,02	
0…+1	**1,01**	47,79	***	**0,55**	5,89	***	**0,44**	4,38	***	**0,39**	3,36	***	**0,34**	2,40	**
-5	**1,02**	114,55	***	**0,80**	16,94	***	**0,69**	11,36	***	**0,59**	7,15	***	**0,50**	4,82	***
+5	**0,00**	0,40		**0,03**	1,31		**0,01**	0,25		**0,06**	0,83		**0,01**	0,08	
-5…+5	**1,03**	82,76	***	**0,83**	19,18	***	**0,70**	10,37	***	**0,65**	6,49	***	**0,51**	4,14	***

Table 12. Regression betas and t-values for period 2002-2014 (South Africa), (, **, ***, 10%, 5%, 1% significant, respectively)*

Riskiness can be witnessed in the results of South African market's reactions. However, as the interbank market volatility was relatively low, there was adequate liquidity in the interbank markets. The market participants were also confident on each other's financial stability which further kept the financial system running. Overnight market rate reacted 79% of the central bank rate change during the before crisis-period on the announcement day and with the same magnitude as the central bank rate during the after crisis period. Overnight rates also had significant anticipatory effects on both periods. This indicates that the overnight rates are closely linked to the central bank's monetary policy implementations for primarily adjusting overnight rates accordingly. As in cases for the majority of the markets being examined, market responses become weaker as the maturity rises.

Overall the South African market rates reacted stronger on the central bank rate adjustments compared to other markets being examined. Probable reason for this is that in contrast to Libor-rates that indicate financial institutions' estimate in the London market of the interbank rates at which they are willing to trade funds in the interbank markets, the Jibar-rate is founded on the interest rates at

which domestic South African banks trade their own negotiable deposit certificates and represent actual rates used in trading procedures.

5.2.5 India

India's economy had a similar situation before the crisis as many other emerging economies. The country has an old and conservative banking system meaning that by the time the crisis hit in, the financial institutions in India had only limited exposure to asset-backed securities and other harmful financial products. Also the Indian economy was developing with healthy path relying significantly more on domestic investments and consumption. Interestingly, external demand accounted for less than 15 per cent of India's GDP during the years after the crisis.

However the globalization and risen integration to global economy brought many harmful effects of the financial crisis quickly to India as well. Practically this meant that Indian companies have had better access to international funding. Despite the risks of volatility and undeveloped banking system, Indian companies showed massive growth potential and the development lured foreign capital into the country. As a consequence, the contagion of the harmful effects started.

Indian banks and institutions began to shift the credit demand more on domestic financial markets as the global situation led to a phase where foreign financing started to eventually decelerate. As searching for substitute financing methods the banks also withdrew their money from domestic mutual funds putting even more pressure on volatile environment. Obviously as the United States, Euro-zone and the countries in Middle East are extremely important for India's goods

and services trade, the drastic deceleration of these economies spread rapidly to measures of India's exports.

The Reserve Bank of India responded quickly. The main policy responses aimed at keeping the domestic money and credit markets running. These attempts were characterized by maintaining rupee's liquidity as well as to increase foreign exchange liquidity. As the central bank was struggling with increased inflation figures before the crisis, the Reserve Bank had follow the global monetary easing actions. Central bank rate was forcefully cut and policy adjustments were made to awaken foreign borrowing. This helped the domestic financial markets to maintain their functioning. The results of Indian interest rates are shown in Table 13.

India									
2002-2006	**O/N**	t-value	sign.	**1m**	t-value	sign.	**3m**	t-value	sign.
0	**0,27**	1,82	*	**0,12**	1,55		**0,10**	1,50	
+1	**0,33**	1,34		**0,12**	1,79	*	**0,12**	2,21	**
0…+1	**0,60**	1,60		**0,24**	1,75	*	**0,22**	1,96	*
-5	**0,10**	0,74		**0,17**	2,59	***	**0,18**	3,82	***
+5	**0,70**	3,35	***	**0,33**	7,30	***	**0,30**	8,47	***
-5…+5	**0,80**	3,49	***	**0,50**	5,52	***	**0,48**	8,31	***
2007-2014	**O/N**	t-value	sign.	**1m**	t-value	sign.	**3m**	t-value	sign.
0	**0,95**	1,76	*	**0,15**	2,44	**	**0,10**	2,05	**
+1	**-0,15**	-0,35		**0,28**	2,42	**	**0,25**	2,42	**
0…+1	**0,79**	1,27		**0,43**	4,19	***	**0,35**	3,94	***
-5	**1,56**	2,97	***	**0,33**	3,22	***	**0,28**	3,11	***
+5	**-0,67**	-0,86		**0,53**	2,89	***	**0,39**	3,34	***
-5…+5	**0,89**	2,37	**	**0,86**	5,06	***	**0,67**	5,86	***

Table 13. Regression betas and t-values for period 2002-2014 (India), (, **, ***, 10%, 5%, 1% significant, respectively)*

The results of Indian markets designate a drastic change in overnight rate reactions. Overnight rate changes are positive and statistically significant on the announcement day on both periods but the overnight rate had only a 27% change of the central bank rate reaction during the before-crisis period, whereas

the overnight rate had almost equal magnitude change with respect to central bank rate adjustment during the after-crisis period. The central bank rates had also statistically significant learning effects on overnight rates during the before-crisis period whereas there where extremely intense anticipatory effect on the latter period. This indicates that the volatility in the overnight rate markets as well as overall market cautiousness spread to Indian markets quickly.

What comes to 1-month and 3-month rates, the development has been somewhat similar to English markets. The market interest rate effects distinguishable decrease as the maturity increase and the effects are spread on both before and after the announcement day. The total effect of -5 to +5 days remains at the level of closely a half of the central bank rate adjustment during the before-crisis period, whereas the market effects rise up to 0,86 on the latter period. This is consistent with the market interest rate reactions of other emerging economies being examined. Generally, this supports Rai et al.'s (2007) observations of markets with higher amount of central bank rate changes having a tendency of market rate responses spreading before and after the announcement day. Reserve Bank of India made 36 central bank rate adjustments during the time period examined which represents the second highest number of changes right after Banco Central do Brasil.

6. Conclusions

The purpose of the thesis was to investigate the interbank market rate reactions on central bank rate adjustment on a global scale before, during and after the financial crisis. As mentioned before the main focus was revolved around three research problems. The thesis attempted to classify the effects of the financial crisis of 2007-2009 comprehensively and point out global differences in both monetary policy-wise and market reactions. The empirical model of the study also provided support that regular rate adjustments conducted by national central banks are distinct from those with irregular central bank rate changes. Finally, the global market rate plunge after the crisis clearly indicated that all participants have made enormous efforts on risk management procedures, as well as on regulations in order to increase information transparency.

When analyzing and evaluating various central bank responses to the crisis, it is crucial to remember that even though the origins of the crisis are common around the world, the recent financial crisis has impacted analyzed economies differently. Importantly, in developed economies in which the crisis originally ignited, it was typical that harmful effects spread from the financial sector to the real sector. Conversely, in emerging economies, the transmission of external born shocks to domestic weaknesses has typically been transferred from the real sector to the financial sector-side. All the economies have then accordingly responded to the crisis symptoms depending on their economy-specific circumstances. That is why, even as policy responses across economies are widely similar, exact design, magnitude, progression and timing of the adjustments have varied significantly. As policy responses in developed countries have mainly attempted to tackle issues related to both stopping the financial crisis to spread further, as well as the worsening recession, emerging economies have had to focus relatively more on deteriorating economic growth and export market development.

Data setting and analysis framework were set straightforward. The analysis data was divided into two categories, one including five developed markets and one including five emerging markets. The research was conducted in a way that the analysis period was also divided into two parts including both before- and after-crisis periods. Central bank rate and market interest rate data were gathered for each market by ThomsonReuters databases and interbank rate data involved exclusively maturities from overnight rate to 12-month interest rate. Due to difficult data availability of emerging markets data, the data of certain markets had only partial maturities and periods to be included in the analysis.

As a whole, similarities within the markets can be found. Firstly, the market interest rate reactions tend be similar maturity-wise. Practically, this means that all the markets evidenced the strongest reaction in overnight rates or spot-next rates and as the maturity rose the effects became weaker. This was also the case when analyzing the differences between the pre-crisis and after-crisis periods. Weaker long maturity reactions were also evidenced in studies of Cook et al. (1989), Dale (1993) and Neumann et al. (1996). Developed countries had two kinds of trends. Euro-zone and the United States had weaker total interbank rate reactions in the pre-crisis period and stronger reactions in after-crisis period. The main reason for this can be found in crisis origination and significantly quick contagion pattern and in addition, in exposures of risky assets in these markets. The countries with smaller exposure to these assets and better preparation for the market volatility in terms of risk management procedures, for example Switzerland and Canada, survived from the crisis with relatively less damage, and therefore, the market interest rate reactions were weaker in the after-crisis period.

Interestingly during the before crisis-period, the anticipatory effects were statistically significant for most of the developed and emerging economies but there were only marginal learning effects to be observed. The exceptions for this were the United Kingdom and Switzerland in which the central banks have a

rather frequent central bank rate adjustment schedules throughout the year and therefore the market rate reactions are more scattered. As the markets reacted forcefully before the announcement day, the interbank markets were mainly anticipating the central bank rate's strategy in the infrequent central bank rate announcement schedule and moreover, that the interest rate policy had more emphasis in the monetary policy framework before the crisis.

During the after crisis-period the market interest rate reactions are more scattered before and after the announcement day as well as the reactions are equal or in many cases even stronger than in before crisis-period. A general reason for this is global uncertainty and volatility in the markets. The trend in the markets seems to rely more on adjusting the rates near the announcement and then fixing and fine-tuning the market rates after the announcement day. Probably even more important explanation for the scattered interbank market reactions during after crisis-period, especially for the emerging economies, is the stronger emphasis on exchange rate policy and relatively lessened effort on interest rate policy. The global crisis had a vast impact on nature resource dependent emerging economies whose markets were shaken. Obviously the national currency's favorable development gain more attention as the domestic markets had to be kept as vital as possible.

Apart from the observations mentioned before the interest rate markets seem to have reacted similarly with slightly different magnitudes. The main reason for this is that despite the fact that economies have different monetary policies with different intentions and policy goals, the interest rate markets are linked globally. This means that both positive and negative interest rate market shocks will have effects on not only the originating market but also on other markets indirectly. The interest rate markets during these volatile years provide many interesting topics for further research. As there have been many national market shocks and crises during the time period examined for example the event study method could be used to analyze individual domestic crisis's impact on interest rate

markets. Also other macro economic factors' and longer term rates' impact on the market rates' development could be of further interest. Finally, the additional data could be gathered with swap rates to provide comprehensive analysis for risk premium-adjusted results. However, the data availability for emerging markets swap rates should significantly improve in order to witness more accurate analysis.

7. References

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8. Appendices

USD Libor						EUR Euribor					
2002-2014	O/N	1-month	3-month	6-month	12-month	2002-2014	O/N	1-month	3-month	6-month	12-month
Mean	1,622	1,714	1,838	1,986	2,216	Mean	1,751	1,877	2,029	2,152	2,326
Maximum	6,875	5,824	5,725	5,640	5,766	Maximum	4,601	5,197	5,393	5,448	5,526
Minimum	0,080	0,148	0,223	0,319	0,534	Minimum	-0,085	0,005	0,078	0,171	0,325
Std. Dev.	1,804	1,808	1,796	1,748	1,635	Std. Dev.	1,398	1,435	1,444	1,402	1,363
Skewness	0,997	0,960	0,928	0,890	0,850	Skewness	0,254	0,324	0,436	0,463	0,468
Kurtosis	2,583	2,494	2,429	2,357	2,302	Kurtosis	1,676	1,887	2,159	2,275	2,339
Probability (p-value)	<0,001	<0,001	<0,001	<0,001	<0,001	Probability (p-value)	<0,001	<0,001	<0,001	<0,001	<0,001
Observations	3392	3392	3392	3392	3392	Observations	3392	3392	3392	3392	3392

Appendix 1. Descriptive statistics for USD Libor and EUR Euribor daily rate data in period 2002-2014 (in percentages)

GBP Libor						Swiss Libor					
2002-2014	O/N	1-month	3-month	6-month	12-month	2002-2014	S/N	1-month	3-month	6-month	12-month
Mean	2,708	2,802	2,941	3,072	3,308	Mean	0,637	0,688	0,783	0,871	1,078
Maximum	6,794	6,750	6,904	6,799	6,654	Maximum	4,583	3,015	3,127	3,202	3,375
Minimum	0,383	0,482	0,504	0,582	0,859	Minimum	-0,030	-0,048	-0,066	-0,034	0,034
Std. Dev.	2,087	2,119	2,106	2,041	1,912	Std. Dev.	0,817	0,842	0,908	0,924	0,925
Skewness	0,049	0,057	0,062	0,059	0,058	Skewness	1,313	1,188	1,211	1,177	1,114
Kurtosis	1,232	1,291	1,353	1,371	1,395	Kurtosis	3,885	3,049	3,122	3,033	2,916
Probability (p-value)	<0,001	<0,001	<0,001	<0,001	<0,001	Probability (p-value)	<0,001	<0,001	<0,001	<0,001	<0,001
Observations	3392	3392	3392	3392	3392	Observations	3392	3392	3392	3392	3392

Appendix 2. Descriptive statistics for GBP Libor and Swiss Libor daily rate data in period 2002-2014 (in percentages)

Canada Interbank						Russia Mosprime				
2002-2014	O/N	1-month	3-month	6-month	12-month	2007-2014	O/N	1-month	3-month	6-month
Mean	2,244	2,318	2,425	2,572	2,852	Mean	5,821	6,754	7,409	8,062
Maximum	5,692	5,250	5,340	5,293	5,100	Maximum	27,300	29,160	29,930	30,310
Minimum	0,172	0,292	0,398	0,693	1,233	Minimum	1,450	2,730	3,730	0,000
Std. Dev.	1,350	1,328	1,282	1,195	1,034	Std. Dev.	2,654	3,862	4,153	4,572
Skewness	0,164	0,178	0,213	0,276	0,344	Skewness	2,386	2,673	2,648	2,220
Kurtosis	1,892	1,933	1,947	1,951	1,955	Kurtosis	15,372	11,529	10,965	8,525
Probability (p-value)	<0,001	<0,001	<0,001	<0,001	<0,001	Probability (p-value)	<0,001	<0,001	<0,001	<0,001
Observations	2979	2979	2979	2979	2979	Observations	2078	2533	2533	2206

Appendix 3. Descriptive statistics for Canada Interbank and Russia Mosprime daily rate data in period 2002-2014 (in percentages)

China Shibor						Brazil Real Interbank				
2007-2014	O/N	1-month	3-month	6-month	12-month	2002-2014	1-month	3-month	6-month	12-month
Mean	2,419	3,641	3,768	3,765	3,944	Mean	13,538	13,604	13,727	14,043
Maximum	13,444	9,698	6,461	5,524	5,256	Maximum	26,900	27,770	28,690	32,560
Minimum	0,801	1,013	1,204	1,466	1,850	Minimum	5,575	6,980	6,990	6,940
Std. Dev.	1,100	1,492	1,316	1,189	1,098	Std. Dev.	4,754	4,820	4,927	5,222
Skewness	1,847	0,402	-0,355	-0,527	-0,601	Skewness	0,872	0,915	1,001	1,303
Kurtosis	11,919	3,232	2,101	1,979	1,865	Kurtosis	3,151	3,219	3,451	4,529
Probability (p-value)	<0,001	<0,001	<0,001	<0,001	<0,001	Probability (p-value)	<0,001	<0,001	<0,001	<0,001
Observations	2148	2148	2148	2148	2148	Observations	3392	3392	3392	3392

Appendix 4. Descriptive statistics for China Shibor and Brazil Real Interbank daily rate data in period 2002-2014 (in percentages)

South Africa Interbank						India Interbank			
2002-2014	O/N	1-month	3-month	6-month	12-month	2002-2014	O/N	1-month	3-month
Mean	7,547	7,855	8,020	8,219	8,513	Mean	6,393	7,018	7,467
Maximum	13,000	13,100	13,598	13,929	14,433	Maximum	63,210	12,500	12,740
Minimum	0,000	4,931	5,063	5,213	5,345	Minimum	0,140	3,380	4,080
Std. Dev.	2,530	2,479	2,529	2,465	2,425	Std. Dev.	2,548	1,920	1,912
Skewness	0,508	0,694	0,718	0,762	0,751	Skewness	7,874	0,002	-0,038
Kurtosis	2,601	2,201	2,299	2,368	2,400	Kurtosis	163,423	2,045	1,890
Probability (p-value)	<0,001	<0,001	<0,001	<0,001	<0,001	Probability (p-value)	<0,001	<0,001	<0,001
Observations	3392	3392	3392	3392	3392	Observations	3392	3392	3392

Appendix 5. Descriptive statistics for South Africa Interbank and India Interbank daily rate data in period 2002-2014 (in percentages)