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MASTER'S THESIS

THE EFFECT OF THE LIBOR SCANDAL ON BANK RETURNS

Ljubljana, October 2017 LUKA VIDONI

AUTHORSHIP STATEMENT

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INTRODUCTION

The London Interbank Offered Rate (hereinafter: Libor) is a reference interest rate at which banks are borrowing and lending money to each other. The most important banks in the world submit every workday a hypothetical expected borrowing rate at which they could obtain additional funds. The submission is private and until the Libor scandal the British Bankers' Association (hereinafter: BBA) was the intermediary. Every day BBA was collecting the quotas from the banks and publishing the most recent average interest rate, based on all the submissions. By some estimates 150 trillion US Dollars (hereinafter: USD) worth of loans and derivative contracts, such as options, futures and swaps, are based on Libor interest rate. Libor is used as a reference interest rate in contracts, savings accounts derivative transactions – it is literally intertwined with whole global economy. Because of its function it is sometimes viewed as an indicator of health for the banking system and even the central banks look at it as one of the gauges. Based on it the central banks might take a decision to intervene in order to stabilize the economy. Above all Libor is important because of the systemic trust which is placed into it.

This is why the global financial markets were in such a shock, when the Libor scandal became apparent in 2012. The manipulation practices were not a brief occurrence, in fact they had been going on since the 90ties. Manipulating the interest rate not only meant stealing form another contractual party, but also that the Libor scandal shook the foundations of our global financial markets. The biggest issue at stake was to restore trust of the markets into the Libor system. A period of uncertainty followed as the banking system was looking for a way to continue to function, while at the same time trying to root out the manipulating practices and reform the system. Lengthy investigations happened both in mainland Europe, in the United Kingdom (hereinafter: UK), in Asia and in the United States (hereinafter: US). Each time one of the banks collaborated with the investigators more had become known about the scale of the monopoly and the players involved. Substantial fines were then given to the banks in question and their share prices reacted sharply to any information about the Libor scandal.

In this master thesis I attempt to find out how the financial markets reacted to the information about the Libor scandal. As the scale of it became apparent and the banks involved became publicly known, the expected fines should have become incorporated into banks' share prices. By using established financial asset pricing models I try to test the responses of the banks on the news stories surrounding the Libor scandal. This master thesis gives a reader also an overview of the milestones and timelines of the Libor scandal, which has been in the global headlines for the last few years. I want to also test, if the cheating banks, despite paying heavy fines, did produce better returns, as the ones, which were not involved into the scandal. In other words, the question is, if the fines the regulators imposed on the banks had a notable effect.

The structure of this master thesis is split into two major parts. The first part contains and overview of Libor and Libor scandal as well as the theoretical methodology review. By reviewing established news sources I create a detailed timeline how the Libor scandal developed for each bank that was involved. For each of the affected banks I also present an overview, to put them into a global context. In the methodology section the current models of estimation are presented in a balanced and critical way leading to the description of my selected approach for empirical testing.

The second part of the master thesis is based on my analysis of the share price data for a sample of banks. I rely heavily on the dates and information outlined in the first part of the thesis, when creating a database to analyze the impact on the share price for banks involved in the Libor scandal. By utilizing different research techniques I attempt to convey my findings in a logical manner and proving and disproving my initial expectations on market behavior in case of negative news events.

1 LIBOR, LIBOR SCANDAL AND THE BANKS

As Cartwright and Menezes (2014) highlight in their work, intensity of competition is an important factor of cheating. With the deepening of the financial crisis after 2008, the banks were under pressure to perform in the difficult climate. Similarly unethical practices were present in the banking industry already during the tech bubble of 2000, where some banks were involved in earnings manipulations (Shleifer, 2004).

On the other hand an intense competition could also lead to less cheating. The rationale behind it is, that in a highly competitive environment there is little room for cheating. In their study Cartwright and Menezes (2014) argue, that the highest levels of cheating normally appear in intermediate levels of competition.

In case of the Libor scandal the public became aware of it on May 29, 2008, when Wall Street Journal aired a story, that several major international banks were reporting unjustifiably low Libor rates. This is date is seen as the beginning of the Libor scandal (Monticini & Thornton, 2013).

1.1 The London Interbank Offered Rate

Libor stands for “London interbank offered rate” which used to be gathered and published by the British Banker’s Association until January 31, 2014. On February 1, 2014, a US operator Intercontinental Exchange took over the administration of the LIBOR which formally changed to Intercontinental Exchange (hereinafter: ICE) Libor. The Libor was meant to be at the beginning a survey of interbank lending rates (Bodie, Kane, & Marcus, 2014). Back in 1984 with the liberalization of the financial markets trading with options was

on the increase (Freese & Kassel, 2013). A standard method was needed to determine how much a bank should charge for a future loan. The British bankers Association was appointed by the banks to define a neutral benchmark, which was to underline many of the new instruments. Libor was initially published only in USD, Japanese Yen (hereinafter: JPY) and British Pound (hereinafter: GBP). It was only later that Libor was quoted in 10 currencies and 15 maturities. This change came later in 1998. Prior to that year banks were making a hypothetical guess, at what rate one AAA-rated bank would lend to another one. From 1998 onwards banks had to estimate the rate at which they themselves were likely to obtain funding every day. A first spike in Libor is seen at the turn of the century with the collapse of Enron (Freese & Kassel, 2013).

For 30 years Libor rate has been calculated based on average daily estimates of short-term interbank borrowing rates. The rates were provided daily by bank employees. Today ICE is trying to base their figures on market transactions, utilizing a bottom up approach. A human input is only needed when the volume of trading falls below a certain threshold. The new calculation however does not only cover the bank-to-bank lending. It is also meant to include short-term funding that comes from central banks, corporations, non-bank financial institutions and other counterparts. The decision to include also the non-bank lending was taken after the interbank lending has gone down, as the banks have tried to reduce their exposer to other banks. At the same time the regulators have also been insisting that banks get longer terms and more secure funding from less volatile sources (Hale, 2016).

The old Libor system, published by the British Bankers' Association saw its beginnings in 1986 and its rates have become an important pillar of international finance throughout the decades. Libor is used in derivatives trading as well as it is paramount for financial swaps and loans around the globe. Therefore having control over Libor would allow individuals to realize substantial gains in the financial markets and beyond (Monticini & Thornton, 2013).

As Bodie et al. (2014) say, Libor interest rates nowadays refer not only to the GBP. They are used for transactions denominated in GBP, JPY, EUR and USD and refer more to a group of banks, active in the UK, than to the reported currencies. European Interbank Offered Rate (hereinafter: Euribor) is a similar rate at which banks in the Euro zone are willing to lend among themselves.

Loans to corporations and governments as well as to the general public have floating rates which get updated daily to the latest Libor rate. A loan in GBP can be set e.g. for one-month Libor plus 30 basis points, where the 30 basis points represent the margin which a lender receives on top of the valid Libor rate. Libor is provided not only for different currencies, but also for multiple maturities (Hull, 2012). They span from overnight – 12-months, producing 35 rates each business day (ICE Benchmark Administration, 2016).

Under the British Bankers Association system as well as under the new ICE system, the rates were based on quotes provided to the BBA / ICE by large banks. According to ICE

Benchmark Administration (2016), banks have to answer the following question: "At what rate could you borrow funds, were you to do so by asking for and then accepting interbank offers in a reasonable market size just prior to 11 A.M.?". This means that the quotes are based on the lowest perceived rate at which a bank could go into the London interbank money market and obtain funding in reasonable market size, for a given maturity and currency. ICE further explains that *reasonable market size* is intentionally left open for interpretation. As a rule, all Libor rates are quoted at an annualized interest rate.

Table 1. Panel composition of international banks involved in Libor submissions

Bank/Currency	**USD**	**GBP**	**EUR**	**CHF**	**JPY**
Lloyds TSB Bank plc	x	x	x	x	x
Bank of Tokyo-Mitsubishi UFJ Ltd	x	x	x	x	x
Barclays Bank plc	x	x	x	x	x
Mizuho Bank, Ltd.		x	x		x
Citibank N.A. (London Branch)	x	x	x	x	
Cooperatieve Rabobank U.A.	x	x	x		
Credit Suisse AG (London Branch)	x		x	x	
Royal Bank of Canada	x	x	x		
HSBC Bank plc	x	x	x	x	x
Santander UK Plc		x	x		
Bank of America N.A. (London Branch)	x				
BNP Paribas SA, London Branch	x	x			
Crédit Agricole Corporate & Investment Bank	x	x			x
Deutsche Bank AG (London Branch)	x	x	x	x	x
JPMorgan Chase Bank, N.A. London Branch	x	x	x	x	x
Société Générale (London Branch)	x	x	x	x	x
Sumitomo Mitsui Banking Corporation Europe Limited	x				x
The Norinchukin Bank	x				x
The Royal Bank of Scotland plc	x	x	x	x	x
UBS AG	x	x	x	x	x

Source: ICE Benchmark Administration (IBA), *ICE LIBOR*, 2016.

Every ICE Libor rate is calculated by using a trimmed arithmetic mean. All received submissions are ranked in order from highest to lowest, and with the lowest and the highest 25% being excluded as outliers. The remaining values are used for the final arithmetic average calculation. The result is rounded to five decimals (ICE Benchmark Administration,

2016). This was also the case under the BBA standard (Hull, 2012). Table 1 shows the list of banks which were involved in Libor submissions, as of May 2016 (ICE Benchmark Administration, 2016).

According to Hull (2012) a bank must have an AA credit rating in order to qualify for a Libor loan. Since the Libor manipulations occurred, additional new measures have been put in place. An Oversight Committee was formed which protects the industry led Code of Conduct. ICE Benchmark Administration has developed a special Conflicts of Interest Policy in order to return credibility back to Libor. The objective of the policy is to ensure that conflicts of interests within the ICE Benchmark Administration are identified and managed accordingly (ICE Benchmark Administration, 2016).

A former Libor administrator, the BBA Enterprises Ltd (2013), gave in into political and media pressure in the aftermath of the Libor scandal and approved the transfer of Libor administration to the New York Stock Exchange (hereinafter: NYSE) Euronext Raters Administration Limited, which owns the ICE Benchmark Administration. At the same time, a decision was also taken, to reduce quoting Libor rates from ten currencies and 15 maturities, to five currencies and seven maturities. In this process Libor quotes of Danish, Swedish, Canadian, Australian and New Zealand Libor rates were terminated.

In the times of low interest rates Libor has had additional indirect importance for the financial system. When the treasury bills are regarded as being too low to be objectively used as a risk-free rate, a swap rate is used instead. The swap rate is a fixed rate which one decides to pay, instead of paying the ever changing Libor rate. Such a swap is called an overnight indexed swap (hereinafter: OIS). It does not necessarily only link to Libor rate, as it can refer to a swap at a fix rate for a different geometric average of overnight rates during a selected period (Hull, 2012).

The OIS rate effectively measures the market’s expectation of the overnight funds rate for the duration of the contract. Because the exchange of principal does not take place, there is very little default risk, since the funds, including the net interest, are payed to another contractual party only when the contracts matures (Thornton, 2009).

The spread between the OIS rate and the Libor rate indicates current health of the banking system. Hull (2012) also says that OIS swap rate is often assumed as a good risk-free rate. A key indicator of stress in the banking system is the LIBOR-OIS spread.

Before August 2007, the Libor-OIS spread amounted to less than 10 basis points. At the beginning of the U.S. real-estate market downturn, as banks started to become weary of lending to each other, the Libor-OIS spread grew. In October 2008 the highest point of 364 basis points was reached around the time of Lehman Brothers bankruptcy (Hull, 2012).

1.2 Overview of banks involved into Libor scandal

In the following section I briefly introduce my sample of banks which were involved in the Libor scandal. I use the same sample of banks also later to analyze markets reaction to the fines these banks received from the regulators. This section does not show these banks' involvement in the Libor manipulations, but rather presents a broader picture about each of the banks involved. The descriptions should therefore serve as a short background information about each of the banks, before diving deeper into their involvement in the coming sections.

1.2.1 Barclays

Barclays PLC (hereinafter: Barclays) is a multinational banking corporation based in London. They pride themselves with their Quaker roots from more than 300 years ago, which back then stood for honesty and hardworking protestant ethic. Today the bank leverages on its global network, where main drivers of business represent Personal and Corporate banking, Investment Banking and Barclaycard; the global payment system. They have finished the year 2015 with 25bn GBP of revenue as seen in Barclays' annual report (2015) and 50bn GBP of total assets. In 2015 revenues and profits were declining in comparison to prior year and the bank is going through a restructuring to streamline its operating expenses. In 2009 during the peak of the global financial crisis, Barclays was under pressure to perform despite the dire economic situation.

1.2.2 Citigroup

Citigroup Inc. (hereinafter: Citigroup) is a New York City based multinational banking corporation. Also they have been active for more than 200 years, having financed some major attempts of mankind such as the Marshall plan, the transatlantic cable, the Space Shuttle Program, the Panama Canal and the foreign exchange network. In 2015 they had revenues of 76bn USD, down -1% in comparison to prior year. The revenue was mostly supported by the consumer banking division (50%), followed by the revenues from institutional clients (26%) and revenues from market and security services for institutional clients (24%), based on the Citigroup's annual report (2015). In year on year growth comparison of income from continuing operations, the driving segments were EMEA in institutional clients business as well as Asia, up 12% and 8% respectively. Net income at 17bn USD in 2015 improved tremendously in comparison to 7bn USD in 2014. The difference was driven mostly by the Corporate / Other section which includes costs of global functions like legal and compliance. Net income in this segment was 425m USD in 2015 and – 5bn USD in 2014, since by 2014 the banks was able to resolve legal claims with regulators and local governments, possibly to some extent also arising from the financial scandals which happened during and after the financial crisis.

1.2.3 Credit Suisse

Credit Suisse AG (hereinafter: Credit Suisse) is a Zürich based multinational financial corporation. It also traces its beginnings back almost 200 years ago. It was involved in financing expansion of Swiss railways and was involved in providing funding to the further industrialization of Switzerland. Credit Suisse is leading global wealth manager with investment banking capabilities and cross border optimization, leading back to its native Switzerland. In 2015 their annual revenue amounted to 25bn CHF, down -9% in comparison to the prior year and net loss of -3bn CHF, down from + 2bn CHF in 2014. Total assets of the company amounted to 821bn CHF in 2015, as reported in the Credit Suisse annual report (2015). In October 2015 also Credit Suisse started a new strategy approach and laid the ground work for its restructuring. Revenues were supported primarily by the Global Markets division, Swiss Universal Bank, International Wealth Management and Asia Pacific division. The goodwill impairment, which further dampened profits in 2015 was mostly related to the International Wealth Management and Asia Pacific division.

1.2.4 Deutsche Bank

Deutsche Bank AG (hereinafter: Deutsche Bank), is one of the words largest credit institutions. It was founded in Berlin in 1870 as a bank focusing on foreign trade, providing direct competition to the British banks which used to finance German international trade at the time. After the First World War, Deutsche Bank was hit hard by the economic downturn which has plagued Germany at the time. During the Nazi era Deutsche Bank was heavily involved and profited from the partnership with the state apparatus and its crimes. After the Second World War, the bank was split in to many regional banks. However later they again merged together to merged to form Deutsche Bank. More recently the bank was also substantially involved in selling collateralized debt obligations, which had paved the way for the financial crash of 2008.

In its annual report Deutsche bank (2015) reported total revenues of 33,525 billion EUR, up +5% in comparison with prior year. The revenue growth was mainly driven by net interest income increases, up +13%. Revenue from noninterest sources was fairly stable. As the bank says, was the increase in interest income related to the strong client activity as well as favorable exchange rate. On the other hand net income turned to a loss of 6.8 billion EUR in 2015, from 1.7 billion EUR in 2014. Total asset in 2015 amounted to 1,629 billion EUR, based on the Deutsche Bank's annual report (2015).

1.2.5 JPMorgan & Chase

JPMorgan & Chase is a multinational financial conglomerate. Over the course of their history, starting in 1799, the bank has been built on more than a thousand predecessor

institutions. It traces its beginnings to the Manhattan Company, which was founded after the American Revolution, and initially focused on building a water pipeline to the lower Manhattan. At the time banking services were also explored as an additional business activity. More recently in the year 2000 J.P. Morgan & Co. Incorporated merged with The Chase Manhattan Corp. By doing so it combined four of the largest and oldest banking institutions in New York City (J.P. Morgan, Chase, Chemical and Manufacturers Hanover) into one firm under the name of J.P. Morgan Chase & Co. In 2008, JPMorgan Chase acquired also The Bear Stearns Companies Inc. The bank was, together with the Goldman Sachs, also reportedly involved in the Greek financial crisis. Over multiple years it was believed to have helped the Greek government to conceal the extent of the Greek indebtedness (Mueller, 2010).

For the year 2015 JPMorgan & Chase (2015) reported 93.5 billion USD of revenue, down -2% in comparison to 2014. Decline was mainly driven by lower corporate private equity gains, lower Corporate & Investment bank revenue reflecting the impact of business simplification, and lower Mortgage Banking revenue. Despite this 2015 for JPMorgan & Chase was more profitable as net income grew +12% to 24bn USD. The growth in net income was mostly driven by the tax savings as the effective tax rate of the company decreased by 9 p.p. in comparison to 2014 (JPMorgan & Chase, n.d.).

1.2.6 Lloyd's

Lloyd's Banking Group plc (hereinafter: Lloyd's) is tracing its beginnings to the 17th century London where Edward Lloyd's coffee house was increasingly getting also involved in insurance of the maritime business, as found on the Lloyd's website (n.d.). For much of its existence Lloyd's was more of a shipping insurance company, than a bank. Throughout the centuries it has specialized in obtaining the information ahead of the competition. It even enjoyed close ties with the British Admiralty and helped the maritime business flourish within the global empire. Today vision of Lloyd's for the future is still an expansionist one, focused on insurance and reinsurance businesses especially in emerging markets.

In 2015 Lloyd's total revenue grew by +4% to 350 million GBP in comparison to prior year. The growth was driven both by its core operations as well as by the Central Fund contributions, according to Lloyd's 2015 annual report (2015). Despite this, Group's net income declined by -19% to 74 million GBP, mainly caused by a reduction financial income.

1.2.7 RBS

The Royal Bank of Scotland Group plc (hereinafter: RBS) is a British banking holding company which is tracing its beginnings to 18th century Scotland. It was initially set up as a relief fund to the Scottish population, after Scotland failed to establish colonies of its own in

Central America, as visible on website of the Royal Bank of Scotland (n.d.). Ever since it was founded in 1727, the Royal Bank of Scotland has been competing with the Bank of Scotland. In the early years the two banks were even buying off competitor's banknotes in order to force the opponent into bankruptcy upon demanding the payment on large sums of competitor's banknotes. Later as commerce and cities expanded the Royal bank of Scotland was there to finance construction of the railway networks as well as industrial expansion. In 2000 RBS obtained National Westminster Bank through a hostile takeover which enabled RBS to become present in the US and in continental Europe. In 2007 RBS was involved in the biggest banking takeover yet. In a consortium together with the Fortis Group and Banco Santander it managed to obtain the Dutch bank ABN Amro; a takeover which left the consortium heavily exposed. In the recent financial crisis of 2008 the Royal Bank of Scotland was therefore recapitalized by the British Government to facilitate a transitional recovery and save the financial sector from collapsing. In 2015 the Royal Bank of Scotland Group reported a loss of 1,2bn GBP. In comparison to 2014, the profitability improved by 56%. The improvement was largely driven by tax savings as actual tax charge in 2015 amounted to 23m GBP, down from 1,9bn GBP in 2014, mainly due to changes in (Reduction)/increase in carrying value of deferred tax asset in respect of losses from the UK, US and Ireland.

1.2.8 Société Générale

Société Générale was founded in 1864 as a bank tasked with financing French industrial development. It was a private bank which was combining the wealth of numerous industrialists of the time. In a span of a few years the bank would open numerous branches all over France, building a truly nation-wide network as well as its first office in London, which was already at the time an important financial center of the world, as the Société Générale (n.d.) describe. The bank also soon partnered with Russian banks to establish operations in the east. It was also involved in financing the construction of the Eiffel Tower as well as French participation in the Frist World War. The Second World War marked a setback in company's history as many of the branches were destroyed during the war and the bank was fully nationalized after the war had ended. It was only in the late nineties that the bank was again privatized. Later the bank also expanded into Eastern Europe, taking over local banks and joining them into Société Générale Group. During the recent financial crisis Société Générale was badly affected because of the losses inflicted by one rouge trade and needed a loan from the French government to weather the crisis.

As reported in the Société Générale (2015) annual report for 2015, Société Générale grew +9% at a nominal rate to 25.6 billion EUR in revenue in comparison to 2014. With its operating expenses growing relatively slower than the top line grow, the gross operating income increase by +16% to 8.7 billion EUR in 2016. With better operating margin as well as leaner income tax contribution the company has seen an increase of Group net income by +49% in comparison to 2014, reaching 4bn EUR in 2015.

1.2.9 UBS

UBS AG (hereinafter: UBS) is a Swiss multinational financial corporation, headquartered in Zurich. The abbreviation UBS stands for Union Bank of Switzerland. UBS traces its beginnings back to 1856, according to the UBS (n.d.). The bank was increasingly involved first in industrial expansion of Switzerland, and later also opened its branches in the US and in other major financial centers. During the latest financial crisis UBS has seen major losses due to the subprime mortgage crisis which has led to company's restructuring and closing down of some of the divisions. The bank was able to emerge from the crisis in the following years, but Libor manipulation was not the only ethically questionable undertaking.

Total operating income in 2015 was 30.6 billion CHF, up +9% in comparison to 2014. It was mostly driven by an increase in net trading income up +49% to 5.7 billion CHF in comparison to 2014, which was in part changed because of valuation changes. Net profit after tax further improved to 6.4 billion CHF, mostly due to 898 million CHF of tax benefits.

1.3 Libor scandal overview

This section provides a description of events how the Libor scandal unfolded. A more detailed case by case description of actual fines, which was used also in the empirical part of the master thesis, will be pressed in the next chapter.

The BBC (2013) reported that it was already in 2005 when Barclays attempted to influence dollar Libor and Euribor for its gains. As it is evident form a later investigation by the Financial Services Authority (2012), the manipulators were widespread, involving Barclays bank employees as well as external traders. Because of this, Barclays was fined 59.5 million GBP by the Financial Services Authority. FSA also published transcripts of traders' communications. Reading through them, one notices how casually the traders and submitters talk about manipulating the Libor interest rate. Some of the submitters even had calendar entries for specific dates to remind them of what kind of Libor interest rate they should falsely declare and for how much. Between 2005 and 2012 Barclays trades, but also trades from other banks, would often report such a low rate, that it will be excluded from the final average calculation. This action shows a well-organized and well spread illegal undertaking, which would in the eyes of some already border to cartel arrangements. Marston (2015) says that the manipulations were so commonplace that Libor rates were able to be change for as little as a Mars bar. In April 2008 the markets started to question the Libor system. UK based Libor rate was notably lower, while its US equivalent, the Fed Funds rate, was continuing to rise, amid the mortgage and banking crisis turmoil. An unsettling detail at the time which could have launched a new wave of additional volatility was the fact that the Bank of England was trying to help the economy by lowering the interest rates. The benchmark for the Bank of England was also Libor. As the central banks were trying to get more liquidity into the economies, banks were building up reserves for later. For big

commercial banks, obtaining funding overnight was not an issue. It was however more difficult to get money on a longer term (Tett and Mackenzi, 2008).

In case of, for example, foreign exchange markets, the rates are calculated based on the actual transactional data. Libor, as it was explained earlier, used to be solely based on averaged hypothetical estimates about the funding costs for each of the big commercial banks involved. Under normal market conditions such estimations are acceptable. By removing the highest and lowest bids, the BBA was meant to ensure for the robustness of the estimate. This works well when a general market risk is low and the risk are contained. During the financial turmoil this was not the case. In an uncertain environment, long term deals have become less commonplace. By increasingly relying on the short-term funding, banks were incentivized to keep the Libor rate low. This way they also would not raise questions of their stability due to the potentially higher costs of funding (Tett & Mackenzie, 2008). At the time, it was also not feasible for Libor to be replaced overnight. With the world at the brink of financial downward spiral, banks and their governing bodies did not want to cause too much of additional market uncertainty. The effects of which could reverberate across the world at the time. Instead a slower transition was chosen. Also in April 2008 the US based Commodity Futures Trading Commission has started an investigation into possible Libor fixing. In November 2009, UK's Financial Services Authority joins the investigation, after the Commodity Futures Trading Commission has shared evidence with the UK, that also British banks might be taking part in the illegal Libor submissions (Freese & Kassel, 2013).

In March 2011 information came out that five global banks are being investigated by the regulators in connection to the Libor malpractices. The banks in question, UBS, Bank of America, Citigroup and Barclays, have reportedly received subpoenas from US regulators for illegal Libor reporting between 2006 and 2008. It has become apparent that the illegal practices have been used also before the financial crash of 2008. As of March 2011, investigators had already reviewed all 16 members of the Libor committee and focused on the above mentioned banks. At the time the investigating agencies were the US Securities and Exchange Commission, the Commodity Futures Trading Commission, the US Department of Justice, the UK Financial Services Authority and the Japanese Financial Supervisory Agency (Masters, Jenkins, & Baer, 2011).

Soon after the spotlight focused on Barclays both in the UK and in the US. The investigators at the time were trying to find out, whether the so called Chinese wall within Barclays had been breached. The Chinese wall security prevents, at least in theory, the trading department to get in touch with the bank's back-office, which is in case of big high-street banks in touch with the Libor authority (Masters & Murphy, 2011).

In September of 2011 the investigation became even more serious with the US authorities focusing on possible conspiracy between traders and bank treasury departments between

2007 and 2008. The investigators were looking into violations of commodities law, which can be penalized with prison sentences. In most cases in the past however investigators have agreed to settle and exchange a prison term for large amounts of money. For example in an investigation into US trading companies, lasting seven years, criminal charges were brought against more than 20 traders from different oil companies for submitting false trade data to the administrative bodies, similar to BBA in Libor's case. The Commodity Futures Trading Commission, which was also investigating Libor manipulations, has in the case of oil companies settled with the 20 energy companies involved for a compensation 300m USD (Masters & Scannell, 2011).

Towards the end of the year 2011 the news came out, that interest rate manipulations also took place in Japan. This had become apparent, after UBS, one of the banks involved collaborate with the investigators and gave the US Department of Justice information about interest rate setting in Japan in return for some degree of immunity. Japan's Securities and Exchange Surveillance Commission found out, that it was UBS and Citigroup, whose employees were repeatedly asking to submit false interest rate figures in order to influence the Tokyo interbank offered rate (Tibor). By doing so they were gaining and advantage on their position over the rest of the market participants. At the time however the Japan's SESC did not confirm if the bankers actually succeeded to falsely influence the rate. The hardest hit between the two, because it was not cooperating with the authorities, was Citigroup. The SESC on the other hand criticized both banks for lacking the internal controls and especially in case of Citigroup for very vaguely responding to regulators demands for information. One could think at this stage that bank was still trying to hide away some of its illegal deals, hence the mentioned lack of sufficient content in the submitted reports. As the Japanese SESC has said, the fixing of Tibor happened at UBS around March 2007, whereas at Citigroup around April 2010 (Whipp, 2011).

At the beginning of the year 2012 investigations of 12 banks also took place in Switzerland following earlier investigations in London, New York and Tokyo. Among these banks were UBS, Credit Suisse, Deutsche Bank, HSBC and Royal Bank of Scotland, as well as Bank of Tokyo-Mitsubishi and Sumitomo Mitsui, and US-based Citigroup and JPMorgan Chase (Simonian, 2012).

The Swiss Competition Commission said that derivatives trades have manipulated the difference between the bid and ask price of derivatives based on the Libor and Tibor rates, creating losses for their clients. During the investigation it became apparent, that the authorities had acted on a tip off from a whistleblower. It is likely that it was UBS which helped the investigators in order to get conditional immunity from the authorities as UBS noted in their quarterly reports. To show their willingness to comply with the investigators, UBS even suspended some of its most senior traders. But UBS was not the only one trying to take drastic action to save their corporate image. Royal Bank of Scotland, Deutsche Bank,

JPMorgan Chase and Citigroup followed suit by either firing, suspending or placing some of their traders on administrative leave (Murphy & O'Murchu, 2012).

The first fine came on June 27 2012 when US and UK prosecutors fined Barclays more than 450 million USD for attempting to manipulate Libor. This also prompted the CEO at the time to waive his bonus for the year, citing collective responsibility. It was also around this time as emails, mentioned earlier, were released to the general public, putting into a public domain just how blunt, open and careless were the traders, who were involved in the illegal Libor manipulations. To curb these illegal practices Barclays had implemented new controls to its rate-submitting process. The investigation did not reveal at the time who in Barclays' organization has initially given a go-ahead for the illegal submissions. It is important to note that the settlement at the time was relating to Barclays attempted manipulation. It did not however cover the fact that on some occasions Barclays' false submissions actually affected the Libor rate. For its cooperation with the authorities Barclays has also received conditional lenience, similarly as UBS in Japan (Masters, Binham & Scannell, 2012).

In summer of 2012 the Libor scandal got also a political spin (Parker and Masters, 2012). Prime minister and member of the Conservative party, which has traditionally been close to the business had been reluctant for a long time to call for a detailed public inquiry into the illegal banking practices concerning Libor. Head of the opposition Labour party, Ed Miliband had on the contrary repeatedly called for a full-scale inquiry. Under the circumstances as Barclays had just been fined both by the UK and US regulators, David Cameron then ordered a short independent review into processes of how the rates had been set. The report was meant to allow the government to amend the Financial Services Bill. The opposition demanded however a tougher new law with possible prison term for immoral banking practices.

In July 2012, giving in to the growing political and media pressure, Barclays' CEO Bob Diamond resigned. British top politician and regulates called his departure the first step towards a new banking culture in Britain. It was also around the same time that it became public, that Barclays' staff was lead to believe that Bank of England authorized them to publish a lower Libor submission. A misunderstanding was believed to have happened after the Bank of England deputy governor Paul Tucker had a conversation with Bob Diamond back in 2008. Tucker's question, why are the reported interest rates so high, was believed to have been wrongly interpreted as a signal to report them lower. It is believed that the signal to lower the reported interest rates initially came from Barclays' Chief Operating Officer, Jerry del Missier (Jenkins et al., 2012).

The Bank of England was concerned over Barclays' financing in the mist of the financial stress. As it became clear in the emails, which were published later in 2012, there was no suggestion from the central bank that the Libor rates should be reported lower (Giles & Kuchler, 2012).

In late July 2012 it also became apparent, that regulators were widening their scope and are investigating attempted manipulation in at least four European banks. Apart of Barclays, which was suspected of being the ringleader, also banks Crédit Agricole, HSBC, Deutsche Bank and Société Générale. It was believed at the time that the traders between all five banks involved were linked to a Barclays' trader Philippe Moryoussef. This was a strong indication, that there is indeed a global problem with the way how Libor was calculated. Voices calling for a change have become ever stronger. At the time, Barclays was however reporting, that all the Libor fixing was orchestrated by one trader, Mr Moryoussef. He worked at Barclays between 2005 and 2007. He was basing his strategy on fixing the three-month swaps pegged to Euribor, by using his network of friends and colleagues at other banks, mentioned above. By the time of the Libor investigations in 2012 these traders have all left the banks in question. It is believed that there were at least 20 requests from traders from other banks made to Barclay's submitters between 2006 and 2008. Therefore a common assumption of the investigators at the time was that most investigated banks were suspected of manipulating their Libor submissions between 2007 and 2009, to appear in a better shape, that they really are, sometimes with an implicit approval of the policy makers. Later investigation however split the Libor fixing practices into two periods. The first one was purely driven by a profit gain, while the second was indeed rooted in financial stability (Jenkins, Scannell, Binham, & Thompson, 2012).

Later investigation of Barclay's trader Moryoussef revealed in early August 2012 that he was aligning on Libor submissions with the Dutch Rabobank (Binham, 2012). As a response to this Rabobank fired four London-based submitters between 2008 and 2011 who had cut deals with traders at other institutions.

On September 25, 2012 The British Banker's Association voted to end its role as the administrator and the watchdog for Libor benchmark, after more than four years after first doubts about the Libor benchmark arose (Masters, 2012a). Leading the UK investigation of the Libor rate was Martin Wheatley, managing director of the Financial Services Authority in the UK. The British Bankers Association had been gradually pulling away from the rate setting process, since 2008, after some have complained that the Libor rate was understated. At the time The British Bankers Association already indicated that it would willingly support any new suggestions which Mr. Wheatley's study might reveal. From the beginning it was both the NYSE Euronext and Bloomberg which offered their administrative services for Libor, replacing the British Bankers Association. On the other hand the calculation mechanism of Euribor, Libor's Euro equivalent, was believed to be sound. In comparison with The British Bankers Associations, where members were private banks, consists the European Bankers Federation of national banking associations.

The Wheatley review was published on September 28, 2012. It was decided concluded that the old Libor is broken and needed immediate fixing. This bold effort was needed by the UK regulators to restore trust in Libor. Apart from reducing the number of reported currencies

and moving the administrative oversight under the control of UK's Financial Services Authority, the new rules would in future also allow that wrongdoings would be punished. The reduction of currencies and daily reported maturities allows the banks to focus on the rates and currencies that investors and borrowers use the most. Under the new system, banks have to demonstrate to the regulators, how they calculated the reported figures. On October 17, UK's Treasury announced that it had approved Wheatley review in all the points, effectively making them a reality (Marston, 2012b).

In October 2012, Thompson (2012) reported that the Royal Bank of Scotland has found itself also in the mists of the Libor investigation. As a precaution Royal Bank of Scotland had suspended its head of rates trading in Europe and Asia Pacific, Jezri Mohideen, who headed trading in Europe, the Middle East, Africa and Asia Pacific.

In December 2012 the public learned about the arrests of three men in the UK as part of the Libor inquiry. The main suspect was Tom Hayes, former UBS and Citigroup trader, who, together with two external traders was questioned by the police regarding the Libor manipulations. It had also become apparent, that UBS has been working with the regulators, to get a reduction of possible fines. Especially in Switzerland UBS began to suspend its traders, which were involved with Libor. They were reported to having fired anyone who was included into Libor-related email chains (Binham, Schäfer, & Masters, 2012).

At the beginning of the year 2013 also the largest interdealer broker in the world, called ICAP, had also become part of the UK Libor investigation. This fact has given the Libor scandal a political sub-tone, as the ICAP's founder Michael Spencer, was the former Conservative party treasurer (Masters, 2013).

Additional information about the scale of Libor misreporting at Barclays became apparent in January 2013. As Binham, Schäfer, Masters, & Thompson (2013) reported, 104 former at current employees of Barclays were publicly named to be involved in the Libor manipulation in front of a London court. At the same time evidence in form of emails was also presented, proving that the bank's leadership knew about the Libor fixing almost a year earlier than previously disclosed. The email conversations were made public during an important legal dispute between Barclays and Guardian Care Homes. Guardian Care Homes sued Barclays for mis-selling of two interest rate swaps in 2007 and 2008. (Schäfer, 2012). The legal case was seen as a president for other similar cases where small businesses were affected by Libor fixing. At the same time, the legal case was used as a way to publicly expose the people who were actually involved in the misreporting process. In February 2013 Chris Lucas, Barclays' finance director since 2007, and Mark Harding, general counsel stepped down from their positions. (Chassany & Jenkins, 2013)

A few days later on February 6, 2013 RBS had decided to pay 612 million USD to settle US and UK investigations for manipulating Libor with one of the RBS's Japanese subsidiaries and at the same time pleading guilty to a US criminal charge. At the time of this article RBS

was 82% publicly owned by the UK. RBS' Japanese subsidiary decided to plead guilty for fraud. It agreed to pay 50 million USD in fines to the US Department of justice. The FSA accused the traders from multiple countries that they together intended to manipulate Libor in the period from 2006 till 2010. As Wilson (2013) notes, also on the same day, Deutsche Bank suspended five of its cash traders amid conducting an internal investigation to find out whether there have been manipulations in Eurozone's largest bank as well. At the time Deutsche Bank built provisions in an anticipation of having to settle with regulators over the Libor manipulation offences (Binham, 2013).

On December 4, 2013 the European Commission (2013) penalized 8 financial multinationals for participating in two cartels, designed to manipulate the Libor interest rate. The combined fine exceeded 1.49bn EUR. The penalty came, as four of the banks were found guilty in participating in a cartel related to interest rate derivatives in EUR, whereas six of the banks were found guilty of having engaged themselves into a cartel organization to influence derivatives denominated in JPY. As the European Commission explained are such violations of competition laws prohibited under the Article 101 of the Treaty on the Functioning of the European Union (TFEU) as well as under the Article 53 of the European Economic Area (hereinafter: EEA) Agreement. Since the banks involved decided to settle, they got a 10% discount on the fines. According to Joaquín Almunia, Commission Vice-President in charge of competition policy, it was not shocking that such an important benchmark was manipulated as Libor is, but the fact that the banks collaborated between themselves on such as grand scale. It was therefore decided to make a clear example of the illegal behavior, by imposing such high fines on the banks involved.

The Euro Interest Rate Derivatives cartel was active between September 2005 and May 2008, so mostly before the financial crisis of 2008 took place. This serves as an evidence of a primarily profit driven motive and raises doubts over the claims some banks made, that they involved in Libor manipulations in order not to look as bad as they were, on the brink of the financial crash of 2008. The banks which settled as part of this cartel were Barclays, Deutsche Bank, the Royal Bank of Scotland and Société Générale. The group was trying to influence the prices of the derivatives with various traders, from different banks, discussing their reported figures as well as possible pricing strategies (The European Commission, 2013).

The European Commission (2013) opened legal proceedings in March 2013, however the initial investigation started already in the second half of 2011. Barclays bank was spared a fine for informing the authorities about the existence of the cartel. Deutsche Bank, the Royal Bank of Scotland and Société Générale received a reduced fine due to their cooperation with the authorities. The banks in question received therefore an additional penalty reduction of 10%.

Another cartel was operating between 2007 and 2010 for the Japanese Yen denominated derivatives. Much like in the cartel with the Euro currency traders from different banks were aligning themselves on the figures they later submitted and were therefore able to manipulate the interest rate. The banks which were found to have been involved in these illegal practices were UBS, Royal Bank of Scotland, Deutsche Bank, Citigroup and JPMorgan.

Apart from the banks there was also a broker firm RP Martin which was involved in facilitation of the cartel behavior. Against the manipulation of derivatives, denominated in the Japanese Yen the European Commission opened an investigation in February 2013. In this case it was UBS which reviled to the European Commission the existence of the cartel and therefore earned full immunity. Citigroup, Deutsche Bank, RBS and broker RP Martin received a 10% lower fine for cooperating with the authorities.

In setting the fines from both in Euro and Japanese Yen denominated cartels, the European Commission (2013) was using Guidelines on the method of setting fines imposed pursuant to Article 23(2)(a) of Regulation No 1/2003 from the year 2006. According to these guidelines the fines are determined based on the net sales an offending party has had in the region of EEA. An overview of penalties can be seen in the table 2 below.

Table 2. Penalties for Euro denominated interest rates

Participants	**Duration of participation in months**	**Reduction under the Leniency Notice in %**	**Fine in EUR**
Barclays	32	100	0
Deutsche Bank	32	30	465,861,000
Société Générale	26	5	227,718,000
RBS	8	50	131,004,000

Source: European Commission, *Antitrust: Commission fines banks € 1.49 billion for participating in cartels in the interest rate derivatives industry*, (2013).

Barclay's was the bank which informed the authorities about the existence of the cartel and hence was spared paying a fine of 690 million EUR.

In case of JPY, UBS was the bank which revealed the existence of a cartel to the authorities and was therefore itself pardoned from paying around 2.5 billion EUR in fines. Citigroup was also relieved of its duties for one of the infringements, which saved the bank 55 million EUR in fines.

In October 2014 the European Commission (2004) reported on its website, that that RBS and JP Morgan were also involved in illegal Swiss Franc denominated Libor benchmark interest rate manipulation between March 2008 and July 2009. For informing the authorities about the illegal practices, RBS received full immunity and only JP Morgan was ordered to pay 61 million EUR. In the words of the European Commission Vice-President in charge of competition policy, this was the third time that major international banks decided to conspire

between each other, instead of engaging themselves in competition. RBS and JP Morgan attempted to manipulate the normal course of the pricing of interest rate derivatives denominated in Swiss Franc. As it is evident from the European Commission's press release (2014), the two banks discussed the future Swiss Franc Libor rate submissions and at times exchanged information about trading positions and intended prices. When deciding on the level of the fine, the European Commission, like in other fraudulent cases took into account the sales of each bank within the European Economic Area in the period in which the criminal offence took place. Because RBS reviled the existence of the cartel to the Commission, it was pardoned of paying a fine of 110 million EUR for its participation in the cartel. Table 3 shows the banks involved in the manipulation of the JPY denominated Libor.

Table 3. Penalties for Japanese Yen denominated interest rates

Participants	**Duration of participation in months**	**Reduction under the Leniency Notice**	**Total fine in EUR**
UBS (5 infringements)	1 month, 8 months, 5 months, 10 months and 1 month	100% for all infringements	0
RBS (3 infringements)	8 months, 5 months and 3 months	25% for one infringement	260,056,000
Deutsche Bank (2 infringements)	10 months and 2 months	35% and 30%	259,499,000
JPMorgan (1 infringement)	1 month	/	79,897,000
Citigroup (3 infringements)	1 month, 2 months and 3 months	35%, 100% and 40%	70,020,000
RP Martin (1 infringement)	1 month	25%	247,000

Source: European Commission, *Antitrust: Commission fines banks € 1.49 billion for participating in cartels in the interest rate derivatives industry*, (2013).

In the same year of 2014 another bank was fined for its involvement in Libor manipulations. This time the fine came from the US Department of Justice (2014) and it was Lloyds Banking Group, which agreed to pay the fine of 86 million USD and also admitted and accepted its responsibility for its wrong doings concerning Libor exchange rates. Libor agreed at the time to continue with its cooperation with the Justice Department in an attempt to discover further Libor benchmark interest rate manipulations by other participants in the financial markets.

As the Assistant Attorney General of the Justice Department said, it was important to restore trust in the markets, since Libor is such an important pillar of international finance. This is why, multiple governmental agencies at the time fined Lloyds in total for 370 million USD. Lloyds was involved in manipulation of Libor rate for the US Dollar, the Japanese Yen and Pound Sterling with an intent to increase its profits. Email conversations between the trades,

which were reviled during the inquiry show in detail how widespread and commonplace the manipulations were among the traders, submitters and other bank staff. The seriousness of the scandal was so great, that also the US President Barack Obama, got involved and established a Financial Fraud Enforcement Task Force to proactively investigate financial criminal activity.

In April of 2015, that Deutsche Bank was forced to pay 2.5 billion USD fine and fire seven of its employees for its involvement in the Libor scandal. It was ordered to do so by the US and the UK investigators. This penalty was also the biggest fine in the interest rigging scandal to date. At the time, Deutsche Bank accrued 1.5 billion EUR for Libor related fines (Strowmatt, Ring & Farrell, 2013).

2 METHODOLOGY

This section describes the models which are most commonly used for valuation of companies. Briefly describing the established Capital Asset Pricing Model (hereinafter: CAPM) and Fama-French models I attempt to explain latest adaptations to them. At the end of this section I also describe the event study and difference-in-difference methods, which I later used in my analysis.

2.1 Models of estimation

In 1952 Harry Markowitz wrote an article which is seen as the birth of the portfolio theory. In his article Markowitz argued that investors can reduce the standard deviation of portfolio returns, by choosing stocks which do not move exactly together. (Brealey, Myers & Allen, 2011). According to the Markowitz's Portfolio theory, an asset should not be analyzed on its own, but rather how it contributes to the overall portfolio risk and return level (Bodie et al., 2014).

This seems to be the key relationship between the risk and return today. The modern financial theory is based on the Markowitz's findings (Brealey et al., 2011). Back then, his concept was able to identify efficient set of portfolios known as the efficient frontier of risky assets (Kumar, 2015).

The efficient frontier combines a number of portfolios which has the maximum return for any given level of risk or minimum risk for every level of return. The logic behind the frontier set of risky portfolios is that in a world of risky assets, investors can optimize their returns by combining risky assets that maximize the expected return for any given level of risk (Kumar, 2015).

The Capital market theory is based on the modern portfolio theory, described in the previous paragraph. The capital market theory has however some additional assumptions. All

investors are assumed to be efficient; investors can borrow and lend any amount of money at the risk-free rate of return; all investors have homogenous expectations and same time horizon. There are no transaction costs or taxes involved, and capital markets are all in the equilibrium. Under these circumstances, a Capital Market Line can be constructed, which represents those risk and return combinations, which an investor is ready to accept (Kumar, 2015).

2.1.1 Capital asset pricing model

The CAPM represents the extension of the capital market theory. According to Danthine and Donaldson (2015), CAPM represents the foundation of modern portfolio theory. In the complex world we live in, one needs to take assumptions. CAPM sets a hypothesis that all participating parties in the market share the same belief about the future returns. A second hypothesis is that there is a risk free asset, which can be borrowed or lent as much as they wish (Kumar, 2015).

The model conveys a relationship between the risk of the asset and the expected return. This enable us to determine an expected return for a security, checking if it is more or less than the what is considered a fair return, considering security's risk. If an asset has not yet been traded in the market, the CAPM model can also help us estimate how to price such an asset (Bodie et al., 2014).

In CAPM, risk is represented by security's beta, indicating how a given security is sensitive to the systemic risk of the stock. The model is following the logic that in a perfect world, where portfolios are fully diversified, only the non-diversifiable (systemic) risk remains. Beta in this case represents the risk of the whole industry or an index and as such captures the relationship a given share is playing in comparison with the wider market. It was in 1990 that William Sharpe received the Nobel Prize for Economics for his work on the CAPM, which he published in 1964 (Fernandez, 2012).

CAPM has had some critique over the years, most notably by Roll (1977), who disputes that in our analysis we are able to include really the whole market portfolio. A market portfolio would in ideal world include everything of value like securities, real estate, personal collections as well anything that has value. According to Roll, CAPM empirical testing is therefore impossible. Despite the critique however, CAPM has been used extensively in the modern world.

In financial valuation one relies heavily on the Security Market Line. The equation (1) identifies the relationship between risk and return, as Brigham and Daves (2007, p. 337) put it:

$$r_S = r_{RF} + (RP_M)b_i \quad (1)$$

The return of the stock is based on the return of a risk-free security, normally a 10-year bond of a stabile sovereign like the US or Germany. Added to this return is the company's own additional return. The latter is based on the return of a market such as an Index, corrected for the beta, which represents how the stock in question respond to the movements of the market (Bodie et al., 2014).

Required rate of return is hard to pinpoint because of various estimates, such as risk return preferences, inflation predictions and company's capital structure all play a role in shaping of this important metric.

2.1.2 Fama–French three-factor model

In 1993, Eugene Fama and Kenneth French published an article in Journal of Financial Economics, which presented an update to the established CAPM. Instead of only using the market risk premium in the CAPM equation, Fama & French (1993) also included two additional variables – company size and book-to-market ratio – into their model. Fama and French say, that on its own the market return variable, used in the CAPM model, has limited expansionary abilities. In their opinion however the additional two variables do well at explaining the cross-section of average returns on NYSE, Amex and NASDAQ stocks between 1963 and 1990. In their approach, Fama and French used the time-series regression based Black and Scholes model. For their time series data, they used monthly stock and bond returns.

A company size matters because small companies are riskier than larger companies. In turn it is expected that smaller companies have a higher stock return than the larger ones (Brigham & Daves, 2007). Fama & French (1993) also differentiate between companies with low earnings on an asset (high book-to-market ratio) and those with high earnings on assets (low book-to-market ratio). Fama-French three factor model comes together in the equation (2).

$$R_i = \alpha_i + \beta_{iM} R_M + \beta_{iSMB} SMB + \beta_{iHML} HML + e_i \quad (2)$$

Variable SMB represents the Small minus Big return of a portfolio where we deduct returns of stocks belonging to smaller companies from that of bigger companies. Variable HML refers to the high minus low approach and represents the return of the stocks with high book to market ratio return of the companies with small book to market ratio. It is expected that the coefficients β_{iSMB} and β_{iHML} are positive values. The higher therefore the SMB and HML ratio, the higher is the return (Kumar, 2015).

Regressions of time-series are convenient for investigating asset-pricing issues. Assuming that the assets are priced rationally, the variables in the three-factor model represent a proxy for sensitivity to common risk factors. Fama and French present the plausibility of beta

coefficients and the value of R^2 as an indicator as proof of their model's validity. The interpretation of their model is, that the size and book-to-market variables explain the gap in average returns between stocks. On the other hand these two variables alone cannot explain the full spectrum of difference between an average return of a stock and a one-month bond. This gap is still explained by the market return variable (Fama & French, 1993).

To understand the details behind the three-factor model, one needs to examine the dependent and independent variables Fama & French (1993) used. The returns they were explaining are government bond portfolios in two maturity ranges, corporate bond portfolios in five rating groups and 25 stock portfolios formed on the basis of size and book-to-market ratios. Distinguishing between bond and stock returns also gives an option to test if variables, determining stock returns also have explanatory abilities for the bond market and vice versa.

The investors are more optimistic about stock's future performance if a company has a higher market value then its book value. This would also imply that investors are pessimistic about the company's future if its book value exceeds its market value. As Fama and French originally discovered, small companies and those with a high book to market value ratio, delivered a higher return. Size, they say, has a significant effect, since small company have lower earnings on assets than big ones. They note however that this has only been the case since 1980s. Prior to 1981 smaller company were only slightly less profitable then their bigger counterparts. This is due to the recession between 1980 and 1982 which badly affected mostly smaller business for the longer period. They argue, that smaller companies are more prone to risks such as a recession and in turn affected for a longer time. This is why they are more risky and investors demand a higher return on their investment (Brigham & Davis, 2007).

When calculating the size variable Fama & French (1993) took the June value of each year between 1963 and 1991 for all the NYSE, Amex and NASDAQ stocks and ranked them on size. They used the median to split the group into small one and a big one. The small group contained a disproportionate amount of shares. On the other hand the smaller group represented only about 8% of the total market value in 1991. When calculating the book-to-market variables, they split the NYSE, Amex and NASDAQ stocks into three groups – the bottom 30%, middle 40% and the top 30%. Book value is defined as book value of shareholders' equity combined with deferred taxes and investment tax credit, diminished for the book value of preferred stock. For preferred stock redemption, liquidation or par value was used to estimate it.

By creating the above mentioned clusters, Fama and French (1993) constructed six portfolios. Based on those six groups monthly value-weighted returns were calculated for the period from July of year t to June of year t + 1.

Despite its plausibility the three-factor model has not been widely used outside of the academic community of researchers. In the corporate world however CAPM is still more

widely used. First issue arises, from data availability where academic staff has more access to the type of data required for the Fama–French analysis than in the corporate world. The second reason are the HML and SMB variables which are hard to be estimated based on the historic returns (Brigham & Davis, 2007).

There have been a few studies which are claiming that the Fama-French model is not entirely correct. Critics say that size effect does not have a significant effect on the returns. Another study, made a couple of years ago, observes a situation where the composition of company's assets (physical assets and intangible assets) has been changing over time. According to that study, changes in company's assets could appear as if they are driven by the size and book-to-market effects (Brigham & Davis, 2007).

There are also other studies, which are supporting the fact that stocks have a so called short-term momentum. Meaning, stocks that perform well, tend to do so 3 to 12 months and the ones trailing behind are performing worse in the short-term future. Also interesting is an observation that stocks which perform better than average over the 5-year period, tend to perform below average in the next 5-year period. A dedicated branch of finance called behavioral finance tries to understand market developments through psychology (Brigham & Davis, 2007).

According to the normative theory, reasonable people should act in a reasonable way. The positive theory however investigates what people actually do. It turns out that people take sometimes non-rational decisions when under risk (Ackert & Deaves, 2010). A study from Hirshleifer and Shumway (2003) has taken a look at 26 international stock exchanges and found out that morning sunshine positively correlated with the higher stock returns. Kamstra, Kramer & Levi (2002) looked at a negative effect of disrupted sleep patterns on the stock exchange returns, caused by the daylight saving time shifts.

Fama–French and CAPM models are widely used technical tools to explain developments in financial markets. They are robust and commonly accepted, however one should keep in mind that people do not always behave rationally and applying psychology to understanding stock return developments might unlock further insight into trading patterns.

2.1.3 Carhart four-factor model

In 1997 Mark Carhart (1997) published an article with a modified version of the Fama–French model. He added the fourth variable, controlling for the momentum factor. The expectation is that a stock which has performed well in the last 12 months, will also continue to perform well in the near future, compared to a stock which has performed badly in the last 12 months. In the consideration the extraordinary accounting events are excluded. The momentum is derived by subtracting the weighted average return of the first decile of the lowest performing firms from the weighted average return of the first decile of the highest

performing firms, over a 12 month period. Carhart's database covers a period between January 1962 and December 1993. The data includes all the possible equity funds, active in this period and does not only focus on those funds which survived whole described period. In total, his sample included 1,892 diversified equity fund and like Fama and French he takes the stocks from NYSE, Amex and NASDAQ. When it comes to models he benchmarks his adapted version of the Fama-French model against the CAPM model.

$$R_i = \alpha_i + \beta_{iM} R_M + \beta_{iSMB} SMB_i + \beta_{iHML} HML_i + \beta_{iMOM} MOM_i + e_i \quad (3)$$

In the equation (3), the variable MOM indicates the momentum factor. All other variables remain the same as in the original Fama-French three factor model. Carhart (1997) notes in his paper that his model with four variables explains much of the cross-sectional variation in the average return of the portfolios. The four factor model, substantially improves also the average pricing errors in comparison to CAPM and the Fama–French 3-factor model. In the case of 4-factor model almost all patters in pricing errors are eliminated, meaning that the model explains the movement of the average share returns quite well.

The additional variable for momentum is calculated based on the reported figures, net of all OPEX and transactional costs, on January 1 each year. The author creates 10 weighted portfolios, which he holds for one year and at the beginning of the next year updates them again. This gives him the time series of monthly returns for each of the 10 portfolios, ranked from the top best performing one to the worst one. When compared between each other, one notes strong deviations between them. The top decile portfolios comprise of mostly smaller stocks, confirming also the Fama-French theory that smaller companies tend to deliver a higher return. Carhart notes also a strong positive correlation of the top decile funds with the momentum variable, whereas the lower performing funds correlate negatively with the one-year momentum variable. The author convey possible explanations for commonalities within the groups. It is possible that funds in each of the portfolios are following specific strategies and are therefore relatively stable over time. On the other hand the unstable funds which are located in a particular decile are probably grouped together with similarly unstable funds. (Carhart, 1997)

Carhart (1997) notes that the best performing funds in the previous year are somewhat more likely to be also the top performance in this year, whereas the lower performing funds are likely to remain low performing or even go out of business altogether. At the same time it is worth noting that the peak performers, who are among themselves responsible for 80% of all the market turnover, are changed every year. Additionally, it is not uncommon that the peak performer of the previous year would become a low performer in this year. The author notes, that the year to year ranking position of different funds at the end seems random. On the other hand, acquiring a top-decile fund from last year and selling last year's lowest performing fund would on average bring us a return of 8 percent per year. 4.6 percent of this difference is explained by market value and momentum of stocks, while variations in

expense ratios explain 0.7 percent and deviations in transaction costs explain 1 percent. The author finds that funds with the high momentum, having been successful in the previous years, all have high turnover and expense ratios. This means, the gains are diminished due to higher expenses and transactional costs. The high performing managers do seem to charge a premium for their stellar performance.

Momentum investment strategies are often used in trading, especially if one needs to take quick decisions between two comparable stocks. In general practice, stocks which have performed badly over the last 12 months, are expected to continue to perform badly also in the near future.

2.1.4 Alternative versions of Fama-French and Carhart models for the UK

An interesting analysis of Fama-French three factor model and Carhart provide Gregory, Tharyan and Christidis (2013). In their paper they develop an alternative version of Fama-French and Carhart models which they apply to the UK market data. They approach their work by introducing multiple recent research methods, such as value-weighted factor components.

Gregory et al. (2013) point out that asset pricing varies between regions of the world, as specialized European models are able to predict better the average returns in Europe as the global models. Fama and French (2012) also support this with their research. Reasons for better performance of regional models over the global ones could be differing exposures to macroeconomic influences in smaller, more open and intertwined economies of Europe, for example. Another factor could be different accounting standards between the regions, which could have a direct impact on the book-to-market rations in the Fama-French model. If regional models outperform global ones, then one could argue, that country-level models are better than the regional ones (Gregory et al., 2013). Average share price returns are therefore better explained by the country-specific three-factor models, than global models. This could be down to country-specific cost of capital estimates (Griffin, 2002).

In a pursuit to find a reliable asset pricing model for the UK, Gregory et al. (2013) construct and examine models using alternative specifications of the factors researched by Michou, Mouselli and Stark (2012) together with a momentum factor, adapted for the UK. They reconstructed the Fama-French factors and used value-weighting instead of equally weighing the portfolios in the dataset consisting of 350 largest companies by market capitalization. The authors then test the models and discover that the models perform well when predicting returns of portfolios, clustered by size and book-to-market variables, but perform not so well when clustered by their momentum factor. In additional tests, the authors discover that the factors are not consistently and reliably priced. They see stock size and its liquidity as one of the reasons for such market inefficiencies.

In their paper Gregory et al. (2013) introduce 3 model groups. Basic, value-weighted and decomposed factor models. Basic models represent the established Fama-French three factor model as well as Carhart's momentum model. Value-weighted factor component models, challenge the equally weighted the six portfolios, which are used to form the SMB and HML variables in the standard three-factor model. Cremers, Petajisto and Zitzewitz (2010) (hereinafter CPZ) argue, that this gives a disproportional weight to small value stocks. This is why Gregory et al. (2013) construct SMB, HML and momentum factors using market capitalization weighting. Equation (4) describes the adapted Carhart's model with the weighted factors.

$$R_i = \alpha_i + \beta_{iM} R_M + \beta_{iSMB} SMB\_CPZ_i + \beta_{iHML} HML\_CPZ_i + \beta_{iMOM} MOM\_CPZ_i + e_i \quad (4)$$

The last group of models are decomposed factor models. Gregory et al. (2013) attempt to test suggestions from Zhang (2008) and other researchers, who say that decomposing the three-three factor model could be helpful. In order to control for smaller or bigger stocks the size is taken as the decomposing measure. They decomposed Carhart's momentum model into small and big variables for HML variable as formula (5) describes (Gregory et al., 2013).

$$R_i = \alpha_i + \beta_{iM} R_M + \beta_{iSMB} SMB_i + \beta^s_{iHML} HML_{S_i} + \quad (5)$$

$$+\beta^b_{iHML} HML\_B_i + \beta_{iMOM} MOM_i + e_i$$

In their last model however it is attempted to additionally decompose both HML and SMB variables, as well as to weight them, including the momentum variable, according to the stock size. Equation (6) describes the final model in their paper:

$$R_i = \alpha_i + \beta_{iM} R_M + \beta_{iMMB} MMB_{CPZ_i} + \beta_{iSMM} SMM\_CPZ_i + \quad (6)$$

$$+\beta_{iBHML} BHML\_CPZ_i + \beta_{iSHML} SHML\_CPZ_i + \beta_{iMOM} MOM\_CPZ_i + e_i$$

The HML variable is decomposed into large and small companies. Similarly the SMB factor is split into medium minus large capitalization factors and small minus medium capitalization factors. To distinguish between small, medium and large the 30th and 70th percentiles are used to divide the population (Gregory et al., 2013).

When testing the models none of the size factors, as well as any of the decomposed factors based on the size factors, are significantly different from zero. HML are significantly different from zero at 10% or less, however if decomposed, the standard deviation increases and the tested variables become insignificant. On the other hand the SHML_CPZ variable is significantly different from zero, while BHML_CPZ is not. When inspecting the correlation between the variables, one notes, that there is a negative correlation between HML and momentum (Gregory et al., 2013). Similar relationship are observed also in the US by Clifford (1998).

As part of their robustness checks Gregory et al. (2013) run the same tests also with the quarterly instead of the monthly data, because Kothari, Shanken and Sloan (1995) find out that CAPM model is sensitive to the time increments being used in a time series. The spreads of the observed coefficients increases under the new test conditions.

This means that within Europe the three-factor model or the Carhart model have difficulties with pricing portfolios which include the momentum tilt. It does not make a difference, if variables are clustered regionally. They show that value weighting and decomposing variables contribute only to a limited extent to improved performance. Specifically the value-weighted decomposed Carhart's momentum model is showing moderate advantage over the other tested models. The model can be of use for analysis of long-term investments into larger firms to explain the cross-section of returns in portfolios without extreme momentum exposures. However it would have difficulties explaining returns of smaller companies in the short run. At the same time Gregory et al. (2013) note, that they could not prove that the risk factors are consistently and reliably priced.

2.1.5 Fama–French five-factor model

More recently, in 2015, Fama and French (2015) published an article, where they presented an update to their three-factor model by introducing two additional variables. The fourth variable is the so called investment and the fifth profitability. Fama and French tried to improve their model, since the three-factor model did not for example well explain the cross-sectional variation in expected returns, related to profitability and investment. In their article Fama and French start their argument with the forward looking dividend discounting model. With the additional two variables, the five-factor equation (7) can be seen:

$$R_i = \alpha_i + \beta_{iM} R_M + \beta_{iSMB} SMB + \beta_{iHML} HML + \beta_{iRMW} RMW_i + \beta_{iCMA} CMA_i + e_i \quad (7)$$

Based on Fama and French (2015), the RMW variable represents the difference in returns between the most and the least profitable firms. CMA variable represents the difference in return of firms with conservative investment strategies minus those with expansionist investment stratetgies. To test their variables, Fama and French created a 5x5 matrix, with size on book-to-maraket variable. They clusterd their data into 5 groups by size. five-factor one proves to be more accurate and explains more of the price return movements. It shows that the companies which are small, profitable and wih a low book-to-market ratio and small investment prospects tend to have the highest expected returns. In general it is expected that book to market ratio is having a negative effect on average return. The relationship between th two is laso known as the value effect. The latter is mostly known to be present among the smaller stocks.

When it comes to the critical reivew of the five-factor model, the biggest challenges to the new model are the small stocks with the lowest profitability and the higest investmet variable values (Fama & French, 2015).

The varable HML becomes less significant, when profitability and investment variables are added to the model, meaning, potentially we could shorten the model into a four-factor one. Fama and French estimate that their five-factor model explains between 71% and 94% of the corss-section variance of expected retrns for the size, book-to-market value, profitability and investment variables. Compared to the three-factor model the five-factor one proves to be more accurate and explains more of the price return movements. It shows that the companies which are small, profitable and wih a low book-to-market ratio and small investment prospects tend to have the highest expected returns (Fama & French, 2015).

The latest research by Fama and French is still very new and as such balanced critical review is still scarce in the academic world. Also their paper from 1993 which has become integrated in how we view and value financial markets today, has been tried and tested and challenged by many influential researchers. In the following paragraphs I attempt to summarize the early critical review, available at the time of writing, about the five-factor model which Fama and French published in 2015. There are some drawbacks of adding two new factors to the established three-factor model, especially while not controlling for momentum and low volatility. The five-factor model, like the three-factor model continues to rely on CAPM and its relationship between market beta and the average return. According to the established theory one would expect that there would be a positive correlation between the two, however assumption does not always hold, as the model does not cover a low-volatility premium aspect (Blitz, Hanauer, Vidojevic & Van Vliet, 2016).

Blitz and Vidojevic (2016) inspect the data from Fama and MacBeth (1973) with the new five-factor model. They find that all the coefficients have relatively high absolute values, except the beta, belonging to the market risk. Blitz and Vidojevic therefore argue, that exposure to market risk does not necessarily bring higher returns. They continue by saying that the low-volatility situation can have an important effect on stock mispricing.

Controlling for momentum as a model variable is another topic, which has been discussed for a long time. It was already in the 1993, the same year as Fama and French published their three-factor model that researchers Jegadeesh and Titman (1993) wrote about the effects of momentum in stock price returns. And nonetheless, the Carhart's four-factor model, which I describe in the previous section, introduces momentum as the fourth variable. Momentum has now become also well accepted in the modern financial practice. In its defense Fama and French say, that their five-factor model is meant to estimate long-term, rather than short-term price swings. It is expected that in future many studies will test a variation of a six-factor model where researchers would add momentum as a sixth variable. Another concern is also the robustness of the two new factors to the Fama-French model as well as the fact,

that the five-factor approach does not solve some of the robustness anomalies, pointed out by researchers in regards to the three-factor model (Blitz et al., 2016).

The question remains whether or not market risk variable should remain to be the independent variable for the short-term cross-sectional variation in share price returns, but without a return premium in the long run (Blitz et al., 2016).

As the moment it seems there a lack of agreement in the academic world, that the five-factor model is the best and final asset pricing model. Hou, Xue, and Zhang (2015) argue that a different pricing model, with only four factors should be used. A year later Hou, Xue, and Zhang (2016) even show, that their 4 factor model is able to explain every factor of Fama-French's five-factor model. At the same time however, they also note, that the Fama-French's five factor model, together with their own proposed q-factor model are proved to be the best models for explaining market anomalies tested in their research.

The five factor model is still fairly new and time will tell, if it will be adopted by the investment community to replace its predecessor from the nineties. Under the test conditions of Fama and French (2015) it does provide a better explanatory power and has the potential to be further investigated.

2.2 Event study and differences in differences

In order to research the influences of a specific event on the affected banks and adaptation of OLS regression is commonly used. The difference in differences approach is an econometrical method used to determine causality effects. The difference in differences approach introduces also an untreated group to simple regression. In effect not only comparing the effect before and after the treatment, but also comparing the reactions of the treated and untreated groups in the same time periods (Cameron & Trivedi, 2005).

It is required that the groups are comparable during the same time (Cameron & Trivedi, 2005). In the study by Ashenfelter & Krueger (1994) the authors were comparing the economic return on schooling between monozygotic twins, which visited different schools. By analyzing twins authors assumed that the twins were enjoying the same upbringing were only the education level was the major differencing variable.

This means there is a need to control for any other factors which might influence the reactions on the treatment. This is hard to fully control, but, for example, when analyzing banks, one could try to include only bigger banks from the same jurisdictions to ensure similar conditions would apply. For the difference in differences method the same assumptions of the simple regression apply.

A simple regression could be used to observe the effects of a treatment event, described in the formula (8) (Cameron & Trivedi, 2005).

$$y_{it} = \alpha + \beta D_t + \varepsilon_{it}, i = 1, \dots, N, t = 0,1 \quad (8)$$

With a regression like this we are controlling for pre- and post-treatment time series, however we are assuming that the group remains comparable over time. Marking the post treatment time series is the variable D_t. β represents the difference between the sample averages of the same group before and after the treatment. Assuming that the group does not change over time, is a strong assumption. One way to control for this would be to include an additional group for comparison, which was not treated. The comparison group would have the data available also for the same period as our study group. The regression would then include multiple dummy variables, as per the equation (9).

$$y_{it}^{j} = \alpha + \alpha_1 D_1 + \alpha^1 D^j + \beta D_t^j + \varepsilon_{it}^j, \quad i = 1, \dots, N, t = 0,1 \quad (9)$$

j represent the differentiation between the two groups. $D^j = 1$ for the treated group and $D^j = 0$ for the control group. $D^j_t = 1$ if both j and t equal 1 identifying the treated group after the treatment. This is useful, because it gives an intuitive approach to compare both affected and not affected groups, exposing the real effect of the treatment effect (Cameron & Trivedi, 2005).

In reality a richer set of methods is used. Instead of the example of difference in differences approach, shown above, a set of multiple variables are used to better explain the dependent variable (Cameron & Trivedi, 2005). Card (1990) for example was analyzing in his article the effects of Marie1 Boatlift of 1980 on the Miami labor market, using the difference in differences method.

2.3 Application of valuation models in the empirical analysis

In this section I explain how the effects of LIBOR scandals and the related fines were detected on the share price returns of the affected banks. The main question I attempt to answer is: Has a negative news in regards to the suspected banks had a significant impact on the stock's return? On one hand I use regression analysis with an established CAPM model. I also enhance the CAPM model with additional dummy variables to control for different milestones and to distinguish between the cheating and non-cheating banks. On the other hand the second approach I use is based on the Fama–French model. I also enhance this model with the same set of dummy variables, in effect testing the robustness of different methods. I decided to use in my empirical work the basic and widely accepted Fama-French three-factor model, despite the fact that in the recent years many reputable authors published advanced versions of this core model. The reason for that is, that the basic three-factor model has been around since 1993 and is as such well accepted in the academic and business

community, while the newer versions of it are still to be tested. Another reason, why I decided to go with the basic models is the number of variables. With the basic CAPM and Fama-French models I am able to keep end testing models compact and more appropriate for interpretation.

2.3.1 The CAPM-based approach

As I already attempted to convey earlier in this work, the CAPM model is one of the key theories for company valuation in finance and it also serves as a basis for the first approach in my analysis. In its simplest form, a CAPM formula consists only of the market risk premium, reduced for the risk free rate for each of the currencies.

In order to research responses of affected banks I use a regression based method difference in differences. With the method difference in differences we observe a reaction of the treated group during the time before and after the treatment event in comparison with the reaction of the untreated group (Cameron & Trivedi, 2005). Both the date of the first involvement as well the penalty date can be viewed as the treatment events. In my case treated banks are those which were involved in the scandal and the control group represent similar banks, which were not involved in manipulations.

To control for the effects of adding additional variables to the regression, I perform multiple regressions with an increasing number of added variables. In its fullest form the CAPM-based regression model can be written with the equation (10).

$$y = \alpha_0 + \beta_{fine\ 5d} D_{fine\ 5d} + \beta_{firstinfo5d} D_{firstinfo\ 5d} + \beta_{finetime\ 5d} T_{finetime\ 5d} + \quad (10)$$

$$+ \beta_{firstinfotime\ 5d} + T_{firstinfotime\ 5d} + \beta_{fined\ B} D_{fined\ B} + \beta_{rm} R_m$$

The dependent variable *y* represents daily share price return of a bank. The independent variable R_m represents daily market returns in excess of German, French, Swiss, UK and US T-bills, to cover different currencies involved in the analysis. These daily market returns form a basis for the CAPM analysis. Additionally to that I add also specific other identifying variables in an attempt to further explain abnormal returns during the times where the cheating banks found themselves under scrutiny. At this point it is hard to give a hypothesis, whether the banks which were caught cheating would on average give a higher return. Variable $D_{fined\ B}$ represents banks which had to pay a fine to any of the authorities, distinguishing them for the banks which were not involved in the scandal. This variable is not period specific as it only indicates if a bank was fined or not. To observe the effects of the incriminating information on the stock price, I mark those specific dates in the database with a marker. Capturing this marker is a variable D_{fine5d}. It is a dummy that represents a window of 5 days when the fine for each of the banks was made public. While preparing my dataset for the analysis I use the dates, described in the previous chapter. To observe the

effect of the news I assign a value of 1 to this variable two days prior to the news taking place, as well as on the day of the news breaking out and on the two following days, for each of the banks involved at the time. I assign a value of 0 to any other date which was not associated with an announcement of fines. I expect that the returns of the banks decrease on average when the negative news about them became available.

In my analysis I attempt to source always the initial news article from the public authority which, which has prosecuted a particular bank. I also use Google date filtering research to check for each of the dates used in this analysis, if any information about the fines had been leaked already, prior to the official announcement. Often such preliminary information is not definite, meaning it does not give a reader a concrete information about the settlement amount or a size of a fine a bank has to pay, however already an information that a bank is being investigated could spread fears in the investment community. This is why I also introduce a variable $D_{firstinfo5d}$ to my analysis. Similarly like the D_{fine5d}, the $D_{firstinfo5d}$ is also calendar-based. It marks the dates, when a first information was detected for a particular bank that the authorities are investigating the business activities for that bank. Also for this variable I have assigned values 0 or 1 two days before and after as well as on the day of the first information of possible investigations became public. I expect that such initial information would also negatively correlate with share price returns of the banks involved.

Since financial markets and the whole banking industry is well connected and because I have already previously attempted to argue that Libor interest rate is a key metric in finance, it also makes sense to introduce a variable that would measure an impact on the whole banking industry, when a negative news about one of the banks breaks out. To test for this I introduce a variable $T_{finetime\ 5d}$ with values 0 and 1. Where 1 represents a date and two days before and after, when a penalty was announced. Although the announcement was connected only to a selected group of banks, I applied 1 in such cases to all banks, those who were involved in the scandal and those which were not. One could set a hypothesis in this case that also banks, which were not involved in Libor fixing, would be in one way or another impacted by the adverse news. Similarly I also applied a variable $T_{firstinfotime\ 5d}$ to a selected number of days around the time when the first information relating to possible investigations became public. This variable was also applied to all banks, no matter if they were involved into Libor manipulations or not. Here I also expect that all banks would be on average negatively impacted due to initial investigations of their cheating peers.

2.3.2 The Fama–French-based approach

As my second analysis model I use a well-established Fama–French approach to test the effects of bank investigations. One could look at Fama–French model as an upgrade from the CAPM, this is why my Fama–French model closely resembles the CAPM, which I described in a previous section. Again following the logic by Cameron and Trivedi (2005)

my difference in difference method is used in combination of multiple variables. Same as in case of CAPM, I gradually add new variables to see how well each of them is explaining the share price movements. The difference in difference formula (11) presents all the variables combined with Fama Frech factors.

$$y = \alpha_0 + \beta_{fine\ 5d} D_{fine\ 5d} + \beta_{firstinfo5d} D_{firstinfo\ 5d} + \beta_{finetime\ 5d} T_{finetime\ 5d} + \quad (11)$$

$$+ \beta_{firstinfotime\ 5d} + T_{firstinfotime\ 5d} + \beta_{fined\ B} D_{fined\ B} +$$

$$+ \beta_{rm} R_m + \beta_{HML} HML + \beta_{SMB} SMB$$

The dependent variable y represents daily share price return of a bank. The independent variable *HML* is the so called value premium and represents the return of the stocks with high book to market ratio return of the companies with small book to market ratio. The variable *SMB* represents Small minus Big return of a portfolio where we deduct returns of stocks belonging to smaller companies from that of bigger companies. All the other variables are the same to the one already described in the previous CAPM section. Similarly like in the previous section I perform multiple regression analysis with increasing the number of dummy variables to the Fama–French model, which I consider as the basis.

I expect that the standard Fama–French variables like R_m, *HML* and *SMB* will explain most of the daily stock return variation. With my additional dummy variables however I expect to be able to further fine-tune the model. For controlling purposes I have in my dataset both banks which cheated and those which did not. I expect banks which were involved in illegal practices to show on average an abnormal level of return in the form of beta coefficient for the variable $D_{fined\ B}$ throughout the whole observed period. This would mean that on average cheating makes sense for the banks and it would explain why market manipulation was so wide-spread. By controlling for the Libor scandal timeline of the affected banks, I expect that in the days around the time of investigations, the affected banks would show on average lower returns. This can be observed in the negative beta of the variable $D_{firstinfo5d}$. Following the same logic I also expect that banks which were at the end forced to pay a fine, would have lower than average returns around the time when the news about the fine became available. This can be observed in the beta coefficient of the variable D_{fine5d}. On the premise that we live in a globalized world where events in the industry are connected, I would expect that investigations of the involved banks would also have a negative effect on banks which were not involved in Libor fixing. This lower than average return, observed in the beta for variable $T_{firstinfotime\ 5d}$ would tell us, that investors might be fearing adverse effects on the whole financial industry, since major banks found themselves under scrutiny. I also have the same expectation logic for the time around the dates when the news of final fines became public. I expect that around this time all banks, both those involved in Libor manipulations and those which were not, would have lower than average returns as a consequence of fears

these fines have for the industry. A beta coefficient to be observed for this variable is $T_{finetime\ 5d}$.

2.4 Robustness checks

In order to validate my model approaches based on CAPM and Fama–French, I perform a second set of regression analyses to check if the results from the main analysis are plausible. I want to validate that for the selected models I get more or less the same findings.

When performing a robustness check of CAPM model, I decide to scale down the time windows in which I measure the effects of the news, that a bank is being investigated or that is has to pay a fine. Instead of a window of 5 days, I take 3 day as an observational reference. Meaning one day before and one day after as well as on the day a news was reported. Also in this case I perform multiple regression analysis and gradually add all the dummy variables. Equation (12) represents a modified CAPM formula, for robustness check purposes, in its most comprehensive form.

$$y = \alpha_0 + \beta_{fine\ 3d} D_{fine\ 3d} + \beta_{firstinfo3d} D_{firstinfo\ 3d} + \beta_{finetime\ 3d} T_{finetime\ 3d} + \quad (12)$$

$$+ \beta_{firstinfotime\ 3d} + T_{firstinfotime\ 3d} + \beta_{fined\ B} D_{fined\ B} + \beta_{rm} R_m$$

I expect that beta coefficients will be developing in the same direction as in my regular analysis. Meaning I expect that the variable D_{fine3d} will show a negative impact on the banks return. This would therefore validate my hypothesis that fines on average always correlates with lower returns for the affected banks. Similarly I also expect that $D_{firstinfo3d}$ variable also has a negative beta coefficient. This would be indicating that on average bank returns increase, when there is news of investigations being led against them. I expect that, due to systemic connection, all the banks, also those not involved in Libor scandal, would on average see reduced returns around the time when fines are announced. Therefore I expect to see a negative beta coefficient for the variable $T_{finetime\ 3d}$. Similarly I also expect that $T_{firstinfotime\ 3d}$ variable, indicating the time of the first investigations, has a negative correlation with the returns of all the banks. Meaning, news of initial investigations is on average in turn negatively impacting also returns of other non-investigated banks.

For Fama–French approach the robustness check contains the same variables so I will not set additional hypothesis for them. My expectations about those variables are as described under CAPM robustness paragraph above. Also in this model I gradually add new variables in order to observe their effect on the model. The Fama Frech robustness check model with all the variables can be seen in the equation (13).

$$y = \alpha_0 + \beta_{fine\ 3d} D_{fine\ 3d} + \beta_{firstinfo3d} D_{firstinfo\ 3d} + \beta_{finetime\ 3d} T_{finetime\ 3d} + \quad (13)$$

$$+ \beta_{firstinfotime\ 3d} + T_{firstinfotime\ 3d} + \beta_{fined\ B} D_{fined\ B} + \beta_{rm} R_m +$$

$$+ \beta_{HML} HML + \beta_{SMB} SMB$$

3 EMPIRICAL RESULTS

In this section I present in detail the data I use for the analysis. In the later parts of this section I will present and comment on the findings of my analysis. In short my results will cover CAPM approach, Fama–French approach and robustness check of both of them, to put the findings into a perspective.

3.1 Data and descriptive statistics

Data collection is an in integral part of every analysis. In this section I describe in detail how I selected my sample of data. I then go on to what databases I use and what are their limitations. Then I continue to describe the steps I took to collect my data. At the end I give a reader an overview of my dataset as well as the insight through the descriptive statistics.

3.1.1 Sample description

In order to test the impact of negative news related to Libor fixing I investigate the high street banking industry. Based on articles from established newspapers such as the Financial Times I piece together a timeline, described in the past chapter. I also determine a list of banks, which were involved in Libor manipulations, according to the article data.

A good thing about performing an event study in a banking sector is, that the banking industry, operating in an international arena can be viewed as homogenous and similar in their core operations (Koch, 2013). An involvement in the investigation and a subsequent settlement with the regulators to pay the fines provides a clear identification of the main banks. I try however to bring a more balance dataset to this master thesis by adding also the banks to my sample which were not involved into the scandal. I intend to have those not involved banks as a control group.

Despite the fact that in general bigger banks operate by similar rules of the international trade and are exposed to similar risks, I choose to segment the banks in the control group by country and size. By definition the banks allowed to influence Libor are one of the biggest in the world. When deciding on additional banks for comparison therefore I look at revenue size, as bigger banks would have more commonalities with the banks involved in the Libor scandal. Table 4 represents the sample banks by country:

Table 4. Sample banks by country

Country	Number of banks in the sample
France	3
Germany	5
Switzerland	8
UK	5
USA	7

3.1.2 Databases

In this section I outline the data sources where I obtain the data for my regression analysis.

I used Bloomberg to obtain share price data for the 28 banks analyzed in this master thesis. Bloomberg is a global hub for business and financial information, which provides the data to the decision makers across industries and continents. They pride themselves for delivering data and news accurately and in a timely manner. They have approximately 325,000 subscribers. Bloomberg's database contains historic share price and other data on around 52,000 publicly traded corporations across the globe. The company was founded in 1981 by the former New York City Mayor Michael Bloomberg and his partners, according to the corporate website (About Bloomberg).

Daily share price data represents the basis of my analysis, for the purposes of calculating the abnormal returns however I need to correct the daily returns for the risk free rate in each market. Based on the reporting currencies of banks in my sample I selected also the corresponding risk free rates. As a EUR risk free rate I use daily returns on the German 10-year bonds. The exact time series data BBK01.WT3229 can be found on the website of the Bundesbank (2016). German central bank has a vast collection of macroeconomic and bank specific information, which it is legally obliged to collect and therefore it represents a trustworthy source of information. To calculate the risk free rate for the Swiss shares I use the returns of the Swiss Confederation 10-year bonds. The source of data in this case is the Swiss National Bank (2016), which in its vast time series library provides, among other data, the daily returns on Swiss bonds dating back to 1988. For shares reported in USD, I use the 10-year returns on US Treasury bills. U.S. Department of the Treasury (2016) has a database of daily returns dating back to 1990. For in GBP denominated shares I use 10-year return rate of a Gilt, a treasury paper, issued by the UK. I select the Government liability curve, corrected for inflation, as provided by the Bank of England (2016). Like the rest of the mentioned central banks also Bank of England is providing daily data on the yearly return of their sovereign debt. These returns need to be then recalculated to make them comparable with the daily returns of the banks. In my case I decide to use a 365-day yearly split, in effect calculating a 365^{th} root of the reported yield for each day.

For the purposes of the Fama–French three factor model I take the three necessary factors HML, SMB and Market risk premium, reduced for the risk free rate, from the Asness and Frazzini's (2013) data library. Their dataset was put together as part of a paper which was challenging the methods of measuring value in academic work. As the authors say their B/P ratios are based on more timely prices and better forecast B/P ratios at year end. They provide daily data for the US and 23 international equity markets, which is updated monthly. The international component of this improved version of Fama–French ratios seems adequate also for my sample setup.

3.1.3 Data collection and preparation process

As the first step in preparing my database for analysis I download all share price data for the banks in the sample from the Bloomberg database. As a scope I select mayor banks in each country and extract their daily share prices in the years between January 2005 and April 2015. The date format, as obtained from Bloomberg serves me, going forward as a main date format, to which I adapt all additional datasets. The database with share information serves me as a base table to which I am adding additional information. When adding additional datasets to my base table, I always make sure that I remove the weekend values, since there is no trading during the weekends. To keep things consistent, I choose to remove the weekends, since some databases provide a 0 value, while others display the price of the latest trading day.

After running the initial summary statistics, it became apparent, that the dataset with daily returns has some pretty significant outliers. For example the minimum daily return was -66.5 percent, whereas the maximum daily return for one of the banks was 86.9 percent. After rechecking and making sure that my calculation steps are correct I decided to remove the outliers which were also distorting my mean value of the sample data. In order to still preserve other information within the dataset, replacing the outliers with the mean values seems like a plausible approach, as apposed to truncating the dataset and completely removing the data rows. I apply a winsorizing transformation on the dataset, effectively replacing one precentile of the biggest outliers with the mean values.

Next I download the three Fama–French factors, the SMB, SML and market return rate. The latter I use also for the CAPM analysis. I inspect the Fama–French database to make sure that the date formats are compatible with my share price database. Based on the country information in my base table I create a derivation logic to determine the appropriate currency denomination for the Fama–French factors. This serves as a key for merging the two databases.

In the third step I download all the risk free rates from all four central banks and add them to the base table, again based on the currency derivation logic. I recalculate the returns from a yearly to a daily level and subtract them from the daily share returns of each bank.

The last step of data preparation is also the most time intensive one. I use established news websites like ft.com and the BBC to crosscheck validity of reported timelines in the Libor scandal. Once having a solid timeline of events, I track down each original article relating to a bank which either appeared in the news for being investigated for illegal Libor manipulations or at the end agreed to pay a settlement fee. I do this by using an advanced search tool within Google search engine, where I locate the initial source of information by narrowing down my scope of past results. I classify these milestones into two categories. First category tracks only the dates when a specific information appears for the first time. The second category tracks dates when an investigated bank agreed to pay. Both categories are actually created as dummy variables with values 0 and 1. Once I have both dummy variables containing date information for each respective bank which was involved in the scandal, I proceed to creating additional controlling dummy variables. Indicating, for all banks in the sample, the dates when an information relating to the scandal became public. This way I can also inspect how all banks in the sample were affected by the news. I also introduce another dummy variable, distinguishing between banks that cheated and those which were not involved in the investigation. This serves as another controlling variable and a way to determine if the cheating banks had a significant return advantage over their more honest peers. This is now my final dataset for the regression analysis.

3.1.4 Descriptive statistics

In this section I provide insights to my sample data which I use for the regression analysis. Table 5 contains descriptive statistics of my sample of data. An average daily return over the period between January 2005 and April 2015 for the 28 banks in my sample was 0.0014981 percent. Since my sample of banks varies in terms of origin of the banks, the average daily return figure seems plausible, especially because my sample involves the highly volatile years during the financial crisis of 2008. The daily returns banking shares vary a lot between the countries. At the same time it is also the size of the country that matters. The smaller the country, the less volatile the daily returns of the banks in that country are (Hagendorff, Keasey, & Vallascas, 2013). The minimum daily return of my sample is -7.05 percent, whereas the maximum daily return is 7.48 percent, after I correct the first percentile of the outliers by assigning them an average daily return rate in order to prevent sample mean distortion. The total number of observations is 75,404. Standard deviation in the observed period is for the sample of banks 2.04 percent. The big swings do make sense if we acknowledge the fact, that within the observed 10 years the world's banking industry has gone through a major financial crisis. Out of 28 banks in this sample 32 percent agreed to accept the guilt and pay the fines. The remaining banks in the sample are the for control purposes.

Table 5. Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Daily return	75404	0.00149%	2.0414%	-7.0526%	7.4778%
BankID	28				
Fine - 5 d.	75404	0.0006665	0.02581	0	1
Fine - 3 d.	75404	0.0003999	0.01999	0	1
First investig. - 5 d.	75404	0.0008397	0.02897	0	1
First investig. - 3 d.	75404	0.0005332	0.02308	0	1
Time of fine - 5 d.	75404	0.0093303	0.09614	0	1
Time of fine - 3 d.	75404	0.0055982	0.07461	0	1
Time of first investig. - 3 d.	75404	0.0190339	0.13665	0	1
Time of first investig. - 5 d.	75404	0.0119428	0.10863	0	1
Fined bank	75404	0.321429	0.46703	0	1
Market risk premium	75404	0.03194	1.33285	-10.095	15.6253
HML	75404	0.0116	0.58886	-12.023	15.494
SMB	75404	-0.00316	0.81978	-35.327	41.9274

An average market risk premium over the given period was 0.03194 percent. The mean values for the dummy variables are so small, because the dummy variables are in most cases 0 and only at marked dates 1.

3.2 Results from the CAPM approach

This section covers the more compact one of the two valuation approaches, the CAPM. In its essence the abnormal return is based only on the market risk premium, reduced for the risk free rate. I however add additional dummy variables for the purposes of this event study.

The regression results from the simplest equation (1) can be observed in the Table 6. In columns (1) to (4) I increasingly add new dummy variables to the standard CAPM model. The variable names used to explain the abnormal return can be found to the left of the table. The values in the table are the beta coefficients for each variable. An asterisk symbol is indicating the degree of statistical significance as per the comment at the bottom of the table. The figures in brackets under each beta coefficient indicate a standard error.

The results in the below Table 6 show that on average there is a relationship between a negative news event and the lower abnormal returns in that specific period. Banks which had to pay a fine for their Libor scandal involvement on average had 0.55 percentage point lower return over the five day observation period when the news came out in case of regression (1). The statistical significance of this coefficient lays at 2%. In case of regression (2) a

similar negative coefficient is observed. On average during the five days surrounding the time of the news that a bank will need to pay a fine, there was a 0.54 percentage point lower daily abnormal return, again moderately statistically significant at 2%.

Additionally to that one can also observe that in the case of regression (2) there is a second variable which shows a correlation between negative daily returns and a five day window around the time when the fact that a bank is being investigating for Libor manipulation was brought to the public for the first time. In case of this coefficient one can see that on average a bank involved in the investigation had 0.37 percentage point lower daily return within the 5 day observation period. This variable is statistically significant at 4%. This confirms my expectations from the earlier sections that a negative news would have a direct negative impact on the share price returns.

Although not statistically significant, however still relevant to point out are the coefficients found in regressions (3) and (4). They relate to the days around the point when either a specific bank was fined for their illegal business dealings, or was put on the spotlight for being investigated. As it can be seen from the coefficients there is a negative correlation, albeit very low for the whole sample of the banks. This also somewhat confirms my expectations that a negative news relating to the Libor scandal would on average have a negative impact on the whole banking industry. According to the regression (3) therefore there was on average a 0.04 percentage point reduction in daily returns of all the banks in the sample around the time where some of them were handed over a fine. A similar relationship can be observed also in the regression (4).

Interestingly enough the dummy variable, indicating the a five day period surrounding the time when a news came out that any of the involved banks is being investigated, appears to be negative as well and very statistically significant at less than 0.01%. This means, on average all banks in the sample, also those not involved in Libor submission process, lost 0.16 percentage points of their daily return, due to a news that one of them is being investigated. If we compare the absolute values of the dummy variables ‘time of the first investigation information’ and the dummy variable indicating for each specific bank, when it became apparent that they have to pay a fine, we see that in the case of first variable, the reaction is smaller. This seems plausible, since the coefficient ‘time of the first investigation information’ relates to all the banks in the sample.

At this point however it has to be noted that the dummy coefficients I have just mentioned only to some extent explain the price movements. Also worth mentioning is the variable indicating an effect on average daily returns over the entire observed period for the banks which were caught red-handed and agreed to pay a fine. Although not statistically significant, the coefficient does point out a positive relationship between cheating and potentially higher average daily returns, however it should not be relayed upon due to the statistical insignificance.

Table 6. CAPM based regression results with a five day event window

	(1)	(2)	(3)	(4)
Fine - 5 d.	-0.552**	-0.538**	-0.511**	-0.52**
	(0.231)	(0.23)	(0.238)	(0.236)
First investig. - 5 d.		-0.369**		-0.211
		(0.176)		(0.182)
Time of fine - 5 d.			-0.043	-0.011
			(0.063)	(0.062)
Time of first investig. - 5 d.				-0.161***
				(0.044)
Fined bank	0.003	0.004	0.003	0.003
	(0.013)	(0.013)	(0.013)	(0.013)
Market risk premium	77.747***	77.745***	77.752***	77.731***
	(0.867)	(0.867)	(0.867)	(0.867)

Note. *, ** and *** represent the statistical significance at the 10%, 5% and 1%, respectively.

Another very important variable is the market return, which is statistically significant at less than 0.01%. Adjusted R^2 for this CAPM based model is 26%.

3.3 Results from the Fama–French approach

In this section I present results based on a Fama–French three factor model which can be seen in the Table 7. The same hypotheses as defined in the previous sections also are tested in this approach.

Much like in case of CAPM the abnormal returns of the fined banks, with a moderate statistical significance, are negatively influenced by the news that they have to pay a fine, within an observed window of 5 days of the news coming out. According to the regression (1) of the below table, among the fined banks, a news that one of them will have to pay a fine, caused on average a 0.53 percentage point reduction in the affected bank's daily returns, over the 5 day observation period. The statistical significance of this variable was also in this case 2%. Roughly the same coefficient is also seen in the case of regressions (2), (3) and (4) for this dummy variable. With moderate statistical significance these values all point out to the same conclusion that the fines did have an impact on the abnormal return of the banks involved.

In a case of regression (2) a dummy variable 'First investing. - 5 d.' is describing a window of five days when a news is published, that a particular bank is being investigated for Libor manipulations. In comparison to the CAPM based model, that coefficient is also negative and it has a somewhat similar impact on the abnormal return of the bank during that period.

Interestingly however, the statistical significance of the variable decreases once we add the Fama–French factors HML and SMB to the regression.

Fama–French based model also supports the general logic, that the initial news, that a bank is being investigated, had a negative effect on the bank's daily return. At a low statistical significance this daily return on average reduced for 0.34 percentage points for the affected during the observed five day period.

When looking at all the banks in the sample, not focusing only on those that cheated, we see that again the times when it became apparent that one of the banks was being investigated for its illicit dealings, are associated with a general decline in daily returns. On average the reduction meant 0.17 percentage point decline in daily returns within the five day observation period, each time such a news broke into the public domain. Also in this case is this coefficient statistically significant at less than 0.01%.

Table 7. Fama–French based regression results with a five day event window

	(1)	(2)	(3)	(4)
Fine - 5 d.	-0.531**	-0.518**	-0.499**	-0.511**
	(0.226)	(0.225)	(0.234)	(0.231)
First investing. - 5 d.		-0.343*		-0.173
		(0.179)		(0.184)
Time of fine - 5 d.			-0.033	0.001
			(0.063)	(0.062)
Time of first investig. - 5 d.				-0.173***
				(0.044)
Fined bank	0.004	0.005	0.004	0.004
	(0.013)	(0.013)	(0.013)	(0.013)
Market risk premium	81.874***	81.872***	81.878***	81.854***
	(0.863)	(0.863)	(0.863)	(0.863)
HML	33.351***	33.343***	33.347***	33.383***
	(1.824)	(1.824)	(1.824)	(1.825)
SMB	19.577***	19.575***	19.578***	19.575***
	(2.827)	(2.827)	(2.827)	(2.828)

Note. *, ** and *** represent the statistical significance at the 10%, 5% and 1%, respectively.

The variable which again indicates for the whole sample of cheating banks a slightly positive relationship to the abnormal returns is 'Fined bank' dummy variable. Although not statistically significant, a penalized bank had on average slightly higher daily returns over the whole observed time series.

Market risk premium as well as additional Fama–French factors Small minus Big and High minus Low were all statistically significant at less than 1%. As a consequence of using these two additional variables, the adjusted R^2 of this model improves to 27%, which still is not a lot and it does indicate to me that there are other variables which can further explain the daily return movements.

3.3.1 Estimating impact of the fine on each bank

In the previous two sections I look at the whole sample of banks trying to understand the drivers of daily return movements for the banks in the mists of the Libor investigation, both for banks which were involved in Libor submission and those which were not. In this section on the other hand I look at each bank individually, among those which were forced by the investigators across the world to pay hefty fines for their involvement in Libor fixing. For the basis of my individual regression analysis I take a limited number of variables. For each regression I create a filter based on the BankId attribute in my database. By doing so I in effect perform a targeted regression analysis only on the selected bank.

I base my isolated regression approach on the Fama–French three factor model, which has proven more capable of explaining the movements of daily price returns. Additionally I intend to focus on the dummy variable 'Fine – 5 d.' specifically, to gain an understanding how each bank's daily share returns reacted to a Libor-related fine in an observed timespan of 5 days.

My expectation is that there is a clear connection between the time when the negative news comes to public and the reduction in the abnormal daily share return. As it can be seen from the Table 8 this is not always the case.

Table 8. Impact of fines on banks returns within a five day window

	Barclays	Citigroup	JP Morgan Chase	UBS
	(1)	(2)	(3)	(4)
Fine - 5 d.	-2.524**	-0.441***	-0.361	-0.286
	-1.144	-0.064	-0.279	-0.519
Market risk premium	125.83***	114.107***	106.206***	115.759***
	-4.713	-5.211	-4.93	-4.287
HML	25.981***	145.342***	148.748***	-22.609***
	-10.133	-12.144	-10.196	-8.188
SMB	26.451***	4.115	6.631	-7.45
	-8.586	-10.863	-9.414	-11.309

Note. *, ** and *** represent the statistical significance at the 10%, 5% and 1%, respectively.

(table continues)

Table 9. Impact of fines on banks returns within a five day window (continued)

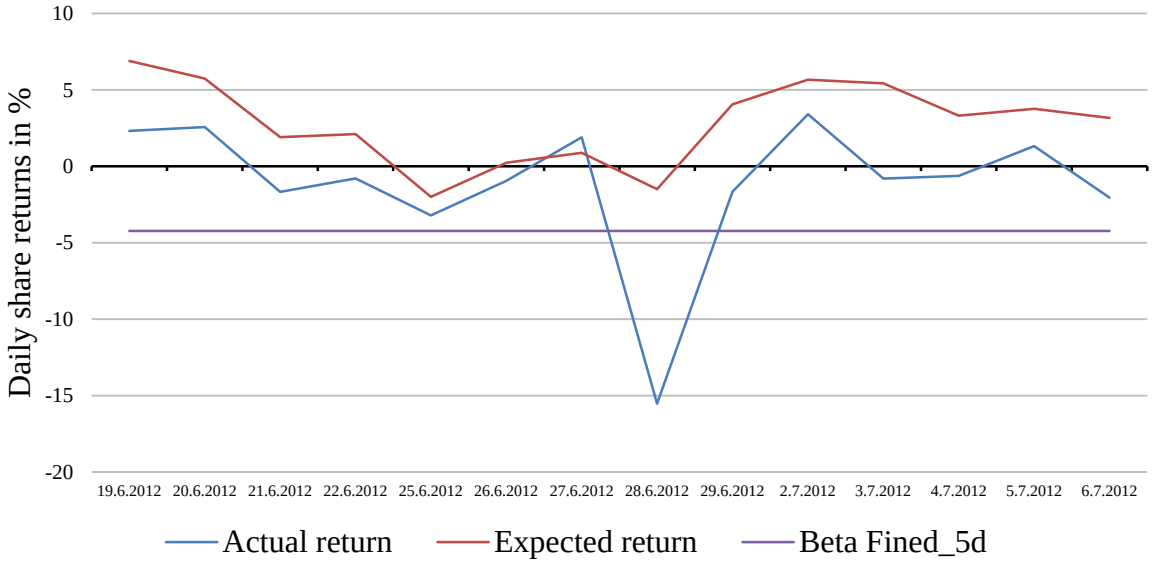
	Credit Suisse	RBS	Lloyds	Deutsche Bank	Societe Generale
	(5)	(6)	(7)	(8)	(9)
Fine - 5 d.	-0.386	0.834***	0.234	-1.248*	-0.073
	-0.48	-0.295	-0.306	-0.651	-0.367
Market risk premium	111.731***	114.654***	102.304***	110.492***	108.991***
	-4.372	-5.833	-5.898	-3.161	-5.194
HML	-21.124***	56.711***	47.2***	-14.357	87.933***
	-7.552	-11.976	-11.649	-9.951	-10.171
SMB	-23.287**	35.092***	18.198*	21.135**	1.081
	-10.124	-10.033	-10.005	-9.57	-8.777

Note. *, ** and *** represent the statistical significance at the 10%, 5% and 1%, respectively.

Additionally to the above mentioned regression analysis for the banks which were fined, I also calculate the estimated daily return for each of them. At this stage I add back the daily risk free rate, to get to the total daily return for the purposes of this representation – as opposed to only calculating with the abnormal returns, like in the above paragraphs. In the paragraphs below I use a graphical comparison of the real and the estimated daily returns. I also put the effect of the fine into a graphical perspective for the banks involved by displaying a beta of a relevant dummy variable in a chart. In my graphical representation I always take a window of 14 days to give a reader an insight into an affected bank's daily share price return development also outside of a strict time window, associated with an impact from a Libor fine.

Looking at both the Table 8 and the Figure 1 for Barclays I can conclude that the bank has a fairly strong reaction to the news that it will have to pay the fine for its Libor fixing.

Figure 1. Reaction of Barclays' returns to a fine and their prediction



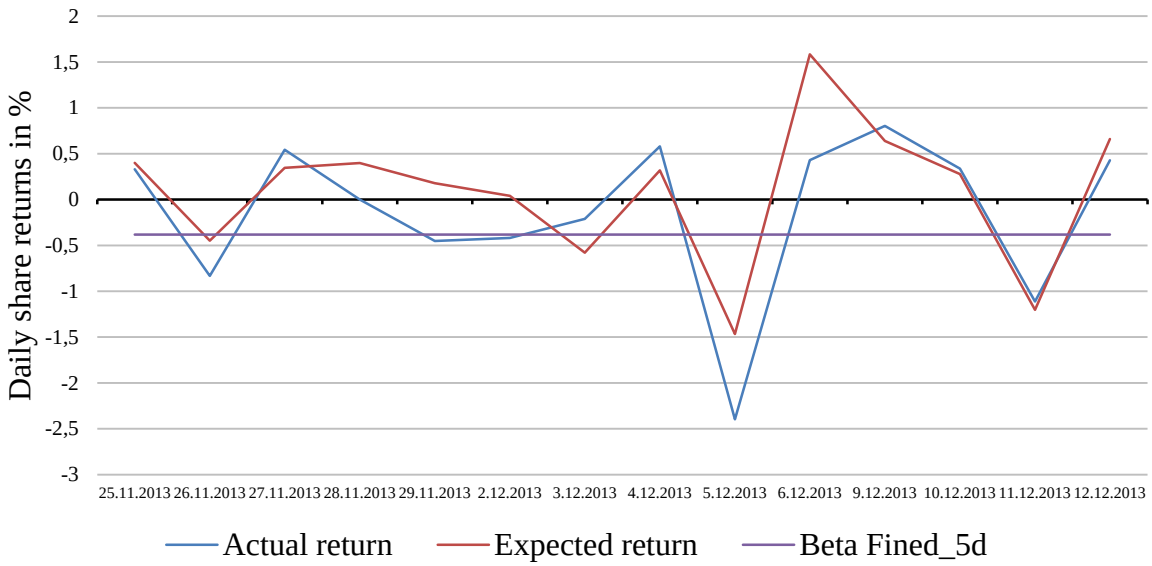
In comparison to other banks in the Table 8, Barclays has the highest beta coefficient as a reaction to the fine and it is also moderately statistically significant. At a reduction of 2.5 percentage points in Barclays' abnormal daily return I expect that the market reacted to such extent in the observed period, because Barclays was the first bank to be fined and also their fine was very substantial also when compared to the rest of the Libor fines. With all the later cases it seems the Libor fixing scandal already received its fair share of media coverage. Possible further surprises were therefore probably more related to the sizes of the fines and to the news of initial investigations being started against the banks.

In case of Citigroup with a graphical presentation in the Figure 2, we can see a much better fit of the expected return to the actual return. Beta coefficient for the dummy variable indicating a fine has a negative impact on the daily returns and is even more statistically significant than in case of Barclays. On average Citigroup lost 0.44 percentage points of its daily abnormal return during the observed period around the time when it received a fine from the European Commission. A smaller absolute value of the beta coefficient, compared to Barclays' can be potentially explained by the fact, that Citigroup at that point in time paid about a third of the fine Barclays was ordered to pay, hence the lower market reaction. Citigroup also cooperated with the investigators and received some fine reduction under the leniency notice. Also contributing was the fact that at the same time, there were also other banks, which were fined by the European Commission. Some of them received significantly higher fines.

Figure 2. Reaction of Citigroup's returns to a fine and their prediction

Such a case was JP Morgan Chase. They were also fined during the same time by the European Commission for a similar amount like Citigroup. Although not statistically significant, the coefficient of a dummy variable marking the time of a Libor fine, does indicate a negative impact of the fine on the abnormal daily returns of JP Morgan Chase's shares. Looking at the Figure 3 one can observe a fairly good fit of the predicted daily returns to the actual returns. Beta coefficient in this case is similar to that of Citigroup.

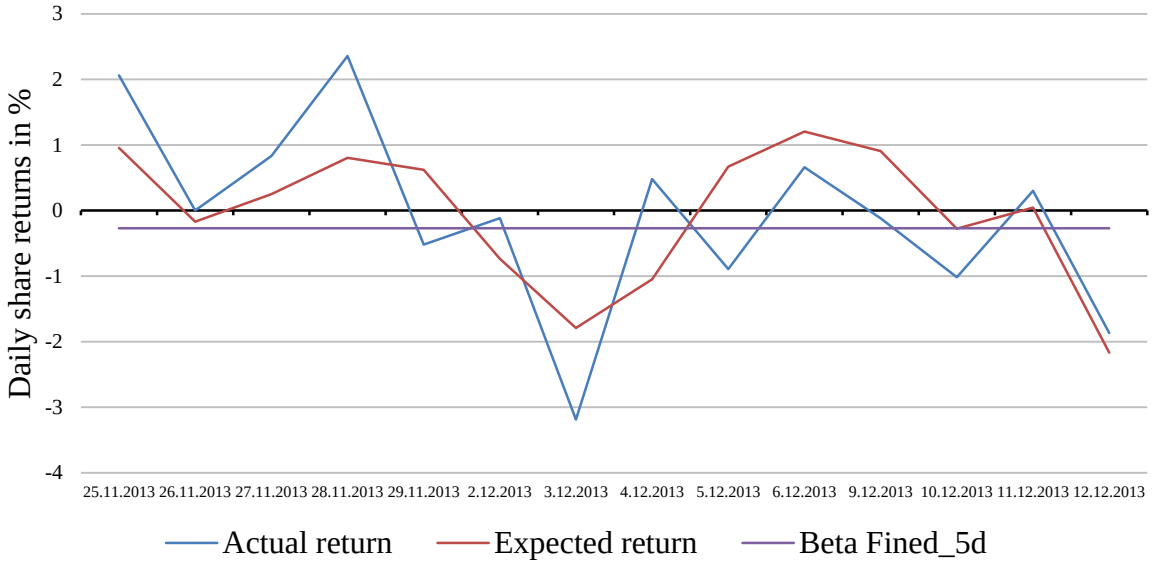
Figure 3. Reaction of JP Morgan Chase & Co's returns to a fine and their prediction



In the Figure 4 one can observe a development of UBS's daily returns around the time it also appeared on the list of the prosecuted banks by the European Commission. Although found guilty of the infringements, UBS was pardoned from paying a 2.5 billion EUR fine for

cooperating with the authorities. I included UBS also to this analysis and the overview, because it seems that the market reacted heavily despite the fact that UBS at the end did not have to pay the fine. An indicator to a somewhat milder reaction can be the beta coefficient for the dummy variable, which is also not statistically significant, but still indicates a negative impact on the daily returns, because of the negative news.

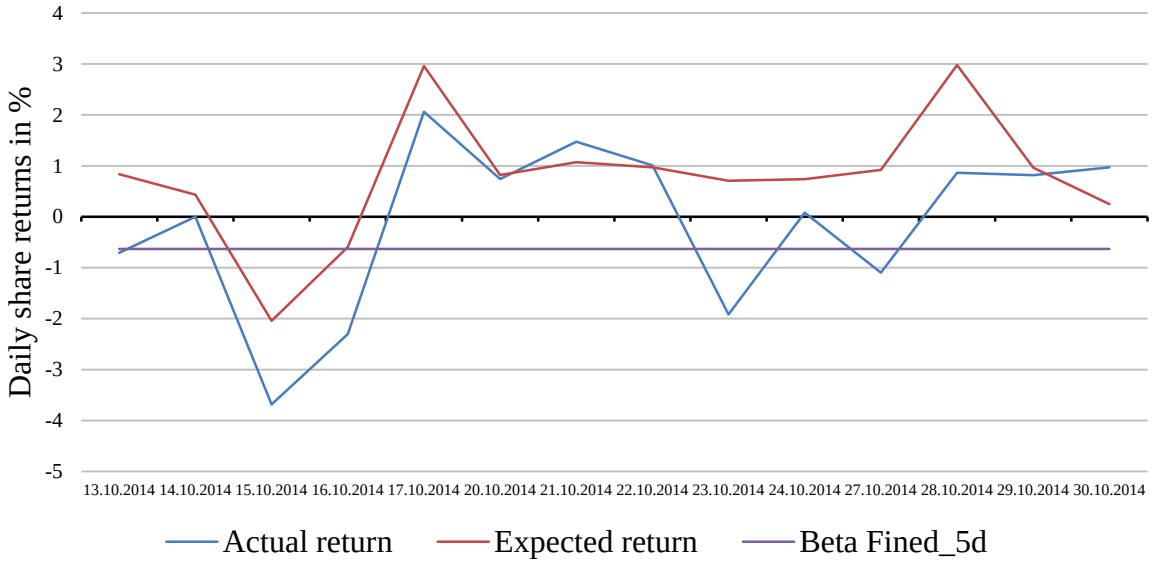
Figure 4. Reaction of UBS's returns to a news about the involvement in Libor fixing



Interestingly in October 2014 UBS at the end did have to pay a fine to the European Commission for another Libor related cheating. At that time however UBS' daily return actually increased, which is why I did not include the event in the above graphical representation. An increase under such circumstances would signal that market already priced in the fine and had expected a higher fine that was at the end given to UBS.

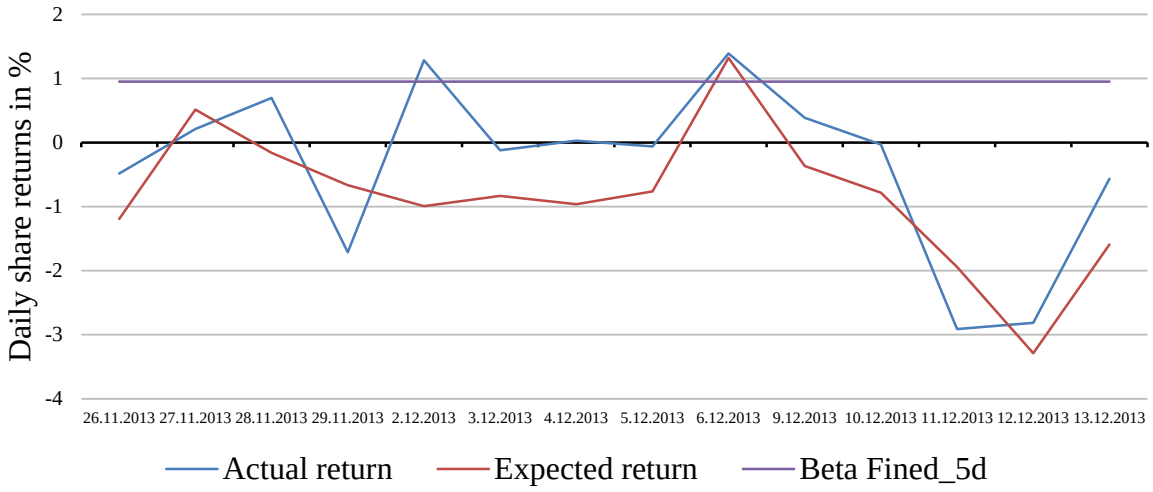
During the same time, as UBS' was ordered to pay a fine in 2014, also Credit Suisse received a fine by the European Commission. In case of Credit Suisse market reaction was more predictable with a corresponding beta coefficient indicating a negative impact of 0.39 percentage points. The coefficient however is not statistically significant.

Figure 5. Reaction of Credit Suisse Group's returns to a fine and their prediction



Also not showing a plausible impact was the Royal Bank of Scotland. It too was fined by the European Commission in 2013, for a substantial amount at the beginning of December.

Figure 6. Reaction of Royal Bank of Scotland Group's returns to a fine and their prediction

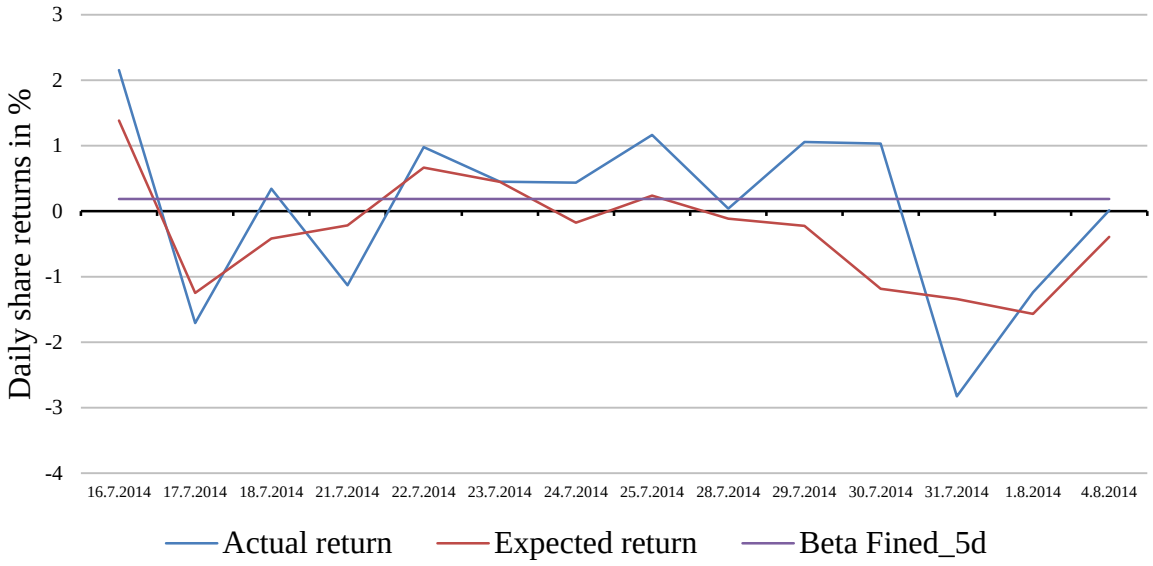


As can be seen from the above Figure 6, were the daily retunes initially not impacted by the negative news and only substantially decreased after a few days. In case of Royal bank of Scotland it is the beta coefficient which seems the least plausible, as it is positive, however it is statistically significant.

Lloyds bank was another bank in my sample which has a counter intuitive, positive, beta coefficient, indicating the time, when Lloyds was fined by the US regulators. The coefficient itself however is not statistically significant. As it can be seen from the Figure ´7, there was a daily return decrease prior to July 24 2014, indicating that markets have already put Lloyds

stocks on sell in an expectation of a big fine, which perhaps at the end did not turn so big as expected. Similarly, like in the case of the Royal Bank of Scotland there is also a couple of days delay after the fine was announced. And after that time, the daily returns of Lloyds bank fall substantially again.

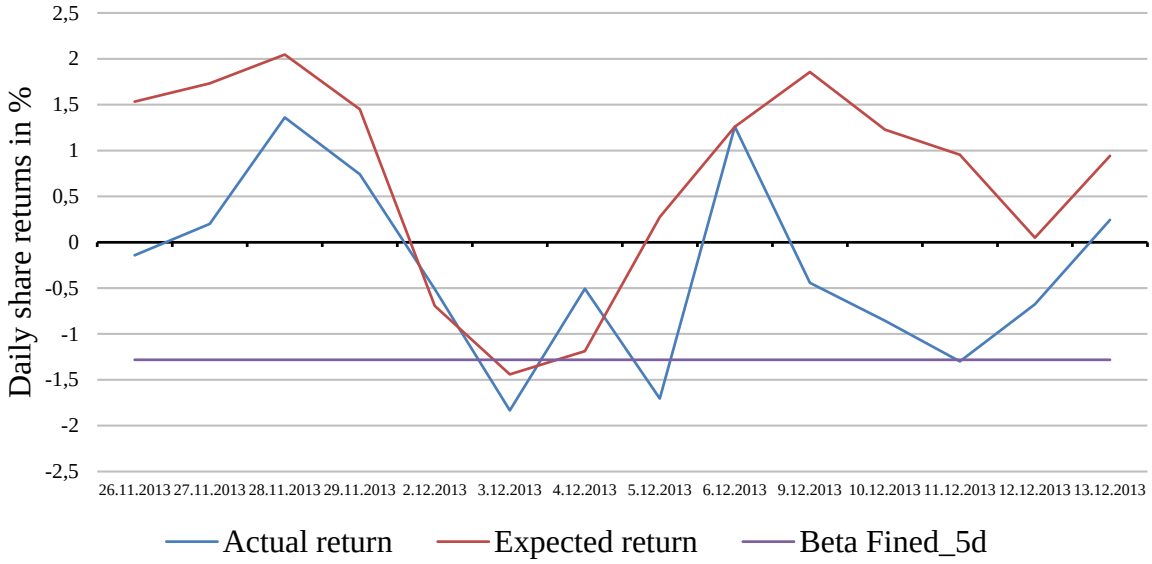
Figure 7. Reaction of Lloyds Banking Group's returns to a fine and their prediction



Deutsche Bank on the other hand did respond as expected to the announcement that it received a fine for being involved in Libor fixing. According to the Table 8, Deutsche bank had a second largest reaction to the negative news in my observed sample at 1.25 percentage point reduction of the daily abnormal return during the observed period.

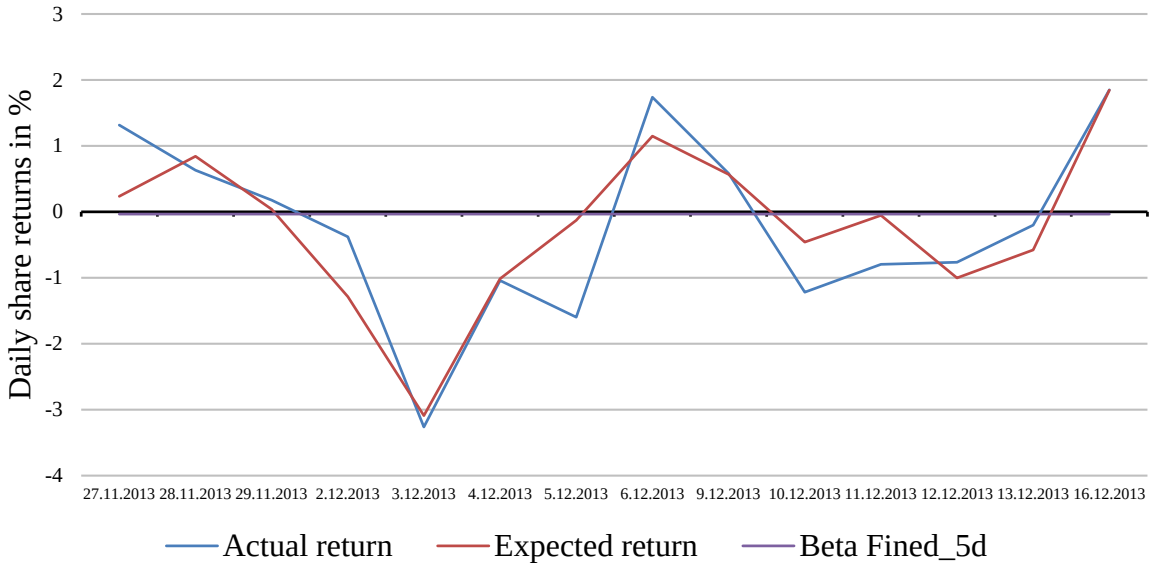
Looking at the Figure 8 one can also obseve a fairly good fit of the predicted values in comparison to the actuals, meaning that a fine by the European Commission did have a signifficant effect on the share price.

Figure 8. Reaction of Deutsche Bank's returns to a fine and their prediction



In case of Société Générale in Figure 9 one can observe a fairly good fit by the predicted values in comparison to the actual returns. However, the beta coefficient measuring the impact of the Libor fine is very small, indicating a limited yet still negative correlation between the returns and a fine being imposed on the bank. The beta coefficient is not statistically significant and therefore needs to be interpreted with caution.

Figure 9. Reaction of Société Générale's returns to a fine and their prediction



3.4 Robustness checks

In this section I briefly describe my robustness checks, to validate the general direction of my results in the main part of the analysis. The main difference in case of regression analyses for robustness checking purposes is that I reduce my observation window around the time when a fine event or investigation event occurred. The reduction is from five days to three days around a particular event.

Looking at the CAPM based regression results in Table 9 one can see that that the coefficients, relating to the time when a specific bank was being investigated or fined, are slightly bigger in absolute terms than in the original five day regression. A higher absolute value of the coefficients would indicate an increased reaction of the share price to the information about the fines. This indicates that the negative reactions to the share price were really concentrated around those dates. The coefficients under robustness testing also display the same level of statistical significance as the original tests. In general the robustness tests also confirm my hypothesis that on average negative information regarding fines and investigations in connection with the Libor scandal, does have a negative impact on the daily returns of the banks involved. At the same time, the robustness test also confirms, at a high degree of statistical significance, that an information, that some of the banks are being investigated for illegal submissions of Libor, does have a negative impact on daily returns of all the banks in the sample.

Table 10. CAPM based regression results with a three day event window

	(1)	(2)	(3)	(4)
Fine - 3 d.	-0.677**	-0.678**	-0.715**	-0.722**
	(0.343)	(0.343)	(0.352)	(0.349)
First investig. - 3 d.		-0.447*		-0.287
		(0.25)		(0.256)
Time of fine - 3 d.			0.039	0.051
			(0.078)	(0.077)
Time of first investig. - 3 d.				-0.178***
				(0.059)
Fined bank	0.003	0.003	0.003	0.003
	(0.013)	(0.013)	(0.013)	(0.013)
Market risk premium	77.744***	77.745***	77.744***	77.749***
	(0.867)	(0.867)	(0.867)	(0.867)

Note. *, ** and *** represent the statistical significance at the 10%, 5% and 1%, respectively.

Similar findings can be observed in the below regression results, based on Fama–French three factor model, in Table 10. The results confirm a negative relationship between the

Table 11. Fama–French based regression results with a three day event window

	(1)	(2)	(3)	(4)
Fine - 3 d.	-0.663**	-0.663**	-0.685**	-0.693**
	(0.331)	(0.331)	(0.341)	(0.337)
First investig. - 3 d.		-0.43*		-0.271
		(0.253)		(0.259)
Time of fine - 3 d.			0.024	0.035
			(0.078)	(0.077)
Time of first investig. - 3 d.				-0.176***
				(0.059)
Fined bank	0.004	0.004	0.004	0.004
	(0.013)	(0.013)	(0.013)	(0.013)
Market risk premium	81.872***	81.873***	81.871***	81.873***
	(0.863)	(0.863)	(0.863)	(0.863)
HML	33.353***	33.348***	33.352***	33.35***
	(1.824)	(1.824)	(1.824)	(1.825)
SMB	19.58***	19.58***	19.579***	19.564***
	(2.827)	(2.827)	(2.827)	(2.828)

Note. *, ** and *** represent the statistical significance at the 10%, 5% and 1%, respectively.

Libor related fines and the investigations. Also in this case the coefficients have the same statistical significance as in original test scenario. Much like in the CAPM based approach, the coefficients indicating impacts on the daily returns, during the three-day period when the banks were fined, were bigger in absolute terms, compared to the original test scenario.

Table 12. Impact of fines on banks returns within a three day window

	Barclays	Citigroup	JP Morgan Chase	UBS
	(1)	(2)	(3)	(4)
Fine - 3 d.	-2.005	-0.45***	-0.21	-0.559
	-1.68	-0.097	-0.43	-0.798
Market risk prem.	125.754***	114.096***	106.201***	115.748***
	-4.724	-5.211	-4.93	-4.287
HML	26.17***	145.322***	148.738***	-22.594***
	-10.143	-12.144	-10.195	-8.187
SMB	26.498***	4.205	6.692	-7.451
	-8.586	-10.861	-9.412	-11.308

Note. *, ** and *** represent the statistical significance at the 10%, 5% and 1%, respectively.

(table continues)

Table 13. Impact of fines on banks returns within a three day window (continued)

	Credit Suisse	RBS	Lloyds	Deutsche Bank	Societe Generale
	(5)	(6)	(7)	(8)	(9)
Fine - 3 d.	0.299**	1.125***	0.619***	-1.977**	-0.644**
	-0.12	-0.41	-0.229	-0.955	-0.317
Market risk prem.	111.673***	114.668***	102.296***	110.477***	109.036***
	-4.369	-5.835	-5.898	-3.158	-5.193
HML	-21.022***	56.663***	47.122***	-14.861	87.872***
	-7.549	-11.979	-11.653	-9.914	-10.167
SMB	-23.342**	35.055***	18.138*	20.915**	1.25
	-10.121	-10.033	-10.009	-9.548	-8.786

Note. *, ** and *** represent the statistical significance at the 10%, 5% and 1%, respectively.

Also in case of this Fama–French based model, during the times of investigations, the returns of all the banks were suffering. Similarly insignificant yet still positive is also beta coefficient indicating if a bank was ever fined. Also according to the robustness test it seems, that the cheating banks do on average reap slightly better daily results. However, this value is not statistically significant and should be interpreted conservatively.

Looking at each of the banks separately in the table 11 we can again see that a three day observation windows do lead to improved results. All banks except from Barclays have had the same or improved levels of statistical significance, in comparison to the 5-day observation windows. The coefficients for the 3-day windows around the time of the fines were in absolute terms bigger for Citigroup, UBS, RBS, Lloyds, Deutsche Bank and Société Générale. Looking at Barclay's coefficients, marking the 3-day windows around the fines, we see that they are less statistically significant and smaller in absolute terms. One could even say that the 3-day window approach performs better than the base case. On the other hand however we can observe higher standard errors across all tested banks under the robustness test scenario. In both cases, either with 5- or with 3-day observation windows we see significant impacts on the share prices, when it becomes publicly known that an affected bank needs to pay a fine.

CONCLUSION

From the evidence in this master thesis it seems clear that on average the banks which were involved in Libor interest rate manipulations had a significant impact on their abnormal returns. From the financial regulator's point of view the fines achieved their effect, since in most cases on average, the owners of the cheating banks were negatively impacted. However the findings do prove to be limited in their ability to explain daily share price returns fully and therefore need further investigation. My research also yielded a result that on average all banks in the sample, also those not involved in Libor submissions at all, are negatively affected even when news comes out that one of the bigger banks is being investigated. This finding might therefore suggest that banks could be prone to cheating in order to minimize the losses. In event when one of them is caught cheating, on average all of them will be negatively impacted. Libor it seems is such a fundamental instrument of the international finance that a structure of the system seems to be at stake. At the same time this spill-over effect of Libor investigations on the whole industry may be attributed to the fact that today's financial world is increasingly connected and dependent on one another. Perhaps it is also due to this connectivity of all the parties in the financial system that I was not able to statistically significantly find out, whether the banks, which were cheating, had on average higher returns. The results on this are too inconclusive, however if one also counts the corporate responsibility, the loss in integrity as well as additional supervisory and transactional costs imposed by the regulator, one can with a fair degree of certainty conclude that cheating does not pay off.

To further improve my analysis I see an opportunity in expanding the Fama-French three factor model. Instead of the basic one I used, one could attempt to analyze my dataset with Carhart's four-factor model, taking into account also momentum. Alternatively also the most recent five-factor Fama-French model could be explored. Another potential for improvement I see in expanding my database with the use of a website crawler. For the purposes of this master thesis I was manually searching for articles and I was entering the publishing dates into my database, which was time consuming. One could use text mining techniques to search through all the quarterly communications of the involved banks as well as reference all the major investigative governmental agencies, which on one occasion or another communicated progress on investigations to the general public. This way one could potentially observe the levels of accruals, which banks have built up in preparation for the law suites. Normally found in the financial statements accruals descriptions contain detailed explanations and some degree of breakdown figures, which, if collected on a mass, could lead to an improved prediction levels of share returns. Another attribute, which would give an extended insight into the adverse effects of cheating, would be the Net promotor score, as described by Reichheld (2003). Net promotor score could be collected with interviews of customers and partners in order to determine, whether illegal practices have eroded the trust consumers and corporate partners place into the high street banks. Introducing also this variable into the analysis one could better control for the loss of trust into the system.

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