The Libor: London Interbank Offered Rate
# Table of Contents

**Executive Summary** ................................................................................................................. 2  

**Libor – An Overview**  
- History and Background ........................................................................................................ 3  
- Usage of Libor .......................................................................................................................... 3  
- Calculation of Libor .................................................................................................................. 3  

**Libor Scandal** .......................................................................................................................... 4  

**Wheatley Review** ..................................................................................................................... 6  

**Libor and Variables**  
- Adjustable Rate Mortgages ....................................................................................................... 7  
- Interest Rate Swaps .................................................................................................................. 8  
- Federal Funds Rate ................................................................................................................... 9  

**Simple Regression Analyses**  
- Adjustable Rate Mortgages ..................................................................................................... 10  
- Commercial Papers .................................................................................................................. 12  
- One Year Swaps ....................................................................................................................... 13  
- Treasury Bills ........................................................................................................................... 14  
- Effective Federal Funds ............................................................................................................ 16  
- Eurodollar Deposits .................................................................................................................. 16  

**Multiple Regression Analyses** ............................................................................................... 17  

**Conclusion** .............................................................................................................................. 18  

**Exhibits (1-7)** .......................................................................................................................... 19  

**Regression Outputs** ............................................................................................................... 24  

**References** .............................................................................................................................. 28
Executive Summary

The paper focuses on the history of the Libor, the Libor scandal, the Libor’s effects on the global financial market, and examines a comparison between the Libor and various short term US rates. The history and background provided us information on how Libor came into existence and why this rate is so widely used today. In addition, the effects of the Libor on Adjustable Rate Mortgages, Treasury Bill, Interest Rate Swaps, Eurodollar deposits, Commercial Paper, and Federal Funds rate give insight into the financial crisis of 2008. The purpose of this analysis was to examine whether the Libor and selected US short term interest rates have a significant correlation.

In order to analyze and determine whether a correlation between the Libor and the six chosen U.S. interest rates exists, simple and multiple regressions were performed. Specifically, the behavior between the Libor and adjustable-rate mortgages, effective Federal Funds rate, Euro-USD deposit, interest rate swaps and treasury bills rate was . According to historical data, these rates move together with the Libor and the spread is minimal however; during the recessionary period the spread between the effective rates and Libor widens highlighting the impact of the Libor on them.

The paper concludes that a strong relationship exists between the Libor and the examined U.S. interest rates. In periods of economic depression, the spread between the Libor and these rates significantly widens. Since, the Libor is subjected to market risk, it is in the best interest of the borrower to choose the Libor as designated index rate.
**Background/ History**

With the dawn of the 1980s, the London financial market saw an increasing number of banks actively trading new instruments. As attractive as these new instruments like the forward rate agreement seemed to the banks, they were apprehensive of the rates which had to be agreed upon before entering a contract. To solve this problem, the banks turned to the British Bankers Association (BBA) to create a uniform measure which could act as a benchmark for the new instruments. This uniform rate had the ability to facilitate the operation of markets and allow more transparent and objective benchmarking. In January of 1986, the use of this rate, called the London InterBank Offered Rate (Libor), became the standard market practice¹.

**Usage of the Libor**

The Libor is defined as “the primary benchmark for short term interest rates globally and is used as the basis for settlement of interest rate contracts on many of the world’s major futures and options exchanges.”² Libor serves as a reference rate for “unsecured loans between London based banks as well as many financial instruments that are transacted across the globe”³. Libor acts as the rate at which the world’s most preferred borrowers are able to borrow money, and as an indicator for less preferred borrowers. The Libor is not important for just financial institutions, but is also relevant to the common man. This benchmark for short term interest rates is used for retail products such as college loans, credit card rates, student loans, and adjustable rate mortgages which is roughly a ten trillion dollar market⁴. The Libor serves another function of acting as a “barometer to measure strain in money markets and as a gauge of market expectation for future central bank interest rates.”⁵

**Calculation**

The Libor is calculated daily for ten currencies with fifteen maturities quoted for each from overnight to twelve months. It is calculated based on the submissions of the daily rate quotes of the banks selected by the BBA. The BBA asks the contributor banks at 11:00 am each morning to base their daily submission according

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⁴ Ibid

to the following question: “At what rate could you borrow funds, were you to do so by asking for and then accepting inter-bank offers in a reasonable market size just prior to 11 am?”

The rates are confidentially submitted to Thomson Reuters by the banks through an installed application where are unable to see the submissions made by the other banks until the final publication of the Libor data at 12 noon G.M.T.. The Libor rate is then calculated by Thomson Reuters by taking the simple average of the submitted rates after dismissing the highest and lowest 25% of the rates to exclude outliers. The top and bottom quartiles are dropped so that an individual panel contributor cannot influence the calculation or affect the Libor rate. The BBA is advised by the Libor Panel Banks and Users Group (LPBAUG) to maintain a reference panel of six to 18 contributor banks for each of the currencies calculated to reflect the true balance of the market. The contributing banks are selected for the currency panels through these criteria:

1. Scale of market activity
2. Credit rating
3. Perceived expertise in the currency concerned

The Libor Scandal

The Libor Scandal made a very public debut during the summer of 2012. On June 27 2012, the world’s fourth largest bank, Barclays Bank PLC, faced criminal charges and was fined a record-breaking $464 million for attempting to manipulate and falsely reporting the Libor. The investigations concluded that the traders and employees of Barclays Bank, who were responsible for the Libor and Euribor submissions, made false reports to benefit the Bank’s derivatives trading position. In addition to setting rates, Barclays Bank was also responsible for asking the assistance of other banks to help manipulate the benchmark rates.

It is important to understand the motivation behind the agreement of the banks to manipulate the Libor. In the market, transactions that utilize Libor as a benchmark for establishing borrowing costs can “generate sizable wealth transfers from lenders to borrowers.” Simply put, banks that are the net borrowers would benefit from lower rates, while banks that are net lenders would benefit from higher rates. Since some financial

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6 Ibid
7 Ibid
instruments such as mortgages and student loans are based on the Libor, a lower Libor will induce a lower mortgage rate, which would encourage the purchasing of more homes and inflate the prices of the homes\(^9\).

The Wall Street Journal suggests that banks have the ability to use the Libor submission process to “manage their public reputation.”\(^{10}\) The Libor calculation process can signal that the operating costs are lower than they are in reality. This small change can indicate a positive health of the bank. Lowering the Libor rate also creates a competitive environment in which other banks are pressured to do the same. Banks which operate in global markets may be “motivated to use Libor as a ‘hedge’ against rate fluctuations elsewhere.”\(^{11}\)

Before the financial crisis of 2008, Barclays Bank was responsible for changing daily Libor “based on their derivatives trading positions to bolster their own profits” (NYT). In 2007, it was estimated that the “loss (or gain) that Barclays stood to make from normal moves in interest rates over any given day was 20 million pounds [32 million dollars]”.\(^{12}\) While the financial crisis raged on, Barclays Bank changed its play and submitted artificially low rates to attract more customers and “give the impression that the bank could borrow money more cheaply and was healthier than it was.”\(^{13}\) Other banks investigated are The Royal Bank of Scotland, CitiGroup, Credit Suisse and Lloyds Bank to name a few.

The manipulation of the Libor also greatly affected the common man. Banks lent out money at lower interest rates and collected lower returns in the process. While loans and mortgages were cheaper for those who had borrowed at floating rates, “the banks that held that loan, as well as anyone else who held floating rate debt in an investment portfolio” lost due to this under-reporting of the Libor. These investments included 401(k)s, pension funds, mutual funds, hedge funds, etc.\(^{14}\)

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\(^{10}\) Ibid


The Wheatley Review of Libor

Following the Barclays Bank settlement in June 2012, the managing director of the Financial Services Authority (FSA) and CEO-designate of the Financial Conduct Authority (FCA) was asked to design reforms for the clearly flawed Libor system. The key points that he proposed are:

1. After the implosion of the scandal, suggestions of wiping out the Libor completely were commonplace. However, the Wheatley Review “concluded that there is a clear case in favour of comprehensively reforming LIBOR, rather than replacing the benchmark.” Wheatley argued that since a large number of financial transactions based on the Libor (approximately $300 trillion) were still outstanding, a decision to abolish the Libor could only “be justified by clear evidence that the benchmark is severely damaged, and that a transition to a new, suitable benchmark or benchmarks could be quickly managed to ensure limited disruption to financial markets.” The Wheatley Review insisted that while Libor had serious issues, it could “be rectified through a comprehensive and far-reaching programme of reform; and that a transition to a new benchmark or benchmarks would pose an unacceptably high risk of financial instability.

2. The second conclusion the Review reached was that “transaction data should be explicitly used to support LIBOR submissions.” The Review enumerates specific recommendations to establish “strict and detailed processes for verifying submissions against transaction data and limiting the publication of LIBOR to those currencies and tenors that are supported by sufficient transaction data.”

3. The third significant conclusion was that “the market participants should continue to play a significant role in the production and oversight of LIBOR.” This would ensure that the financial institutions and government would have limited control over “a benchmark which exists primarily for the benefit of market participants.” Alternative benchmarks do exist in a number of markets and the role of authorities is “to ensure the integrity of the process by which benchmarks are determined rather than to direct users
to adopt a particular benchmark.” This said, the market is likely to demand the “most reliable and verifiable benchmark” for a transaction.\textsuperscript{15}

On November 8 2012, the BBA conducted a press release where they stated that they were working with Martin Wheatley and his team and be following the recommendations made by the Wheatley Review to improve the Libor.\textsuperscript{16}

\textbf{Libor and Adjustable Rate Mortgages}

One of the questions that the general populace should consider is how the Libor affects them. The answer to that is their adjustable rate mortgages (ARM) i.e. their mortgage rate, are based on two indices, the US treasury rate and the Libor rate. The interest rate on an ARM is calculated based on the index rate it follows and a margin. While the index rate moves and is flexible, the margin does not change over the life of the loan. The margin is expressed in terms of percentage points, and large margins are linked to borrowers with high risk loans.\textsuperscript{17}

By 2007 all the subprime ARMs and an increasing number of prime loans were tied to the Libor. As the financial markets worsened, the difference between T-bills and Libor rates, which previously moved together, now separated. This gap widened at the start of 2007 when concerns regarding the mortgage backed assets began to rise.\textsuperscript{18}

“The initial difference in August 2007 between the six month Libor and Treasury rate was one percentage point which exceeded 3.5 percentage points by October 2008.”\textsuperscript{19} Due to the poor economic situation at the time, financial institutions grew critical of lending money to each other. This was caused by a high risk of defaulting which led to an increase in Libor rates. On the other hand, the Treasury rates fell steeply, which further widened the gap for the same maturity Libor and Treasury rates. The demand for Treasury bills increased tremendously during this period, as there was no risk of default, which in turn caused the yield to

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\textsuperscript{17} http://search.proquest.com.ezproxy.babson.edu/docview/233620603/fulltextPDF?accountid=36796
\hfill
\textsuperscript{18} IBID
\hfill
\textsuperscript{19} IBID
\end{flushright}
decline close to zero. Those with mortgages based on Libor were at a risk of being subjected to higher rates, as compared to the mortgages based on Treasury rates.\textsuperscript{20}

What then was the impact of an inflated Libor dependent on mortgages? Libor is the index rate typically used for subprime mortgages. From Exhibit 3, we can notice that between the periods, end of 2007 till January 2008, the Libor rates fell. This gave the impression that the mortgages based on Libor, helped the people, but in fact when compared to the Treasury rates the difference was noticed. In order to understand this, the Economic Commentary used an inflated six-month forward Libor set at 3 percent and a six-month Libor which was close to the six-month Treasury rate. Upon calculating, the latter was set to 1.25 percent.\textsuperscript{21} The difference in the two rates for the subprime holder meant that “there was a $100 monthly payment difference of a remaining principal of $100,000. This is total amounted to $34 million in 2009, for those whose mortgages were based on Libor.”\textsuperscript{22}

From the Fred database, we can see that the UK and US governments have taken effective actions and restored the interbank lending operations to lower the Libor. “The Libor, which was inflated during the crisis in 2008 to approximately 3 percent, is now down to 0.5 percent in 2012.”\textsuperscript{23} Also, we can conclude that if the mortgage is based on the Libor, ARM and Libor are directly related and move in the same direction.

**Libor and Swaps**

As an investor, a key issue to consider is how the Libor affects the interest rate swaps market. A swap is an agreement between two parties, in which companies promise to make future interest payment to one another for a specified principal amount. What an interest rate swap does is that, a fixed interest payment is exchanged for a floating payment linked to a specific interest rate (Libor). The benefit of doing this is to immunize against variations in interest rates and to achieve a marginally lower interest rate\textsuperscript{24}. Swaps are directly related to Libor, through the floating rate, such that; as the Libor increases so does the swap and vice-versa.

\textsuperscript{20} [http://search.proquest.com.ezproxy.babson.edu/docview/233620603/fulltextPDF?accountid=36796](http://search.proquest.com.ezproxy.babson.edu/docview/233620603/fulltextPDF?accountid=36796)

\textsuperscript{21} IBID

\textsuperscript{22} IBID

\textsuperscript{23} [http://research.stlouisfed.org/fred2/data/USD3MTD156N.txt](http://research.stlouisfed.org/fred2/data/USD3MTD156N.txt)

\textsuperscript{24} [http://www.investopedia.com/articles/optioninvestor/07/swaps.asp](http://www.investopedia.com/articles/optioninvestor/07/swaps.asp)
When Barclay’s manipulated the Libor and set it artificially lower than what it should have been during the financial crisis, it created an impact in the swap market. According to the Bond Buyer article, the municipal issuers had invested around “$50-$100 billion in the Libor-related transactions, most tied to the one-month Libor rate.”25 They did this in order to hedge against the variable-rate of the Libor, and gain the proceeds from the floating rate received by swaps.

Hence, when the Libor was artificially low, due to it being manipulated by banks, the municipality issuers received lesser on their swaps than they should have, highlighting how a lower Libor resulted in lower swap payments.

**Libor and Federal Funds Rate**

The federal funds rate is set by the Federal Open Market Committee, of the Federal Reserve Bank. It is the overnight interest rate for borrowing fed funds.26 The rate changes whenever the Committee meets and realizes a need to influence the monetary policy. Both these rates are used for short term borrowing purposes, and mostly move together.

As observed in Exhibit 4, the fed funds rate tends to be lower than the Libor, and the spread between the graphs is minimal until the financial crisis of 2008. This is due to the fact that the fed funds have a low risk nature of defaulting, whereas; there are no such guarantees for the Libor. The Federal Reserve sets the rate, which is affected by the demand for interbank lending and their actions. Until 2007, the fed funds rate and Libor moved in the same direction. In 2007, the mortgage backed assets began to decline, and banks began to get concerned about lending money, as a result of which the interbank market came to a standstill. Due to this, the default risk became high and, the Libor rose. On the other hand, the fed funds tried to keep the rates low so as to prevent a panic situation caused by the financial markets. To add to the woes of the common people, Lehman Brothers and AIG failed in September 2008, which caused the overnight borrowing rate to increase.

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significantly. Thus, Libor further escalated, while the fed funds rate was deliberately kept low, which increased the spread between these two rates.\(^{27}\)

In order to prevent further losses, the Federal Reserve injected more money into the banks, so as to stabilize the financial situation at the time. This lowered the Libor, so that the two rates have a low spread.\(^{28}\) We can conclude that there is a direct correlation between the fed funds rate and Libor, as they keep the rate in check with the other.

**Effects of Libor rate on one year Adjustable Rate Mortgages, Commercial Paper rate and one year Swap rate**

**Adjustable Rate Mortgages**

As mentioned before, Libor rate has a significant impact on global financial market. The particular sectors this paper will deeply conduct analysis on are how Libor rate affects 1 year adjustable rate mortgages, commercial paper rate, one year swap rate, Treasury bill rate, effective Federal funds rate and EURO USD Deposit rate. “Although Libor is a foreign interest rate, its effects on the U.S. interest rates are tremendous (Fuscaldo)\(^{29}\)”

Adjustable rate mortgage (ARM) is a type of mortgage tied to an economic index, which is mainly the Libor. “Of the mortgages in the United States that are adjustable-rate, about 45 percent of prime mortgages and 80 percent of subprime have interest rates based on the Libor” (Behind the Libor Scandal)\(^{30}\). Therefore, Libor has direct impact on the amount customers have to pay on the ARM. If the index, the Libor, is low at the period the mortgage rate resets, borrowers’ monthly payments will be lower. Vice versa, if the Libor rate is high,


borrowers’ monthly payments will increase (Tynan). This statement can be proven by the regression analysis of Libor and ARM.

### Regression Table 1 - Libor and 1 year ARM

<table>
<thead>
<tr>
<th>Time Periods:</th>
<th>R-Squared:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986-1995</td>
<td>88.4%</td>
</tr>
<tr>
<td>1995-2004</td>
<td>78.8%</td>
</tr>
<tr>
<td>2004-2012</td>
<td>67.7%</td>
</tr>
</tbody>
</table>

According to table 1, the R-squared of the Libor rate and ARM is 88.4%, during period 1986 to 1995, 78.8% during years 1995-2004 and 67.7% during years 2004-2012. Although there is a decrease in the value of R-squared in every period, its value is still considered fairly high, according to the (≥ 60% rule-of-thumb). This indicates that the regression equations are a good fit for the data. The p-value of the t-test also remains constant throughout the three periods, at 0.000. This indicates that there is evidence of a linear relationship between ARM and the Libor since p-value is less than 0.1. The relationship between the two rates can be seen in exhibit five. The Libor rose more than double from 2.57% on September 29, 2008 to 6.88% on September 30, 2009. The financial crisis caused financial institutions to have doubts in lending to each other. Therefore, they only lent money at high overnight rates. Since the ATMs were tied to Libor, the ARM also rose according to the Libor. This made more difficult for low-income borrowers to cover the cost they have to pay for mortgage commitments.

However, the relationship between Libor and ARM has weakened after the financial crisis, as displayed in the decrease in value of R-squared throughout the three periods. According to exhibit five, there is a wider gap between Libor and ARM rate during 2008-2012. This is also the time Libor is believed to be manipulated.

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by many of the world’s largest banks. Banks decreased the Libor to a very low rate in order to gain confidence from clients. The rates were so low that the ARM could not follow as closely as before

**Commercial Paper**

Not only does Libor affect ARM, but it also affects commercial paper rate. Commercial paper (CP) is an unsecured short-term promissory note issued by a corporation to raise short-term cash. It is generally sold in large denomination, about $100,000 to $1 million with maturities up to 270 days. Therefore, it is considered to be one of the largest of the money market instruments. As commercial paper is very much dependent on Libor, the CP rate tends to move in the same direction as the Libor. This can be seen in exhibit 1 where the two rates move together very closely. Additionally, the relationship between the Libor and CP rate is also displayed in the regression analysis of Commercial Paper rate versus 3 months Libor.

<table>
<thead>
<tr>
<th>Time Periods:</th>
<th>R-Squared:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997-2004</td>
<td>100%</td>
</tr>
<tr>
<td>2005-2012</td>
<td>99.4%</td>
</tr>
</tbody>
</table>

According to table 2, The R-squared is 100% during year 1997 to 2004 and 99.4% during year 2005-2012. An extremely high R-squared value indicates that there is a strong correlation between Libor and CP rate. The p-value from the t-test during both periods also remains constant at 0.000. This indicates that there is evidence of a linear relationship between ARM and the Libor since p-value is less than 0.1. As a result, the returns earned by investors in money funds would decline if Libor were kept lower.

Nevertheless, although the regression analysis indicates that the CP rate is mainly driven by the Libor, the regression analysis of CP rate and ARM proves that the movement in CP rate is also driven by the movement in Libor.

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33 IBID
35 IBID
Regression Table 3- CP rate and 1 year ARM

<table>
<thead>
<tr>
<th>Time Period:</th>
<th>R- Squared:</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-2012</td>
<td>77.4%</td>
</tr>
</tbody>
</table>

According to the table 3, the R-squared of CP rate and ARM is 77.4%, which indicates strong correlation between the two variables. Also, the p-value from the t-test is 0.000, which indicates that there is evidence of a linear relationship between the ARM and CP rate since p-value is less than 0.1. This is because during 2007-2008, many of the mortgage-backed securities performed poorly than expected. The rise in ARM caused many low income borrowers to have a hard time trying to meet the cost they have to cover. Since credit rating is important in determining the marketability of a CP issue, CP rate is indirectly influenced to follow the rising movement of ARM. Although the Federal Reserve was able to bring CP rate down during the crisis, the market has not yet recovered.\(^{36}\)

**One year Swap Rate**

Libor is also used as a base rate for many derivatives instruments including futures, options and swaps. The instrument being analyzed in this paper is swap. There are several types of swaps: interest rate swaps, currency swaps, commodity swaps and equity swaps. This paper will analyze the one year interest rate swaps, which is when parties agree to swap interest payments on a stated notional principal amount for a set period of time.\(^{37}\) When the money center bank has different loan rate for assets account and liabilities account, one being floating-rate loans and the other being fixed-rate loan, there is a mismatch in the maturity term. For example, if the money central bank has floating-rate loans in its asset and fixed-rate loan in its liabilities account, the money center bank will have a negative duration gap. The duration of its assets is shorter than that of its liabilities. Therefore, the money central bank does a swap agreement with savings bank in order to hedge the interest rate risk exposure and to make sure that both money central bank and savings bank are able to cover the cost of meeting the coupon payment if the market interest rates rise or fall.\(^{38}\) According to CNN Money, $350 trillion in

\(^{36}\)IBID

\(^{37}\)IBID

\(^{38}\)IBID
derivatives are tied to Libor\textsuperscript{39}. As a result, the movement of Libor can greatly affect investors and loans to individuals and businesses. It would determine the consumer payouts for people who invest in these derivatives\textsuperscript{40}.

\begin{table}[h]
\centering
\begin{tabular}{|l|c|}
\hline
\textbf{Time Periods:} & \textbf{R-Squared} \\
\hline
2000-2006 & 98.2\% \\
2007-2012 & 98.8\% \\
\hline
\end{tabular}
\caption{Regression Table 4: Libor and 1 year Swap rate}
\end{table}

As indicated in exhibit 5, the movement of 1 year swap rate goes almost perfectly along with the movement of the Libor. This strong correlation between Libor and 1 year swap rate can also be seen in regression data 3. In the data, the R-squared of 1 year swap rate and Libor is 98.2\% during years 2000 to 2006 and 98.8\% during years 2007 to 2012. Additionally, the p-value of 0.000 in both periods also shows that there is evidence of a linear relationship between the Libor and 1 year swap rate since p-value is less than 0.1. The strong relationship between these two rates can greatly affect many individuals. While many lenders could have been harmed by the low Libor, people who invest in derivatives could have benefited. This is because investors who invest a fund in an interest-rate swap and pay a floating rate based on Libor, the lower Libor would enable them to pay less than they should have (Grind)\textsuperscript{41}.

**Effects of Libor rate on 3-Mon Treasury Bill, Effective Federal Fund, and Euro-USD Deposit Rate**

**Treasury Bill**

The relationship between the U.S. treasuries interest rates and Libor rates is interesting to analyze because it is and has been a “key indicator of perceived credit risk”. “The TED spread, or the spread between the 3-month T-bill and 3-month Libor denominated in basis points (bps), can serve as another measure of the


\textsuperscript{40} Ibid

liquidity freeze experienced after the 2006 financial crisis”. In the past, a rising TED spread has indicated a downturn in the U.S. stock market, indicating that liquidity is being withdrawn. When the TED spread is too high this indicates that US money supply is being reduced. This trend of a rising TED spread from 2005 to 2007 can be related to Regression Table 4. According to Regression Table 4, the R-squared of the Libor rate and T-Bill is 97.5% during the period 1986 to 1995, 99.4% during the years 1995 to 2004 and 97.5% during years 2004 to 2012. All R-squared values are rather high according to the (≥60% rule-of-thumb). Furthermore, as observed in Regression Data 5, the p-values all exactly 0.000 indicate that there is strong statistical significance between T-bills and the Libor from 1986 to 2012. A drop of 2% in the r-squared between 1995-2004 and 2004-2012 points to the 2008 economic recession in which T-bills were considered “risk free” and thus heavily invested in to the point where it’s yield dropped significantly. During the 2008 financial crisis and after the Lehman Brothers firm failed, investors turned to Treasury bills. This drove the T-bill rate down to close to zero. As Exhibit 7 shows, “when the financial crisis began to spread more widely, the TED spread widened to 240 bps on August 20, 2007 from an average of 38 bsp over the period December 2005 to July 31, 2007. The TED spread widened further to 464 bps on October 10, 2008. This last spread was 80 percent higher than the prior historical high set in November of 1987.”

**Regression Table 5 - T-Bills:**

<table>
<thead>
<tr>
<th>Time Periods:</th>
<th>R-Squared:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986-1995</td>
<td>97.5%</td>
</tr>
<tr>
<td>1995-2004</td>
<td>99.4%</td>
</tr>
<tr>
<td>2004-2012</td>
<td>97.5%</td>
</tr>
</tbody>
</table>

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44 IBID
Effective Federal Fund

Both Federal Funds and the Libor relate because both reflect unsecured loans between large, global banks and are used as alternative sources of overnight funding. As evident in Regression Table 5, the Libor and U.S. Effective Federal Funds are very closely related. The R-squared is 98.3% from 1985 to 1995, 99.2% from 1995 to 2004, and 96.1% from 2004 to 2012. As seen in Regression Data 6, these extremely high R-squared value and p-values across all three periods of 0.000 indicate that there is strong statistical significance between the Libor and Effective Federal Fund rates. While both rates are nearly substitutes for eachother, the federal funds rate is commonly lower than the Libor. This is because of the low risk nature of U.S. bank deposits versus foreign bank deposits. “U.S. banks are covered by deposit insurance up to certain levels. Moreover, there is a perception that large U.S. banks and large U.S. bank depositors are implicitely ensured via “too big to fail” or TBTF guarantees”. However the tight spread of the two rates greatly fluctuated in the summer of 2007 with the onset of the financial crisis. The Libor rate spiked drastically as the interbank market began to freeze. Federal fund rates on the other hand, were kept low by the Federal Reserve in order to prevent crisis from breaking out in the financial markets. The demise of AIG and Lehman Brothers in 2008, the Federal Reserve again lowered the fed fund rates. Thus, there is a 3.1% decrease in the correlation between Federal Funds and the Libor between 1995-2004 and 2004-2012. “At the height of the financial crisis, the spread between the Libor and the fed fund rates jumped to about 3%”.

Regression Table 6- Effective Federal Fund:

<table>
<thead>
<tr>
<th>Time Periods:</th>
<th>R-Squared:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985-1995</td>
<td>98.3%</td>
</tr>
<tr>
<td>1995-2004</td>
<td>99.2%</td>
</tr>
<tr>
<td>2004-2012</td>
<td>96.1%</td>
</tr>
</tbody>
</table>

Eurodollar Deposits

The Libor has become a standard in the interbank Eurodollar market. “Eurodollar deposits are U.S. denominated certificates of deposit in foreign banks. Maturities on Eurodollar deposits are less than one year and

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46 Ibid
most have a maturity of one to six weeks”. Historically, the overnight Libor rate and the overnight federal fund rates have been called “near-perfect substitutes” since their rates track each other very closely. According to Regression Table 7, the R-squared of the Libor and Eurodollar Deposits is 97.5% from 1985-1995, 100% from 1995 to 2004 and 99.0% from 2004 to 2012. Such high R-squareds from 2004 to 2012 further demonstrate that there is a strong correlation between “short term US and Eurodollar rates in recent global financial markets”. Also as evident in Regression Data 7, the p-values from the t-test for all three time periods is 0.000. This again indicated evidence of a significant, linear relationship between the Libor and Eurodollar Deposits.

Regression Table 7-Eurodollar Deposits:

<table>
<thead>
<tr>
<th>Time Periods:</th>
<th>R-Squared:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985-1995</td>
<td>97.5%</td>
</tr>
<tr>
<td>1995-2004</td>
<td>100%</td>
</tr>
<tr>
<td>2004-2012</td>
<td>99.0%</td>
</tr>
</tbody>
</table>

However, there is a slight decline of 1% from 1995 to 2012 in the R-squared. This can be linked to the increase in the rates of Eurodollar deposits in comparison to the US deposit rates during the 2008 financial crisis. Essentially, this fluctuation in deposit rates was due to the low risk nature of US bank deposits relative to foreign bank deposits. The spread between the Libor rates and the Eurodollar deposits thus slightly increased from 1995 to 2012.

Multiple Regression: Libor Rates and T-Bill Rates, Effective Federal Fund, Euro USD Deposit, Adjustable Rate Mortgage, 3-Mon AA Commercial Paper, 1 Year Swap Rate

From analyzing the T-bill, Federal Fund, Eurodollar Deposit, Adjustable Rate Mortgage, Commercial paper and Swap rates with the Libor, it is apparent that not only each rate is affected by the Libor, but each rate is also dependent on one another. The high correlation between these rates is evidenced in Table 8. The high value of R-squared adjusted of 99.9% indicates that there are high correlations between all the rates and Libor.

Additionally, the p-value of 0.001 indicates that there is evidence of linear relationship between the Libor and these rates. This statistical analysis supports the fact that historically, in stable times, markets keep the interest rates for instruments of similar maturities and risks very comparable. However, during times of financial crisis, this statistical analysis shows that the spreads comparing the Libor and these rates have widened.

**Conclusion**

The purpose of this analysis was to understand the general background of the Libor, how it affects the global financial market and the correlation between the Libor and other U.S. interest rates. These rates include the one year adjustable rate mortgages, commercial paper rate, one year interest rate swaps, treasury bills rate, effective federal fund rates and the Euro USD deposit rates. During the completion of this work, the background of the Libor, the Libor scandal and the movements of Libor and other U.S. interest rates were analyzed. After realizing that Libor and other U.S. interest rates move fairly close together, it is apparent that there are direct relationships between the change in Libor and fluctuations in other U.S. interest rates. This can be supported by the regression analysis between Libor and the U.S. interest rates mentioned above. The regression analyses were done in three time periods of 1985 to 2000 or before the financial crisis, 2004-2008 or during the financial crisis in, 2009-2012 or after the financial crisis. Although the R-squared between the Libor and the various U.S. interest rates is lower during the times of financial crisis than during the stable financial time, all the R-squared values are greater than 60% throughout the three periods. This indicates that since 1985, there have always been high correlations between the Libor and the other U.S. interest rates. Additionally, the p-value of the Libor and these rates are all less than 0.1 throughout the three periods. Thus, there is evidence of linear relationship between the Libor and these rates. These statistical analyses reveal that though each different short term rate significantly impacts one another, the width or amount of basis points that the spread between the Libor and these rates can significantly rise and drop. These spread fluctuations vary based on current global, economic situations. As a result, it should be made clear that Libor is not a good index to borrow on. Rather, “it is a great index for the right borrower”.
Exhibit 1: Libor Processes

Exhibit 2: A ten-point plan for comprehensive reform of LIBOR

Regulation of LIBOR

1. The authorities should introduce statutory regulation of administration of, and submission to, LIBOR, including an Approved Persons regime, to provide the assurance of credible independent supervision, oversight and enforcement, both civil and criminal (see Chapter 2).

Institutional reform

2. The BBA should transfer responsibility for LIBOR to a new administrator, who will be responsible for compiling and distributing the rate, as well as providing credible internal governance and oversight. This should be achieved through a tender process to be run by an independent committee convened by the regulatory authorities (see Chapter 3, paragraphs (3.5 to 3.16).

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3. The new administrator should fulfil specific obligations as part of its governance and oversight of the rate, having due regard to transparency and fair and nondiscriminatory access to the benchmark. These obligations will include surveillance and scrutiny of submissions, publication of a statistical digest of rate submissions, and periodic reviews addressing the issue of whether LIBOR continues to meet market needs effectively and credibly (see paragraphs 3.17 to 3.38).

The rules governing LIBOR
4. Submitting banks should immediately look to comply with the submission guidelines presented in this report, making explicit and clear use of transaction data to corroborate their submissions (see paragraphs 4.5 to 4.13).

5. The new administrator should, as a priority, introduce a code of conduct for submitters that should clearly define:
   - Guidelines for the explicit use of transaction data to determine submissions;
   - Systems and controls for submitting firms;
   - Transaction record keeping responsibilities for submitting banks; and
   - A requirement for regular external audit of submitting firms.
   (see Chapter 4, paragraphs 4.14 to 4.31)

Immediate improvements to LIBOR
6. The BBA and should cease the compilation and publication of LIBOR for those currencies and tenors for which there is insufficient trade data to corroborate submissions, immediately engaging in consultation with users and submitters to plan and implement a phased removal of these rates (see Chapter 5, paragraphs 5.3 to 5.13).

7. The BBA should publish individual LIBOR submissions after 3 months to reduce the potential for submitters to attempt manipulation, and to reduce any potential interpretation of submissions as a signal of creditworthiness (see paragraphs 5.14 to 5.18).

8. Banks, including those not currently submitting to LIBOR, should be encouraged to participate as widely as possible in the LIBOR compilation process, including, if necessary, through new powers of regulatory compulsion (see paragraphs 5.19 to 5.28).

**Exhibit 3: Libor and T-bill comparison**

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[Exhibit 3 Image]

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50 [http://search.proquest.com.ezproxy.babson.edu/docview/233620603/fulltextPDF?accountid=36796]
Exhibit 4: Libor vs Fed Funds Rate

Fed Funds Target Rate vs. U.S. Prime Rate vs. 1-Month LIBOR vs. 3-Month LIBOR,
July 1, 1999 - November 30, 2012

Exhibit 5: Graph of Libor and Adjustable Rate Mortgage, 3-Month AA Financial Commercial Paper, 1-Year Swap Rates

Rates of Libor, ARM, CP and 1 yr Swap

52 http://research.stlouisfed.org/fred2/series/MORTGAGE1 US?cid=114
http://research.stlouisfed.org/fred2/series/CPF3M?cid=120
http://research.stlouisfed.org/fred2/series/DSWP1?cid=32299
http://research.stlouisfed.org/fred2/series/DED3?cid=32298
http://research.stlouisfed.org/fred2/series/TB3MS?cid=116
http://research.stlouisfed.org/fred2/series/FEDFUNDS?cid=118
Exhibit 6: Libor and T-bill, Effective Federal Fund and Euro USD Deposit Rates

Exhibit 7: Widening Spreads of Securities Affecting Treasury Bills and Fed Funds

Figure 5: Widening spreads of home-equity, credit card and auto loan asset-backed securities (weekly, January 2006 – November 20, 2008)

Sources: Datastream, Milken Institute

IBID
Figure 6: Widening spread between mortgage-backed securities and high-yield bonds (weekly, 2004–October 31, 2008)

Basis points, spread over yield on 10-year Treasury

Maximum spread: 10/31/2008: 1834 bps
Merrill Lynch Mortgage-Backed Securities Index
Average, 2004–October 31, 2008: 327 bps
Merrill Lynch High-Yield Bond Index
Average, 2004–October 31, 2008: 389 bps

Sources: Bloomberg, Milken Institute
Regression Outputs

Regression Data 1: Libor rate and Adjustable rate mortgages Regression

Regression Analysis: 1 yr ARM avg in the US versus 3 months Libor rate between 1986-04-01 to 1995-01-01

The regression equation is 1 yr ARM avg in the US - 3 month = 2.71 + 0.684 3 months Libor rates

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coef</th>
<th>SE Coef</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>2.7068</td>
<td>0.2825</td>
<td>9.58</td>
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<tr>
<td>3 months Libor rates</td>
<td>0.68445</td>
<td>0.04248</td>
<td>16.11</td>
<td>0.000</td>
</tr>
</tbody>
</table>

S = 0.513920  R-Sq = 88.4%  R-Sq(adj) = 88.1%

Regression Analysis: 1 yr ARM avg in the US versus 3 months Libor rate between 1995-04-01 to 2004-01-01

The regression equation is 1 yr ARM avg in the US - 3 month = 3.51 + 0.440 3 Months Libor rate

<table>
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</thead>
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<tr>
<td>Constant</td>
<td>3.5133</td>
<td>0.1901</td>
<td>18.49</td>
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<tr>
<td>3 Months Libor rate</td>
<td>0.44006</td>
<td>0.03898</td>
<td>11.29</td>
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</tbody>
</table>

S = 0.450586  R-Sq = 78.9%  R-Sq(adj) = 78.3%

Regression Analysis: 1 yr ARM avg in the US versus 3 months Libor rate between 2004-04-01 to 2012-07-01

The regression equation is 1 yr ARM avg in US - 3 months = 3.43 + 0.408 3 Months Libor rate

<table>
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<td>Constant</td>
<td>3.4319</td>
<td>0.1532</td>
<td>22.40</td>
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<tr>
<td>3 Months Libor rate</td>
<td>0.40810</td>
<td>0.04984</td>
<td>8.19</td>
<td>0.000</td>
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</table>

S = 0.573011  R-Sq = 67.7%  R-Sq(adj) = 66.7%

Regression Data 2: Libor rate and Commercial Paper Rate Regression

Regression Analysis: Commercial Paper rate versus 3 months Libor rate between 1997-01-01 and 2004-10-01

The regression equation is Commercial Paper rate = -0.0578 + 0.975 Libor rate

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<thead>
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<tbody>
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<td>-0.057805</td>
<td>0.006732</td>
<td>-8.59</td>
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<tr>
<td>Libor rate</td>
<td>0.974978</td>
<td>0.001508</td>
<td>646.53</td>
<td>0.000</td>
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</tbody>
</table>

S = 0.0176048  R-Sq = 100.0%  R-Sq(adj) = 100.0%

Regression Analysis: Commercial Paper rate versus 3 months Libor rate between 2005-01-01 and 2012-04-01

The regression equation is Commercial Paper rate = -0.173 + 1.00 Libor rate
**Regression Data 3: Libor rate and 1-Year Swap rate**

Regression Analysis: 1 yr Swap versus 3 months Libor rate between 2000-07-01 and 2006-10-01
The regression equation is
1 yr Swap = 0.471 + 0.938 Libor

<table>
<thead>
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<th>Predictor</th>
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<th>SE Coef</th>
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<th>P</th>
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</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.17329</td>
<td>0.04692</td>
<td>-3.69</td>
<td>0.001</td>
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<tr>
<td>Libor</td>
<td>1.00032</td>
<td>0.01457</td>
<td>68.65</td>
<td>0.000</td>
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</tbody>
</table>

S = 0.163919    R-Sq = 99.4%  R-Sq(adj) = 99.4%

**Regression Analysis: Swap versus 3 months Libor rate between 2007-01-01 and 2012-04-01**
The regression equation is Swap = 0.189 + 0.913 Libor Rate

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coef</th>
<th>SE Coef</th>
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<tbody>
<tr>
<td>Constant</td>
<td>0.18855</td>
<td>0.05922</td>
<td>3.18</td>
<td>0.005</td>
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<tr>
<td>Libor</td>
<td>0.91327</td>
<td>0.02262</td>
<td>40.38</td>
<td>0.000</td>
</tr>
</tbody>
</table>

S = 0.202730    R-Sq = 98.8%  R-Sq(adj) = 98.7%

**Regression Data 4: CP rates and ARM (Adjustable Mortgage Rate)**

Regression Analysis: CP rate versus ARM between 2002-07-01 and 2012-04-01
The regression equation is CP rate = - 5.37 + 1.72 ARM

<table>
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<th>Coef</th>
<th>SE Coef</th>
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<tbody>
<tr>
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<td>-5.3731</td>
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<tr>
<td>ARM</td>
<td>1.7243</td>
<td>0.1204</td>
<td>14.32</td>
<td>0.000</td>
</tr>
</tbody>
</table>

S = 1.04875    R-Sq = 77.4%  R-Sq(adj) = 77.0%

**Regression Data 5: Libor rate and T-Bill**

Regression Analysis: Libor Rates 3-mon USD versus T-Bill Rates 3-mon between 1986-04-01 and 1995-01-01
The regression equation is Libor Rates = - 0.109 + 1.16 T-Bill Rates

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coef</th>
<th>SE Coef</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.1094</td>
<td>0.1828</td>
<td>-0.60</td>
<td>0.553</td>
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<tr>
<td>T-Bill Rates</td>
<td>1.16477</td>
<td>0.03138</td>
<td>37.12</td>
<td>0.000</td>
</tr>
</tbody>
</table>

S = 0.324586    R-Sq = 97.5%  R-Sq(adj) = 97.5%

Regression Analysis: Libor Rates 3-mon USD versus T-Bill Rates 3-mon between 1995-04-01 to 2004-01-01
The regression equation is Libor Rates = 0.0660 + 1.12 T-Bill Rates
Regression Analysis: Libor Rates 3-mon USD versus T-Bill Rates 3-mon between 2004-04-01 to 2012-07-01

The regression equation is Libor Rates = -0.109 + 1.16 T-Bill Rates

Regression Data 6: Libor rate and Effective Federal Funds Rate

Regression Analysis: Libor Rates 3-mon USD versus Effective Federal Fund Rates between 1986-04-01 and 1995-01-01

The regression equation is
Libor Rates = 0.561 + 0.825 Effective Federal Fund Rates

Regression Analysis: Libor Rates 3-mon USD versus Effective Federal Fund Rates between 1995-04-01 to 2004-01-01

The regression equation is
Libor Rates = 0.0562 + 1.03 Effective Federal Fund Rates

Regression Analysis: Libor Rates versus Effective Federal Fund Rates between 2004-04-01 to 2012-07-01

The regression equation is
Libor Rates = 0.455 + 0.965 Effective Federal Fund Rates
### Regression Data 7: Libor Rate and Euro USD Deposit Rate

#### Regression Analysis: Libor Rates 3-mon USD versus Euro USD Deposit Rates between 1986-04-01 and 1995-01-01

The regression equation is Libor Rates = 0.342 + 0.835 Euro USD Deposit Rates

<table>
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<tr>
<td>Constant</td>
<td>0.3417</td>
<td>0.1498</td>
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<td>Euro USD Deposit Rates</td>
<td>0.83541</td>
<td>0.02292</td>
<td>36.45</td>
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</table>

S = 0.277829  \( R^2 = 97.5\% \)  \( R^2(\text{adj}) = 97.4\% \)

#### Regression Analysis: Libor Rates 3-mon USD versus Euro USD Deposit Rates between 1995-04-01 to 2004-01-01

The regression equation is Libor Rates = 0.0652 + 1.01 Euro USD Deposit Rates

<table>
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<tbody>
<tr>
<td>Constant</td>
<td>0.065215</td>
<td>0.008417</td>
<td>7.75</td>
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<tr>
<td>Euro USD Deposit Rates</td>
<td>1.00815</td>
<td>0.00176</td>
<td>572.15</td>
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</tbody>
</table>

S = 0.0202011  \( R^2 = 100.0\% \)  \( R^2(\text{adj}) = 100.0\% \)

#### Regression Analysis: Libor Rates versus Euro USD Deposit Rates between 2004-04-01 to 2012-07-01

The regression equation is Libor Rates = - 0.123 + 1.01 Euro USD Deposit Rates

<table>
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<tbody>
<tr>
<td>Constant</td>
<td>-0.12300</td>
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<td>-2.20</td>
<td>0.035</td>
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<tr>
<td>Euro USD Deposit Rates</td>
<td>1.01213</td>
<td>0.01792</td>
<td>56.47</td>
<td>0.000</td>
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</table>

S = 0.202584  \( R^2 = 99.0\% \)  \( R^2(\text{adj}) = 99.0\% \)

### Multiple Regression Data 8: Libor Rates versus T-Bill Rates, Effective Federal Fund, Euro USD Deposit, Adjustable Rate Mortgage, 3-Mon AA Commercial Paper, 1 Year Swap Rate

#### Regression Analysis: Libor Rates versus T-Bill Rates, Effective Federal Fund, Euro USD Deposit, Adjustable Rate Mortgage, 3-Mon AA Commercial Paper, 1 Year Swap Rate

The regression equation is Libor Rates = 0.179 - 0.0799 T-Bill Rates + 0.269 Effective Federal Fund Rates + 0.601 Euro USD Deposit Rates - 0.0600 Adjustable Rate Mortgage + 0.092 3-Mon AA Commercial Paper + 0.157 1 Year Swap Rate

<table>
<thead>
<tr>
<th>Predictor</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.17918</td>
<td>0.04966</td>
<td>3.61</td>
<td>0.001</td>
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<tr>
<td>T-Bill Rates</td>
<td>-0.07986</td>
<td>0.05366</td>
<td>-1.49</td>
<td>0.144</td>
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<tr>
<td>Effective Federal Fund Rates</td>
<td>0.26901</td>
<td>0.07304</td>
<td>3.68</td>
<td>0.001</td>
</tr>
<tr>
<td>Euro USD Deposit Rates</td>
<td>0.60124</td>
<td>0.04734</td>
<td>12.70</td>
<td>0.000</td>
</tr>
<tr>
<td>Adjustable Rate Mortgage</td>
<td>-0.06004</td>
<td>0.01603</td>
<td>-3.75</td>
<td>0.001</td>
</tr>
<tr>
<td>3-Mon AA Commercial Paper</td>
<td>0.0919</td>
<td>0.1110</td>
<td>0.83</td>
<td>0.413</td>
</tr>
<tr>
<td>1 Year Swap Rate</td>
<td>0.15692</td>
<td>0.05061</td>
<td>3.10</td>
<td>0.003</td>
</tr>
</tbody>
</table>

S = 0.0486029  \( R^2 = 99.9\% \)  \( R^2(\text{adj}) = 99.9\% \)
References


“I pledge my honor that I have neither received nor provided any unauthorized assistance during the completion of this work.”

“The authors of this paper hereby give permission to Professor Michael Goldstein to distribute this paper by hard copy to put it on reserve at Horn Library at Babson College or to post a PDF version of this paper on the internet.”