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Department of Economics and Finance

Course of Mathematical Finance

From LIBOR to OIS: exploring the transition to risk-free rates and how it affected Interest Rate Swaps

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Introduction

With the recent termination of the London Interbank Offered Rate (LIBOR), a pillar of the financial system for decades, the global financial landscape has undergone a seismic transformation. International financial authorities have pushed for the replacement of LIBOR with risk-free rates due to LIBOR's susceptibility to manipulation and its waning usefulness as a benchmark. Overnight Indexed Swap (OIS) rates have emerged as the new reference standard as a result of this enormous change, ushering in a new era of interest rate benchmarking.

In light of episodes of manipulation and fraud, and a decreasing number of transactions that support its calculation, LIBOR, formerly seen as the cornerstone of the world's financial markets, is now in crisis of trust. Therefore, the switch from LIBOR to risk-free rates has been championed by financial regulators, led by the Financial Stability Board (FSB) and the Alternative Reference Rates Committee (ARRC). This change attempts to provide benchmark rates that are more reliable, transparent, and representative and that appropriately reflect borrowing costs in the interbank market.

In response to the need for a trustworthy replacement for LIBOR, Overnight Indexed Swap rates have gained prominence as the preferred choice for benchmarking interest rates. OIS rates provide an accurate picture of short-term borrowing costs without any risk because they are based on actual transactions in the overnight lending market. When compared to the estimations included in LIBOR submissions, central banks' OIS rates, which are based on real overnight indexed transactions, offer a more accurate depiction of the current market conditions.

Consequently, the establishment and growth of the Interest Rate Swaps-OIS spread is one of the most important outcomes of the switch from LIBOR to OIS rates. This spread, reflective of evolving market perceptions of risk and liquidity premia, embodies the complex dynamics stemming from the displacement of LIBOR by RFRs. In this paper, the Overnight Indexed Swaps are explored in depth, with a focus on the OIS curve as a pivotal component of the newly established benchmarking framework. Additionally, the relationship between the IRS-OIS spread and the OIS-LIBOR spread will be extensively examined, dissecting its components including default and non-default elements, and scrutinizing the role of instruments like Credit Default Swaps.

In conclusion, the switch from LIBOR to OIS rates represents a fundamental reconfiguration of the financial landscape rather than merely a change in benchmark rates: in order to manage the complexity and take advantage of the opportunities presented by this shifting financial environment, market participants, regulators, and institutions must adapt to this structural transition. This thesis attempts to provide a comprehensive understanding of the consequences this change holds for the world of Interest Rate Swaps by analysing the cessation of LIBOR, the rise of OIS rates, and the complex dynamics of the IRS-OIS spread.

Chapter 1

The Rise and Fall of LIBOR: From Global Benchmark to Discontinuation

1.1 The London Interbank Offered Rate

The London Interbank Offered Rate (LIBOR) is the reference rate at which large banks can borrow short-term wholesale funds from one another on an unsecured basis in the interbank market.

The first occurrence of LIBOR in the financial markets can be attributed to the establishment and growth of the syndicated loan market in 1969 as well as the expansion of Eurodollar deposits during the second postwar period. A significant number of US dollars began to circulate in Europe following Bretton Woods in 1944 and as a result of the Marshall Plan. At the same time, however, there were a number of factors that made it unfavourable for investors to keep US dollars on US soil: Regulation Q, which set limits on the interest rates that could be paid on US deposits (1% for 30-day deposits and 2.5% for 90-day deposits), Russians' concern over having their deposits seized, and British regulations that forbade using sterling to finance international trades between third parties due to sterling's low liquidity in England.

Due to all of these elements, investors began looking for investments that would yield higher returns. In June 1955, Midland Bank offered 1.88% interest for a 30-day USD deposit, which was 0.88% more than the highest interest rate available for deposits made on US soil. Then, Midland Bank instantly sold these dollars at the market rate for sterling and quickly purchased them back again at a rate of 2.18%. As a result, Midland Bank paid a total of 4% for sterling (the cost of dollar deposits was 1.88%; the cost of purchasing back dollars was 2.12%); the rate the bank was willing to offer was 4.5%. These offshore deposits, which went by the name of **Eurodollars**, were primarily utilized by banks in London to acquire pound more cheaply than they could with dollars put by foreign investors seeking for lucrative opportunities.

The market became more competitive once other banks in the City of London began to imitate Midland's technique, and Midland eventually lost its advantage. Following the formal introduction of convertibility in 1958, which allowed non-sterling nations to move sterling into and out of the sterling area, Eurodollars' main function was not anymore to achieve local currency, but rather became the main source of dollar funding, as the demand for liquidity loans increased.

In this perspective, the creation of LIBOR is attributed to Minos Zombanakis, a Greek banker who, in 1969, was seeking a loan of $80 million to fund a brand-new government agency.

A loan of that size carried a significant risk for any bank during those years due to both the size of the debt and the risk associated with interest rates. Greek banker Minos Zombanakis, who was employed by Manufacturers Hanover in London, had a brilliant concept that forever altered the corporate credit market. He suggested making the loan as a syndicate to a dozen Western and Middle Eastern lenders in order to split the money and get around regulations that placed a limit on the amount of risk banks could take on individual consumers.

Back then, it was common practice for large loans to have a fixed rate for the duration of the loan. Despite how straightforward it was, banks were still at danger from interest rate fluctuations. To reduce the risk, Zombanakis thought it would be a good idea to attach the loan to a variable that changed along with the market. He suggested that the banks average their cost of funding (via Eurodollar deposits), provide a supplement to make the loan profitable, and disclose this information on a regular basis. The interest rate on the loan would have changed in this fashion every few months to reflect changes in the average financing cost of the banks. He named this interest rate LIBOR. The bank syndicate agreed, and the euroloan was successfully executed.

From that point forward, the amount of syndicated loans increased to hundreds of millions of dollars in value, and LIBOR began to be utilized as the reference rate for this class of loans.

Successively, in order to better codify the process of data collecting and governance, the British Bankers' Association (BBA) took over responsibility of the rate in 1986. In that year, LIBOR fixings were computed for the British pound, the Japanese yen, and the US dollar.

It was calculated by asking a panel of 16–18 banks, who collectively represent the strongest and most significant global banks, "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 11am?" The question used to be repeated for a total of 35 possible combinations of seven different maturities (overnight, one week, one, two, three, six, and twelve months) and five different currencies (USD, GBP, JPY, EUR, and CHF).

The submitted rates were collected and the LIBOR computation was carried out on behalf of BBA by Thomson Reuters, one of the top international suppliers of news and information-based solutions to professionals. To calculate a trimmed mean, the top quarter and bottom quarter bids for each currency/borrowing-period submission were eliminated. From 1986 to 2014, when the Intercontinental Exchange (ICE), an American business that owns and runs financial and commodity markets and exchanges, took over management of Libor from the BBA, Libor was published every day at 11:30 a.m. (U.K. time).

1.2 The 2007 LIBOR decline

Over the years, LIBOR has emerged as the rate of choice for financial markets to serve two main purposes: as a benchmark rate as well as a reference rate.

Financial instruments can make agreements based on a reference rate to determine the conditions of the deal. A benchmark rate provides a comparative performance metric, frequently for finance costs or investment returns.

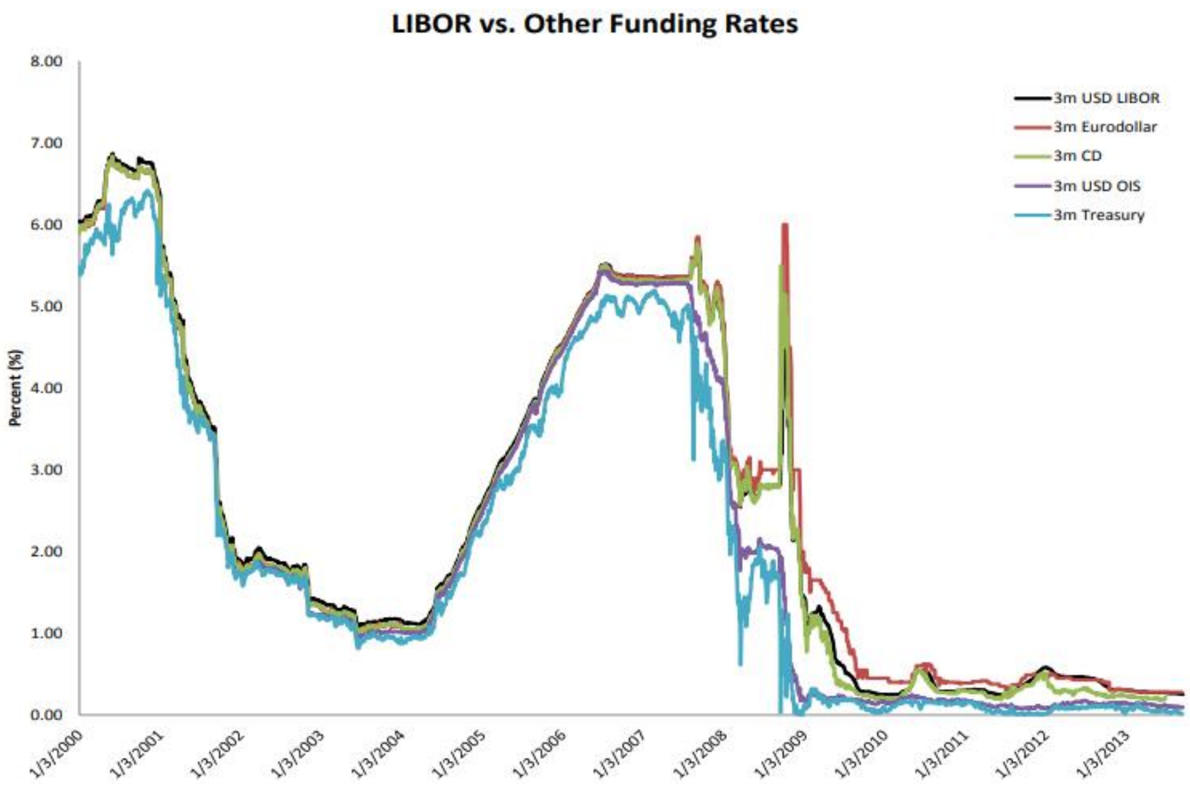
The justification behind LIBOR's widespread use in contracts comes from the way it was constructed: ceteris paribus, LIBOR acts as the lower bound for the borrowing rate of other less creditworthy institutions and individuals since it indicates the terms at which the largest and most financially stable institutions in the world are able to get money on a short-term basis. Rates are commonly stated as "LIBOR + x," where x is the premium added on top of the LIBOR rate for the corresponding maturity term for each specific borrower in basis points. Interest rate swaps, other derivative financial instruments, fixed income securities, as well as ARMs (Adjustable Rate Mortgages), are the financial instruments that are most frequently linked to LIBOR. In this way, by ensuring that the interest rates they charge are correlated to their cost of funds with a positive premium built in, banks offering variable rate loans may ensure a positive net interest margin.

Hence, the main reference rate for short-term floating rate financial transactions, such as swaps and futures, was LIBOR, at least until 2007, year in which the financial crisis started.

Before the middle of 2007, LIBOR had a tendency to fluctuate in lockstep with other short-term interest rates like Treasury yields and the Overnight Index Swap (OIS) rate. But once the financial crisis got underway in August 2007, LIBOR started to exhibit more volatility. The 3-month USD LIBOR reached 5.62% on August 31, 2007, compared to an average of 5.36% over the preceding six months. This increase was caused by a mix of counterparty credit and liquidity worries. The maturity-matched OIS rate reflects expectations for unsecured overnight bank borrowing rates, which in the US are equivalent to the effective average federal funds rate.

As a consequence, the LIBOR-OIS spread, which is a well-established indicator of the term risk, and of the health of the banking system in general, widened enormously during the peak of the crisis: It increased to more than 360 bps shortly after Lehman Brothers declared bankruptcy on September 15, 2008, and it stayed high well into 2009.

And also LIBOR rates declined below what might be predicted based on related rates.

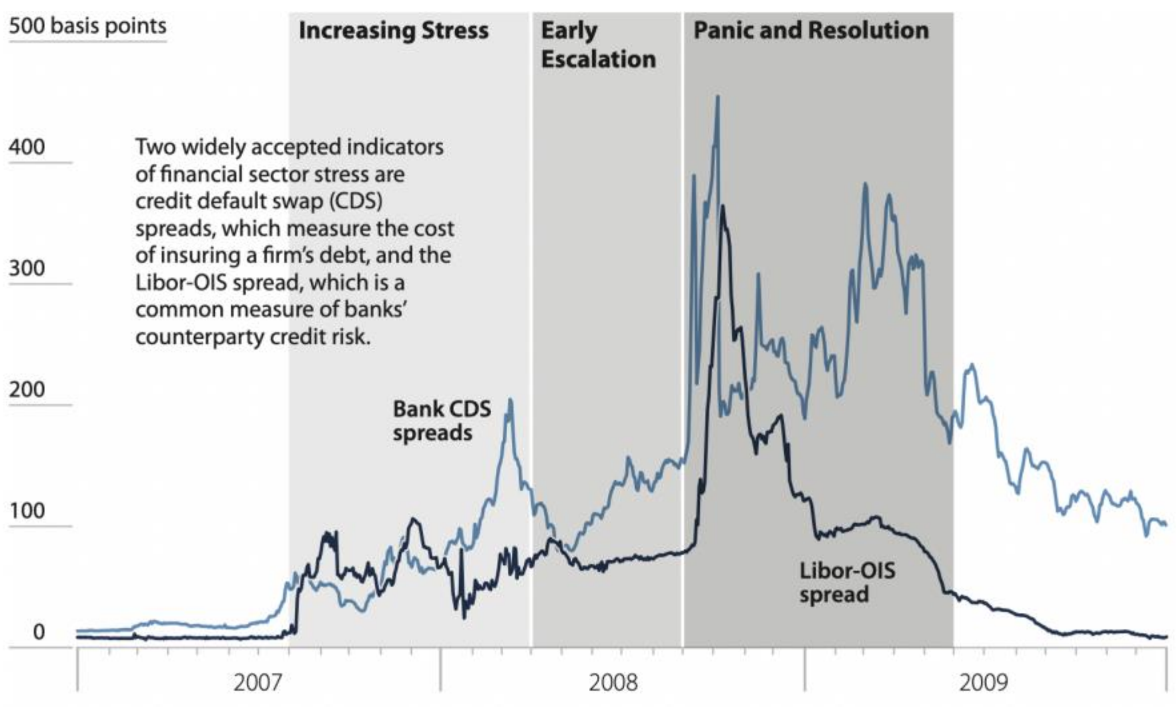


Rising spreads indicated that the crisis was worsening, as liquidity and credit concerns forced interbank lenders to reduce lending while demanding larger returns.
Through a positive feedback loop that increased the credit risk component of LIBOR and ultimately led to wider spreads, banks' inability to acquire funding in interbank markets fuelled perceptions of a loss in creditworthiness.

Furthermore, LIBOR's performance during the 2007–2008 financial crisis raised some early warning signs concerning potential **manipulation** and incorrect reporting behaviour in a scenario when rates were rising and the money supply was decreasing due to the panic and fear in financial markets. As a measure of the market's financial stability following the collapse of Lehman Brothers, LIBOR skyrocketed. The average rate at which banks used to borrow from one another was supposed to be represented by LIBOR, but in a credit crunch like the one that occurred in 2008, the number of transactions made by banks was insufficient for LIBOR to be regarded as a reliable indicator of the market it was supposed to represent.
Nevertheless, LIBOR continued to be published every day. Bankers were aware that submitting a rate that was greater than that of their competitors would have given the impression that they were weak and short on cash. As a result, bankers started reporting borrowing rates based only on educated guesses. They began to speculate as to what their competitors' submissions could have been, and they set the value of their report at or just below that estimate. Then came a waterfall-like effect, where no one really knew what the true LIBOR value should have been and dishonest behaviour was encouraged by the need to seem stable financially in order to access liquidity.
As a result, one of the most important reference rates in the financial markets and also one of the primary measures of banks' financial health was corrupted.

Many journalists, academics, and bankers began to question whether the benchmark rate was high enough and reliable during this time of economic unrest. For instance, on May 29, 2008, The Wall Street Journal published an item titled "Study Casts Doubt on Key Rate." The article contained research to demonstrate how LIBOR submissions from the 16 panel banks were at that time lower than comparable indices of market health, faking a better condition than what actually existed in order to make LIBOR reflect that situation.

The credit default swap market is one of those comparable measurements. Investors can buy (sell) insurance against company default on this market by paying (asking) a risk premium. The study brought attention to the fact that, up until January 2008, LIBOR and the cost of protecting against panel banks' default (credit default swap spreads) moved in the same direction; they both increased during periods when the market was concerned about the soundness of banks. However, LIBOR began to diverge from the credit default swap spreads curve in late January.



The results of the investigation sought to demonstrate that the LIBOR methodology was no longer very dependable and that panel banks may have reported rates that were lower than they actually were in order to seem higher.

However, statistical evidence has not been attained despite several attempts by academics, economists, and journalists to demonstrate manipulation through empirical methods. Studies that explain how changes in LIBOR's spread with other short-term rates were motivated by liquidity issues rather than credit concerns contradict empirical findings. Additionally, bankers refuted the first claims of low-balling, saying that the rates they had given accurately reflected their actual cost of borrowing.

When Barclays was under investigation, it tried to defend itself against accusations of low-balling rates at the height of the subprime crisis by pointing out that its filed rates were typically in the top 25% of rates, making them ineligible to take part in the process of averaging to calculate LIBOR.

It's important to note that submitted rates merely needed to deviate from the actual cost of borrowing in order to manipulate LIBOR; they weren't need to be lower than those of their competitors.

Despite finding no empirical evidence of LIBOR manipulation, most of the panel banks were fined for the behaviour of their brokers: Barclays paid a $435 million fine to US and UK authorities in 2012 as part of a settlement, and another $100 million to 44 US states as part of a settlement in 2016. UBS Bank was hit with the largest LIBOR-related sanction, forcing the Swiss behemoth to pay $1.5 billion in fines to international regulators. Then, RBS was fined $612 million by US and UK authorities for engaging in illegal activity and manipulating rates. EU regulators fined Deutsche Bank, RBS, and Société Générale a combined sum of $2 billion for fraud and collusion in December 2012. Citigroup and J.P Morgan became the first U.S institution fined. Deutsche Bank, however, reached the largest settlement in the LIBOR case in 2015, paying $2.5 billion to EU and US regulators, reaching a total payment of $3.5 billion.

Therefore, it is clear how one of the most important rates in the financial markets was influenced by the actions of Brokers and Traders, who actively pursued the rate and made promises of money and favours to one another in order to collude. The establishment of a reference rate using the LIBOR system, which was formerly pinned to 100 trillion dollars in loans, derivatives, and mortgages, was no longer sustainable. After learning about the fraud, there was a clear need for change, and a

period of transition was started with the goal of replacing not only LIBOR but also other Interbank Offered Rates (IBOR) that weren't based on actual transactions.
Because of this, LIBOR’s publication for all currencies beside Dollar ended in 2021 for all tenors, while ICE Benchmark Administration Limited announced that it will no longer publish U.S dollar Libor for all tenors after June 30, 2023.

1.3 Implications and hurdles of LIBOR discontinuation

Due to LIBOR's widespread usage in the financial markets, it was expected that the phase-out would present numerous operational difficulties, particularly for banks and other financial institutions. Although the phase-out roadmap gave financial institutions around the world a bit of room to use limited USD LIBOR settings for the 18 months between the transition deadlines, it was crucial that they create early, precise strategies to deal with these challenges.

The initial step in this approach required identifying all exposures and transactions that were either directly or indirectly based on LIBOR, by currencies, products, locations, counterparties, and duration.

The urgent task was to analyse the current fallback terms and rewrite the financial contracts for the legacy deals that would continue to be in effect after the transition dates. This required choosing an appropriate **Alternative Reference Rate** to replace LIBOR and providing the proper fallback language. The client's comfort level, the features of the product, and the accessibility of the relevant benchmark would all be factors in the ARR choice. For instance, corporate borrowers who were comfortable with the term LIBOR set in advance for greater certainty of interest costs would prefer adopting a similar forward-looking term ARR as opposed to the in-arrears overnight ARR.
Given the variations between LIBOR and the chosen ARR, the investment made by clients and counterparties would also be subject to spread adjustments. Without a fair

spread, the switch from LIBOR could bias the value of the contract in favour of one party over the other, posing hazards to conduct, reputation, and the law as well as accounting issues. Industry working groups suggested using a standardized, static Credit Adjustment Spread (CAS), estimated as a median value of the difference between the LIBOR and corresponding ARR for different tenors, based on a historical look back period over 5 years' daily data points, in order to minimize value transfer as much as possible.

The second step involves the revision of the valuation analytics for various ARR-linked instrument types, necessary for the essential component of the LIBOR changeover plan. Thus, yield curves for various ARRs have to be established in order to support both discounting and cash flow prediction. On the occurrence of fall-back triggers, these would serve as the inputs for reevaluating outstanding positions. The affected organization would need to carefully analyse the accounting and tax ramifications of the revalued portfolios. In this regard, with effect starting on March 12, 2020, the Financial Accounting Standards Board (FASB) of the United States issued guidance to provide temporary (until end-December 2022) respite and exceptions to the treatment of contract modifications and hedge accounting differences resulting from the switch from LIBOR to an ARR.

The next step involved upgrading current internal models, procedures, and systems for managing risk and asset liabilities to account for changing deals and new ARR-related activities. In order to do this, new data streams of ARRs would need to be incorporated, implied term structures for overnight rates would need to be computed, suitable hedging instruments would need to be identified in order to reduce basis risk, and the basis risk of new benchmark rates would need to be taken into consideration.

The last but not least step is that financial institutions should stop issuing new LIBOR contracts after 2021. As a result, they will be required to create new financial products that have been developed in accordance with ARR criteria, market protocols, and regulatory expectations, and they would also have to begin educating current and potential clients about the same.

Chapter 2

Transitioning to Stability: The Adoption of Risk-Free Rates Post-LIBOR

2.1 The new risk-free rates

When news of the LIBOR scandals broke in 2012, a period of transition started with the goal of changing the benchmark rate.

To ensure the accuracy of the provided rates, the Intercontinental Exchange (ICE) took over LIBOR administration from the British Bankers Association in 2014.

However, in the same year, the Financial Stability Board, an international organization founded in 2009 with the goal of monitoring global financial stability, promoted the creation of alternatives that might have replaced LIBOR.

The goal was to develop new benchmarks for different currencies that would keep the LIBOR's positive characteristics while basing themselves on transactions in liquid markets.

These ARRs were expected to accomplish the following:

1) offer a strong and trustworthy representation of risk-free interest rates in the core money markets that were impermeable to manipulation;
2) provide trustworthy 5 reference rates for financial contracts outside of the money markets;
3) act as benchmarks for term lending and funding.

Starting in 2017, central banks published options for suitable LIBOR substitutes based on recommendations from working groups on alternative reference rates. The various options put out by financial organizations are known as Risk Free Rates (RFRs).

Actually, financial market regulators from numerous countries had already developed and started publishing Alternative Reference Rates long before the FCA formally announced the end of LIBOR:

ARR	***SOFR (Secured Overnight Financing Rate)***	***SONIA (Sterling Overnight Index Average)***	***ESTR (Euro Short Term Rate)***
Region	United States	United Kingdom	Europe
Authority	Federal Reserve Bank of NY	Bank of England	European Central Bank
Working Group	Alternative Reference Rates Committee (ARRC)	Working Group on Sterling Risk Free Rates	Working Group on Euro Risk Free Rates
Publication Date	April 2018	March 1997	October 2019

The three most popular RFRs currently being proposed and employed are the Secured Overnight Financing Rate (**SOFR**) for USD-LIBOR, the Sterling Overnight Index Average (**SONIA**) for GBP-LIBOR, and the European Short-Term Rate (**€STR**) for EUR-EURIBOR (European Interbank Offered Rate).

The Secured Overnight Financing Rate (SOFR) is a measure for the cost of overnight borrowing money from the US Treasury through repurchase agreements (Repo). In a repurchase agreement, a party sells securities to another party with the promise to buy them back at a higher price later. This is a type of collateralized short-term borrowing.

In this method, securities serve as collateral, and the implied rate from the repurchase agreement is the repo rate.

SOFR is calculated based on actual transactions in the U.S. repurchase agreement (repo) market. The calculation process is designed to be transparent and based on observable market data, and goes through five main steps.

1) **Data collection:** various market participants who participate in the repo market provide transaction data to the New York Federal Reserve (NYFR). The transactions that are taken into consideration are substantially three:

   Tri-party Treasury repo (if they are transactions cleared and settled by a third party agent), Treasury repo transactions occurring within the Depository Trust and Clearing Corporation's (DTCC) through the General Collateral Finance (GCF) service, and Bilateral Treasury repo transactions cleared through the FICC's Delivery-versus Payment (DVP) service.
2) **Transaction Volumes:** the NYFR compiles information on the number of overnight transactions involving U.S. Treasury securities as collateral that take place in the repo market. The value of the securities that were lent and borrowed as well as the associated interest rates are also included in this data.
3) **Transaction Weighting:** SOFR is a median rate that is volume-weighted. This implies that the interest rate is calculated by computing the median of the interest rates from the transactions that were gathered, with the rate for each transaction weighted according to the volume of the transaction.
4) **Averaging:** SOFR is determined as the daily average of the reported transactions. For accuracy, this average is typically stated with eight decimal places.
5) **Publication:** The NYFR publishes SOFR every working day at 8 a.m. ET. It normally reports the rate with an overnight tenor, representing the cost of borrowing money overnight with U.S. Treasury securities as collateral. The NYFR may also release SOFR rates for additional tenors, such as 1-month and 3-month SOFR, in addition to the overnight rate.

It is crucial to highlight that SOFR is founded on a deep and liquid market, which implies that it is supported by genuine market transactions. Because of this, SOFR is a trustworthy benchmark interest rate that is less prone to manipulation or distortion.

The Sterling Overnight Index Average (SONIA) is the alternative risk-free rate to the GBP-LIBOR rate that the Bank of England recommended. The SONIA rate is a reflection of the cost of sterling's wholesale overnight borrowing. It is calculated as the trimmed mean, rounded to four decimal places, of interest rates paid on unsecured deposit transactions in sterling with a value greater than or equal to £25 million and a term of one business day. Similar to SOFR, SONIA is a rate that is transparent and trustworthy because it is based on transactions that banks record and the Bank of England examines.

Since its introduction in the late 1990s, SONIA has offered a trustworthy indicator of overnight interest rates in the UK for more than 20 years. The methodology of SONIA, which is based on actual overnight transactions, distinguishes it from other benchmark rates. It provides an accurate and transparent indicator of short-term interest rates in the UK by reflecting the real cost of borrowing money overnight in the sterling money markets.

Because of this, SONIA is a very reliable and accurate benchmark.

The Euro Short Term Rate (€STR) is the rate that, on 3 January 2022, replaced the Euro Overnight Index Average (EONIA) and EUR-LIBOR but not EURIBOR. The average overnight reference rate, or EONIA, was used by European banks to lend money to one another in euros. The sole distinction between it and EURIBOR's methodology was the latter's longer maturities. Regulators replaced EONIA since the LIBOR scandals also had an impact on other interbank offered rates. €STR is a rate that represents the costs of wholesale overnight euro unsecured borrowing for banks in the euro zone. It is based on borrowing transactions in euros, occurred with financial counterparties, that banks report to the ECB in compliance with the Money Market Statistical Regulation (MMSR).

€STR is derived using overnight unsecured fixed rate deposit transactions above €1 million as a trimmed mean (ECB, 2021). The EUR RFR Working Group asked market players to use ESTR as the primary reference rate in derivatives contracts in September 2022. The goal is to make the €STR landscape stronger and more liquid while keeping in mind that its growth is essential for the establishment of a strong forward-looking term €STR that, when compounded, can be utilized as a fallback rate for EURIBOR.

2.2 Key challenges in the transition from LIBOR to RFR

The LIBOR cessation provoked a substantial transformation in the financial market.

In particular, the contracts that were referenced on LIBOR, and that have been adjusted into RFRs contracts, needed to be amended taking into account the structural differences between the new risk-free rates and the old IBORs.

These divergencies are mainly two, and they provide significant transitional issues.

First of all, the quotes have a different tenor. Overnight rates, which are established daily and act as an indicator of changes in short-term interest rates, are used as a benchmark for the proposed RFRs. LIBOR, on the other hand, is quoted for tenors up to one year and consists of overnight rates and forward-looking term rates. A price at the start of a period must be determined using a forward-looking term rate, which is based on future expectations. The proposed RFRs should be modified in order to render them comparable with LIBOR when the shift from term rates to overnight rates happens.

Secondly, the risk premium included into the rate differs. The fact that the RFRs are formed from market transactions and referenced by Overnight Index Swaps (OIS) makes them (almost) risk-free. The suggested alternatives in the United States (SOFR) and the United Kingdom (SONIA) are based on secured and unsecured transactions, respectively, and result in almost risk-free rates where a risk premium is eliminated.

Because LIBOR are offered on the interbank market, credit risk, one of the elements of the total risk premium, is present.

In order to set common line guides for the transition and the conversion of the IBORs into RFRs, the International Swaps and Derivative Association (ISDA) published the 'ISDA 2020 IBOR Fallbacks Protocol' on October 23, 2020, and it became effective on January 25, 2021. The document includes techniques based on waterfall-like fallback rates (RFRs) to modify LIBOR-based derivatives that did not mature prior to LIBOR's dismission and that will be modified once again in the event that the initial fallback rate's publication would be permanently discontinued. If parties to the contracts agree to the protocol or if the contract already incorporates the "2006 ISDA Definitions protocol," the benchmark rate would "fallback" to a new one if it were no longer available due to a "permanent cessation," as ISDA declared.

Even though the creation methods of RFRs vary widely and significantly, ISDA fallback rates are built using a standardized procedure: they are made of an **adjusted reference rate**, and of a **spread adjustment**.

The adjusted reference rate is required to account for the fact that IBORs are forward-looking while RFR are overnight rates, while the spread adjustment is required to take into account the credit component of LIBOR that is not embedded in RFRs and is represented by the five-year historical median between LIBOR and the RFR used to amend the contract.

2.2.1 The tenor difference and the adjusted reference rate

The transformation of the RFR from a *spot rate* (also known as the current market rate) to a *term rate* (also known as the forward fixed rate) is necessary to enable comparison with the associated LIBOR and to ensure that the rate characteristics are aligned, given that RFRs are referenced by daily overnight rates while IBORs in general are term rates. In order to overcome technical difficulties when converting RFRs to term rates, ISDA recommended two approaches, evaluated according to their degrees of understandability, data availability and similarity with OIS.

Spot Overnight Rate

In the spot overnight rate strategy, the Risk Free Rate that sets on a date a few business days before the official start of the equivalent LIBOR tenor will be the fallback rate. Mathematically, the relation between the spot overnight rate and the risk-free rate is expressed by the formula

$$SOR_f(t) = RFR_t$$

In which f is the LIBOR term, t is the LIBOR's setting date, assumed to be two business days before the start date, and RFR_t is the overnight rate set on date t, used as adjusted RFR from the period T (start date of the LIBOR accrual period), to the period $T + f$ (which indicates the payment date), where $T = t + 2bd$.

Since the necessary data is easily accessible, this strategy is straightforward to understand and put into practice. Another benefit is that borrowing for one day before the LIBOR tenor begins reflects risk-free market circumstances.

However, since it does not resemble the structure of OIS, this strategy is not usually chosen as the preferable approach. Moreover, the ignorance of the intrinsic difference in RFRs across different tenors is another drawback. It's also possible that, when taken into account as a term rate, this rate is more volatile than it is supposed to be.

Compounded Setting in Arrears Rate

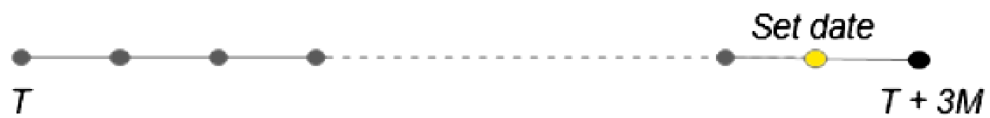
The feedback paper on the ISDA Consultation revealed that this is the strategy that market participants prefer.

In particular, four potential benefits were outlined in the ISDA Consultation: it "reflects actual daily interest rate movements during the relevant period"; it "is calculated as a 'average' rate and should therefore be less volatile than the spot overnight rate"; it "should be understandable by most market participants"; it also "mirrors the structure of overnight index swaps referencing the RFRs".

The compounded setting in arrears methodology uses a backward-looking way to convert RFRs to a term rate, whereas IBORs use a forward-looking approach. The first is founded on observations, whereas the second is founded on expectations. The RFR that is originated from the process explained here below is known as the **adjusted RFR**.

We take into consideration the term period that starts at time T, and ends on the payment date $T + t$ (e.g. $t = 3\ months$). The rate will be set a few business days before the payment date, in order to facilitate the payment calculation and the settlement, so we suppose the set date to be $T + t - \#bd$ (namely, the set date in our example will be $T + t - 2bd$). From T until the set date, each day's values of the overnight rate are compounded daily, and the space between each dot represents the overnight accrual period. Now we can comprehend one of the disadvantages of this method, highlighted in the ISDA Consultation: the information required to calculate this rate is available at the set date, not at the beginning of the term period.

However, it should be pointed out that this computation reflects real daily interest rate movements over the period, so it is a reliable indicator, given also the fact that it is generated from daily compounded overnight rates, thus is less volatile than the spot overnight rate itself.



From a computational point of view, the above situation can be translated in the following formula, in which the compounded setting in arrears rate (namely, the **adjusted reference rate**) at the set date is calculated.

$$ARR_t(T) = \frac{1}{\delta_t}\left(\prod_{u=T}^{T+t-2bd}(1+\delta_u RFR_u) - 1\right)$$

Where:

δ_t is the day count fraction for the accrual period (in our case, 3 months), calculated as the fraction of the number of calendar days from the start date T over the number of reference business days (i.e. 365 in our convention);

δ_u is the day count fraction for the overnight accrual period from u to $u + 2bd$ (i.e. $\frac{2}{365}$ in our assumption) , since we assumed that from the start period T to the set date $T + t - 2bd$ the overnight rates are compounded daily;

RFR_u is the observed overnight rate in the accrual period going from u to $u + 2bd$.

It is also meaningful to mention the other two relevant approaches to convert RFRs into term rates, namely the **Convexity-adjusted Overnight Rate** and the **Compounded Setting in Advance Rate.** However, those two methods have some issues that do not make them desirable to choose in the conversion process.

In fact, the first is a more complex and less understandable approach with respect to the Spot Overnight Rate, given the fact that it also presents the same disadvantages.

The second, in contrast with the Compounded Setting in Arrears Rate, fails to reflect changes in interest rates during the period in question.

2.2.2 Discrepancy in risk premiums and the spread adjustment

As already discussed, LIBOR contains a risk component that cannot be negligible, while the new RFRs are, by construction, basically risk free. Since this component is not present in the new rates, it is necessary to add a **spread** to the RFRs in the conversion process.

Again, the ISDA set various approaches for the spread estimate, reflecting each one's capability of mitigating the following risks:

- *Risk of manipulation*
  Refers to the possibility that individuals or organizations could consciously influence or change benchmark interest rates for their personal gain, frequently at the expense of fairness and market integrity. Manipulation can be, for example, submission-based, if the rates are calculated based on submissions from a panel of banks (e.g. LIBOR), transaction-based, if RFRs are determined by observable transactions (e.g. SOFR) or collusive, if market participants collude to coordinate their actions in order to influence RFRs.
- *Risk of market impairment*
  Refers to the possibility that a financial market may experience disruptions, inefficiencies, or a breakdown in regular operations caused by a variety of reasons, among which are liquidity shortages, operational failures and systemic risks.
- *Risk of value transfer*
  Refers to the possibility that values could be changed or modified in a way that would compromise the precision or integrity of spread computations. This may be caused by illiquid markets (low trading volumes make easier for a big trade to impact disproportionately on the spread), increase in market volatility and data quality, whose misrepresentation may lead to incorrect spread estimations.

It is important to clarify that all the proposed approaches to calculate the spread are static (i.e. the value of the spread does not change over time), assuming that the credit risk and the overall market conditions remain constant.

Moreover, in determining which approach is the better, is crucial to remember that IBORs have historically been manipulated, which is the primary justification for moving away from them, so the most effective approach for calculating the spread has to be substantially unmanipulable.

Forward approach

The static spread in the forward approach comes from the market's observed forward spread between the IBOR and adjusted RFR for the related tenor. Theoretically, a value transfer would be reduced because this method bases the spread calculation on market expectations. There is a chance, however, that the spread expectation might rise momentarily due to manipulation or other market disruption-causing factors.

The reliance on data accessibility and market liquidity, which may not be satisfactory at the time of change, is another drawback.

Historical mean approach

This approach estimates the fixed spread by using the mean spread level of the five or ten years before to the announcement date that the fallback will be activated on a specific date.

The key benefit of this strategy is that it limits the possibility of manipulation because it uses a relatively long time frame and doesn't rely on expectations. Therefore, it is the best approach to relying on.

A 5-year time frame also allows for the recording of current market conditions. However, a 10-year time frame should be employed to capture the economic cycle. The mean approach, along with the selected time horizon, determine the static spread level. This choice may result in a value transfer, and the resulting market interference cannot be avoided. Another drawback is the requirement for historical RFR data, which is not accessible for all recently proposed RFRs.

The process of calculating the spread through the historical mean approach requires a mathematical tool called **linear interpolation**, which is a procedure used to estimate values that fall within a range of known values.

In particular, it uses known data points in a straight-line relationship. The intermediate value is calculated as a weighted average of the data points nearest to it.

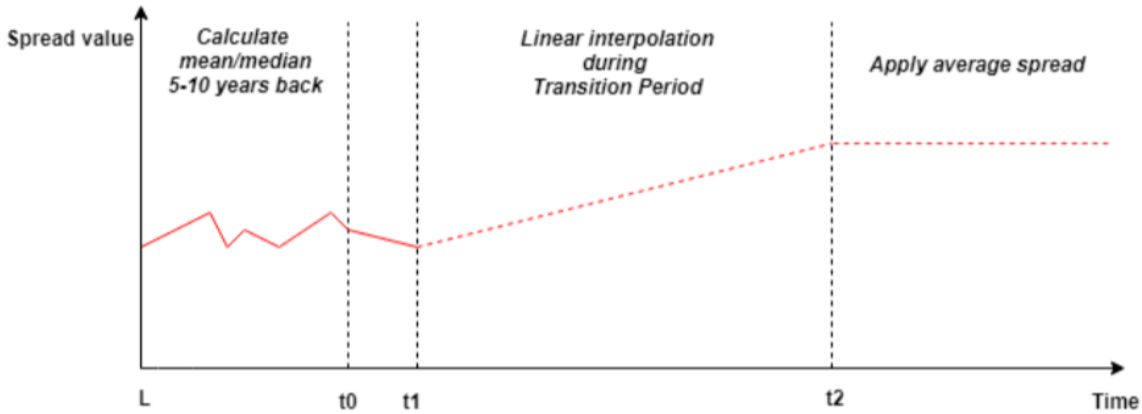
It is often used in mathematical finance in order to calculate the interest rate $R(m)$ for the maturity $T = m$, given the spot term structure of the investment (i.e. knowing the rates $R(l)$ and $R(n)$, with $l < m < n$), according to the following formula:

$$R(m) = \frac{R(n) - R(l)}{n - l}(m - l) + R(l)$$

With l, m, n expressed in the convention $\frac{days}{365}$ (e.g. if $m = 3months$, will be translated in $\frac{90}{365}$ for the computation of the formula above).

Similarly, for the calculation of the spread with the historical mean approach, we have the following situation, in which t_0 coincides with the date of the announcement of the activation of the fallback, t_1 is the date of the activation and the last date of the LIBOR publication taken into consideration for LIBOR-RFR spread calculation, and $t_2 - t_1$ is the transition period, where the interpolation method is used.

The spread will be calculated according to the mean LIBOR-RFR spread in the 5-10 years before t_0. After the transition period, the mean spread will be attached to the adjusted RFR.



The primary advantage of this method is that it reflects actual market conditions, given the fact that the transition period begins with the current spot spread between IBOR and the adjusted RFR, and through the linear interpolation, it extends the spread value to a long-term average over time. This approach gets beyond the issue of market distortion and potential manipulation by using a long-term average, and is also based on information that is easily accessible, making the technique robust and straightforward.

2.3 Transition impact: the value transfer

Once the RFR has been adjusted, overcoming the issues of tenor differences and discrepancy in risk premiums, another difficulty may emerge in the transition process, namely the **value transfer**. It occurs when financial contracts using IBOR as the underlying rate are repriced with an RFR plus fixed spread that differs from the ideal IBOR, causing an unjustified gain in favour of one party of the financial transaction (e.g. if the interest paid by the borrower is higher than it should be, value transfer occurs in favour of the lender, and vice versa).

This value transfer may take place on the day of the final cessation of the IBOR as well as earlier. The permanent discontinuation date of IBOR is mentioned in relation to value transfer in the ISDA consultation, assuming that value transfer is already taking place as a result of transition methodology announcements.

In this case, the impact that can be observed at the time of discontinuation will be minimized, thanks once again to the historical mean method that we previously analysed. In fact, if the current spread moves in the direction of the historical spread, the observed spread at the cessation date will match the announced spread, in the event that the precise methodology is known.

Being that the market spread goes in the direction of the historical spread suggests that value transfer is already taking place as a result of announcements of fallback methodologies.

2.3.1 Pricing an IRS

In order to better understand the situation depicted in the paragraph above, we evaluate the transition's effect on linear derivative, the Interest Rate Swap, in terms of price. Financial instruments with a value that is linearly correlated to the value of the underlying rate are known as linear derivatives.

The IRS is typically an exchange between two parties, in which one commits himself to pay according to a fixed interest rate regime, with the promise of receiving a compensation from the other party, which depends on floating rate based on IBORs.

Given the fact that the IRS market is heavily reliant on IBORs, it is an appropriate derivative category to evaluate for value transfer.

There are two methods for determining the value of an IRS contract:

- Considering the swap as the difference between two bonds
- Considering the swap as a portfolio of Forward Rate Agreements (FRAs)

swap as the difference between two bonds

The first approach assumes that the IRS principal payments are made and received at maturity without affecting the swap's value. The value of the IRS at time t, with strike price P, is then given by the following relation, considering the payer's point of view (short position on a fixed rate bond, long position on a floating rate bond)

$$V = B_{float}(t) - B_{fixed}(t, P)$$

In order to value the floating component, it is important to recall that after each interest rate payment, the value of the bond is the notional N.

The borrower pays the floating leg (LIBOR) for each following accrual period in this interest exchange, which can be viewed as a fair agreement.

If the subsequent payment k is made at t', just before the payment we have that

$$B_{float} = N + k$$

Which today is equal, by discounting, to

$$B_{float}(today) = \frac{N + k}{(1 + r \cdot t')}$$

Where r is the LIBOR rate for maturity t'.

swap as a portfolio of Forward Rate Agreements

in the second approach, we recognize the swap to be interpreted as a portfolio of FRAs. They ensure that a specific interest rate will be applied to the borrowing or lending party's principal amount over a predetermined time period in the future.

Assuming that lending and borrowing will be performed at Libor rates, utilizing forward Libor interest rates, we denote the dates on which is determined the floating rate by $T_0, \dots, T_{n-1}$, and by $T_1, \dots, T_n$ the payment dates of the FRA, in which payments are exchanged.

The forward LIBOR rate is then

$$R(t; T_i, T_{i-1}) = \frac{1}{T_i - T_{i-1}} \left(\frac{v(t, T_i) - v(t, T_{i-1})}{v(t, T_{i-1})} \right)$$

With $i = 1, \dots, n$ and T_i, T_{i-1} are two consecutive dates.

Now, we calculate the general discounted payoff for an IRS, that is given by the following relation

$$PAYOFF_{IRS} = \sum_{i=1}^{n} P(t, T_i) N_{T_i - T_{i-1}} (L(T_i, T_{i-1}) - R_F)$$

Where R_F is the fixed rate and N is the notional.

Now, substituting into the forward LIBOR rate into $PAYOFF_{IRS}$ formula, we obtain the future value of the IRS at time t

$$\sum_{i=1}^{n} P(t, T_i) N_{T_i - T_{i-1}} (R(t; T_{i-1}, T_i) - R_F)$$

Summarizing, we used the forward LIBOR rate as the variable rate in the IRS structure, highlighting its strictly correlation with this liner derivative.

We draw the conclusion that in linear derivative contracts, the transition results in value transfer. Value transfer is already taking place, according to the analysis that shows the market spread moving in the direction of the historical spread. We presume that a rising or falling forward rate is what drives the change in spread. The value of an IRS in which the fixed rate is substituted for the changing forward rate depends on the level of the forward rate.

For example, if during the relevant period the spread between the RFR and the LIBOR decreases, due to a decrease of the LIBOR (the floating rate for the IRS), the payer of the IRS (who pays fixed and receives floating) will experience a decrease in its discounted payoff as the result of the decrease in the floating forward rate, causing its Net Present Value to decrease consequently.

The influence on the value of a payer swap and the direction of spread movement, which is comparable to forward rate movement, are positively associated.

Chapter 3

IRS-OIS Spread: an Indicator of the Interbank Risk

In the previous chapter we introduced the Interest Rate Swap as the chosen financial derivative to highlight the possible issue of the value transfer in the transition to Risk-Free rates. This choice, however, was not casual: in fact this instrument, one of the more widespread across the financial landscape, permits the exchange of interest rate cash flows between two parties for an established period of time, with one side paying a fixed rate and the other a floating rate, frequently based on an index like LIBOR.

In addition to this, IRS forms, along with another type of swaps, called **Overnight Index Swaps (OIS)**, a very important indicator of the future health of the interbank system: their spread incorporates the risk of suffering a loss as a result of lending in the interbank money market.

Now we will break down the components of the IRS-OIS spread, starting indeed with the OIS, in order to understand how they can depict such a reliable image of the conditions in the interbank market.

3.1 The Overnight Index Swaps and the OIS curve

The OIS is a type of forward derivative contract, in which two parties accept to exchange cash flows over a predetermined time based on the difference between a fixed interest rate and an overnight interest rate index.

Although the structure is very similar to the Interest Rate Swap, the key difference between the IRS and the OIS relies on the rates used to calculate the floating leg: while for the IRS the benchmark rate is usually the 3-month LIBOR, for the OIS the floating rate is determined by the prevailing **overnight** rate, chosen between the FFER (Federal Funds Effective Rate), SONIA, EONIA or TONAR (Tokio Overnight Average Rate), depending on the currency and the country involved.

It is important to point out that the underlying reference rate is calculated overnight, not the OIS term, which can be deducted for various maturities, generally lower than one year.

Its overnight nature is what distinguishes the OIS from the other interest rate derivatives, making it way more attractive for covering the benchmark role: given the fact that the rates are basically continuously compounded, they reflect the actual market conditions. Because of their trustworthiness, institutions and big corporations choose OIS contracts to prevent short-term interest rate volatility.

The OIS framework can be described as follows:

Considering the tenor structure $t = T_0 < T_1 < \cdots < T_n = T$ and let $\delta = T_i - T_{i-1}$ for $i = 1, \dots, n$.

At every time T_i, one party pays δP, while the other pays $\delta L(T_{i-1}, T_i)$, where $L(T_{i-1}, T_i)$ is the **continuously compounded overnight rate** for the period $T_i - T_{i-1}$.

This rate can also be expressed by the continuously compounding formula

$$L(T_{i-1}, T_i) = \frac{1}{\delta}\left(e^{-R(T_i, T_{i-1})}\right)$$

The OIS rate, instead, is given by the value of P that makes the OIS value equal to zero at the inception date

$$OIS = \frac{1 - v(t, T_n)}{\sum_{i=1}^{n} \delta v(t, T_i)}$$

Regarding the **OIS curve**, the first step that we must carry out is the construction of the discount curve. This can be done directly through the quoted OIS rates, given the fact that for maturities of less than a year, the quoted OIS rates are simple interest rates, but for maturities of more than a year, they yield yearly interest payments.

We can use the par rates of OIS swaps with a one-year maturity as discount rates to construct the shorter section of the curve, given that these swaps do not pay intermediate interest.

For short-term maturities, we have the discount factor in the simple interest convention, and is given by

$$v_{OIS}(T_i) = \frac{1}{\left(1 + R_{T_i} \sum_{i=1}^{n} (T_i - T_{i-1})\right)}$$

For the longer parts of the OIS curve, we can take advantage of the **bootstrapping** tool, which is a method used to build a yield curve from market-observable rates of fixed-income securities. It involves using known prices of certain securities to infer the yields of other securities with different maturities. Hence, bootstrapping is a process that helps derive implied spot rates for different maturities.

In our case, we only need the spot term for the shorter maturities in order to calculate the long-term part of the OIS curve, thanks to the formula

$$Spot\ Rate\ Year_n = \left(\prod_{l=1}^{n} (1 + Spot\ Rate\ Year_i)\right)^{\frac{1}{n}} - 1$$

3.2 The Relation with the OIS-LIBOR spread

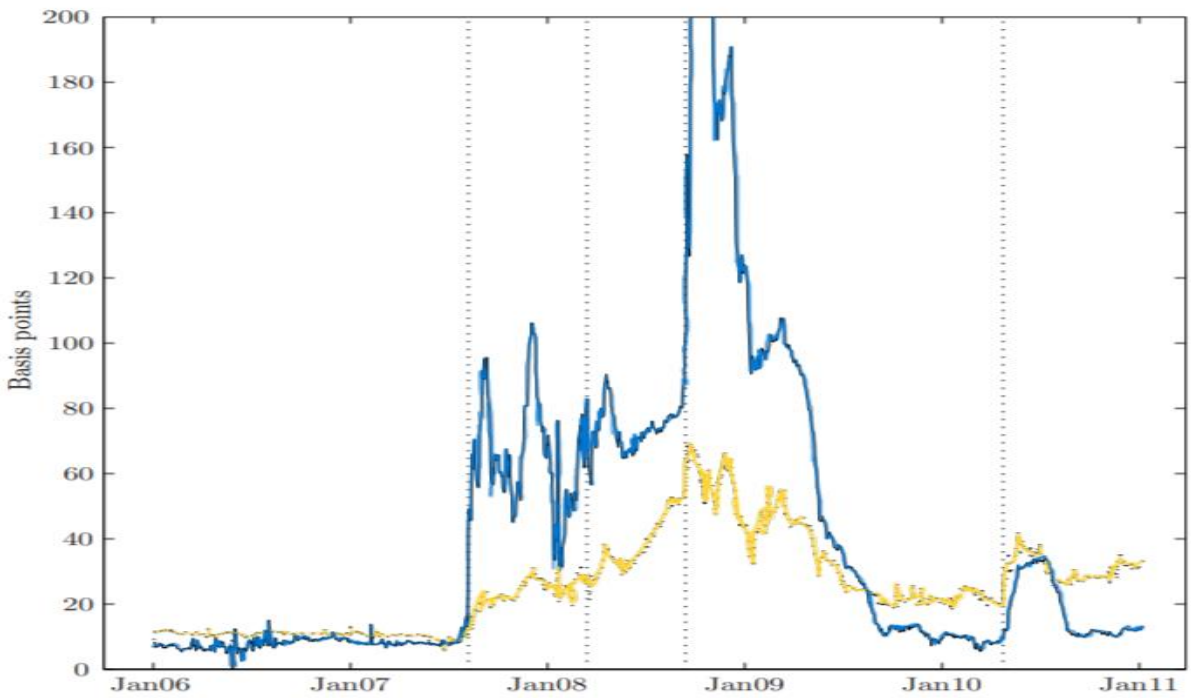
In this third chapter we are focusing on the term structure of the interbank risk. As previously pointed out, the IRS-OIS long-term spread is a key indicator of the interbank risk.

What has not been mentioned, however, is that it depicts the expectations of the future short-term **LIBOR-OIS** spread. In other words, is the fact that the IRS-OIS gives expectations about the future relation between fixed rates (e.g. LIBOR) and Risk-Free rates (e.g. OIS rates) that makes it one of the best indicators for credit risk.

It is precisely at the level of the spread between rates that the game concerning the health of the interbank market is played: if the interbank system is in a condition of panic and credit risk, the LIBOR-OIS spread would be wider, given the fact that lenders are more cautious when there are uncertainties regarding the stability or creditworthiness of banks. They might be reluctant to lend money to banks that are thought to be at a higher default risk. Because of the increased credit risk, banks could request a higher interest rate (LIBOR), which would cause the spread to rise.

That is the importance of the IRS-OIS spread: thanks to its expectations for future LIBOR and OIS rates, it makes possible to predict, to the extent possible, periods of market stress, credit risk and liquidity shortages in the economy.

In order to better understand the usefulness of those spreads for assessing the term structure of the interbank risk, we look at the spread situation before, during and after the 2007 crisis.



The blue line represents the spread between the 3-month LIBOR, used for unsecured interbank loans, and the fixed rate on a 3-month OIS, a common risk-free rate. This spread is also called “money market spread”, given its reflection of the actual conditions and the cost of borrowing in the money market in the short-term.

Instead, the yellow line depicts the spread between the fixed rate on a 5Y IRS, having the floating leg indexed to the 3-month LIBOR, and the fixed rate on a 5Y OIS.

It can be noted that the term structure of interbank risk was largely flat before the credit crisis hit, with swap spreads only slightly higher than money market spreads. After then, money market spreads rose significantly more than swap spreads at the start of the crisis in August 2007. As a result, the term structure of interbank risk had a sharp upward slope, showing that market participants anticipated the exceptionally high levels of interbank risk seen in the money market to be a relatively transient event. Finally, money market spreads were mostly back to pre-crisis levels from Fall 2009 to the conclusion of our sample period, except for a brief spike attributable to the expansion of the European sovereign debt crisis.

However, swap spreads continued to be much larger than money market spreads and well above pre-crisis levels. Interbank risk's term structure ended up being upward-sloping, which shows that market participants projected interbank risk to rise in the future, and demanded a high risk premium for assuming future transaction risks.

It is evident that the term structure given by the IRS-OIS spread provides crucial interbank risk information that money market spreads do not.

In fact, given that a long-term IRS-OIS spread reflects expectations about future short-term LIBOR-OIS spreads, the term structure of IRS-OIS spreads mirrors the term structures of LIBOR-OIS spreads' **non-defaultable** and **defaultable components**.

Non-defaultable components

A LIBOR-OIS spread can also occur due to variables other than default risk, most notably **liquidity**. There are a number of factors that can contribute to a decline in market liquidity for longer-term interbank funding. For example, banks may choose not to make long-term loans out of caution, if they are concerned about negative shocks to their own funding situation, or out of speculation, if they are concerned about potential asset fire sales by other financial institutions.

We propose a "**residual**" factor that represents the portion of the LIBOR-OIS spread that is not caused by default risk. The residual factor captures the portion of liquidity that is not affected by default risk, to the extent that liquidity effects are connected with default risk.

Defaultable components

Clearly, the default risk can cause the LIBOR-OIS spread to rise:

in the interbank money market, LIBOR serves as a benchmark for the typical rate at which major, creditworthy banks that have been chosen as members of the LIBOR panel can access unsecured lending for longer maturities.

An OIS is a swap with variable payments based on a reference rate for unsecured overnight funding that we estimate matching the average cost of unsecured overnight funding for LIBOR panel banks. The LIBOR panel's composition is revised over time to ensure that it only consists of creditworthy institutions; any bank whose credit quality significantly declines will be removed from the panel and replaced by a bank with better credit status.

Hence, while LIBOR takes into account the risk that the average credit quality of an initial group of creditworthy banks may deteriorate throughout the course of the loan, the OIS rate represents the average credit quality of a renewed pool of creditworthy banks. As a result, LIBOR is higher than the OIS rate.

In order to deduce the default component, is useful taking information from **the Credit Default Swap (CDS) market**. With the assumption that CDS spreads are accurate indicators of the underlying companies' default risk, the term structure of a typical panel bank's CDS spreads reveals the mechanism causing the risk of credit quality deterioration.

General structure of the LIBOR-OIS spread

We can describe the general structure of the LIBOR-OIS spread taking into account those two components that have been illustrated above.

For simplicity, we assume that the panel is represented by an average bank at a specific time. In particular, $\forall t_0 \geq 0$ a random time $\tau_{(t_0)>t_0}$ is used to model the default time of an average bank within the t_0-panel.

This default time permits a process $\lambda(t_0, t)$ for $t > t_0$with nonnegative intensity.

The time t_0-value of an unsecured loan with notional 1 made to a typical bank inside the time t_0-panel is equal, over period $[t_0, T]$, to

$$V(t_0, T) = E_{t_0}^{Q}\left[e^{-\left(r(t_0,t)+\lambda(t_0,t)\right)}\right]$$

Where $E_{t_0}^{Q}$is the conditional expectation under the risk-neutral measure Q.

As we previously analysed, in the real economy variables unrelated to default risk may have an impact on LIBOR.

For instance, banks may decide not to make long-term loans due to excessive caution or speculative motives. In either case, the number of longer-term interbank loans declines and their rates rise above what is reasonable given the risk of default.

We enable a non-default element in LIBOR by setting

$$L(t_0, T) = \frac{1}{T - t_0}\left(\frac{1}{V(t_0, T)} - 1\right)\phi(t_0, T)$$

In which $\phi(t_0, T)$ is the **residual** term that satisfies $\lim_{T \to t_0} \phi(t_0, T) = 1$

Finally, combining the formula above with the OIS formula illustrated in the previous section, we have the final LIBOR-OIS relation that incorporates all the defaultable and non-defaultable components

$$L(t_0,T) - OIS(t_0,T) =$$

$$\frac{1}{T-t_0}\left(\left[\frac{1}{V(t_0,T)} - \frac{1}{v(t_0,T)}\right] + \left[\left(\frac{1}{V(t_0,T)} - 1\right)(\phi(t_0,T) - 1)\right]\right)$$

Where the first square-bracketed term incorporates the defaultable components, while the second one incorporates the non-defaultable ones.

Conclusions

The transition from the LIBOR rate to risk-free reference rates represented a significant development in the global financial markets horizon. Due to the LIBOR rate's unreliability and lack of transparency during the 2007 financial crisis, this adjustment was required in order to prevent as much as possible volatility and uncertainty.

In this thesis, the transition has been analysed from the start, examining in depth the rise of the LIBOR as the global benchmark rate and the factors that contributed to its dismission in favour of the RFRs. Afterwards, the attention was given to the difficulties that arose during the transition process: the need for an adjusted reference rate, necessary for facing the hurdles presented by the tenor difference and the discrepancy in the risk premiums.

Facing the value transfer problem, a fundamental financial derivative was introduced, namely the Interest Rate Swap, which covered a role of primary importance in this thesis, given its reliance on the forward LIBOR rate.

Thanks to the IRS relation with LIBOR, I moved the focus from the transition of the rates to a wider horizon: the interbank risk.

In order to measure this risk, the Overnight Index Swap, another fundamental financial derivative contract, was introduced. In fact, the interbank risk resides right in the spread between IRS and OIS.

Another relevant fact has been pointed out it the third chapter: the IRS-OIS spread reflects the expectations of future short-term LIBOR-OIS spread, and includes both the defaultable and non-defaultable components of the latter. This relation was further analysed through the example of the 2007 crisis, focusing on the graph that illustrated the trend of both spreads.

Moreover, this spread incorporates precisely the comparison between the LIBOR, used for the IRS, and the new overnight risk-free rates, used for the OIS, that is object of the first chapter, and also is the central point of the whole thesis.

In conclusion, the transition from LIBOR to OIS rates marks a crucial turning point in the development of financial markets. While it presents difficulties, it also creates opportunities for a more robust and open financial system. Even though market participants continue to struggle with the complexities of this transformation, they do so with an eye toward a longer-term, more efficient, and stable financial environment.

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