TLREF Products User Guide Interim Report

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IBOR Transformation

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2 Introduction

As a consequence of the many manipulation scandals that occurred regarding LIBOR, which was published by the British Bankers Association (BBA) and later the Intercontinental Exchange (ICE) from the 1970s to 2014, at the G20 summit held in 2013 the FSB (Financial Stability Board) was tasked to reform the LIBOR market and, if necessary, establish alternative reference interest rates ("RfR"). For this purpose, an Official Sector Steering Group (OSSG) comprising national authorities and various working committees in member states were established and in the same year, benchmarks with a more general purpose but similar to the LIBOR criteria were published and they gained international recognition. As a result of the studies, the tendency started to stand out to abandon LIBOR in due time with a suitable process and identify alternative reference interest rates. For this purpose, a National Working Committee was established in Turkey on January 22, 2020 comprising the Ministry of Treasury and Finance, the CBRT, BIST, the BRSA, the CMB, the Settlement and Custody Bank and banks.

LIBOR was the most commonly used global reference interest in short-term interest markets for half a century. ICE LIBOR is published mostly in five different currencies (USD, EUR, GBP, JPY, CHF) and in seven different maturities (overnight, one week, 1 month, 2 months, 3 months, 6 months and 12 months). Local rates such as TRLIBOR are also used but mostly have low volumes. Although the total contractual value of LIBOR-based financial and commercial contracts is not precisely known, they are estimated to be more than 500 trillion USD. USD LIBOR-based financial contracts have the greatest share here with a value of 200 trillion USD.

Examples of RfR considered for replacing LIBOR include TLREF in Turkey, SOFR in the US, €STR in the Euro zone, SONIA in the United Kingdom, TONAR in Japan and SARON in Switzerland. TLREF and SOFR resemble each other both in terms of calculation methods and collateral structure. Briefly comparing IBOR and TLREF (or SOFR) in general, the main differences are as follows:

- IBOR is a forward-looking rate known from the start, whereas TLREF is an overnight rate.
- TLREF is a risk-free rate whereas IBOR is a rate containing credit and maturity premiums.
- TLREF transactions are fully secured whereas IBOR is unsecured.
- IBOR is a criterion based on a few number of real transactions and sometimes also reflects "expert opinion" whereas TLREF is a benchmark fully based on free market transactions.

As seen, TLREF and SOFR generated from fully secured real transactions solve two major problems that were criticized in LIBOR and led to the decision to abandon it. Both are risk-free rates and are prices based on the free market. Following this assessment, two issues require practical solutions for a smooth transition process:

1. It is necessary to find how existing IBOR-referenced financial and commercial contracts can be revised without causing legal problems.
2. LIBOR is a forward-looking interest rate with various maturities. TLREF is only a daily rate. Therefore, calculating and publishing "estimated mean" TLREF rates for maturities longer than one day will be helpful in some products both for return calculations and pricing. Real returns will be calculated mostly based on actual rates. This calculation may vary for different products and maturities but the calculation methodology will be retrospective in the overall framework.

The first section of the report discusses the development of the TLREF market and the compliance of the TLREF management model to the IOSCO criteria. The subsequent sections will assess the return calculation methods for TLREF, which is the main purpose of this report. In this context, the answers will be sought for three questions:

- Differences between the mathematical and financial meaning of the calculation methods
- How TLREF-based term rates can be generated
    - Forward-looking
    - Backward-looking
- Studying potential methods on a product or user basis

3 Background

3.1 The TLREF Market

The overnight repo rate TLREF published by Borsa Istanbul since June 2019 is a reference interest rate that is the starting point for Turkey of the global transition process from IBOR. It is calculated until 14:00 every day as the volume-weighted average of overnight rates given by banks and other non-bank financial institutions. Its calculation and publication methods are similar to the methods in other countries.

The TLREF market functions healthily in terms of transaction volume and number of participants and has sufficient depth. The following graph shows the time series of its daily transaction volume since its first transaction date:
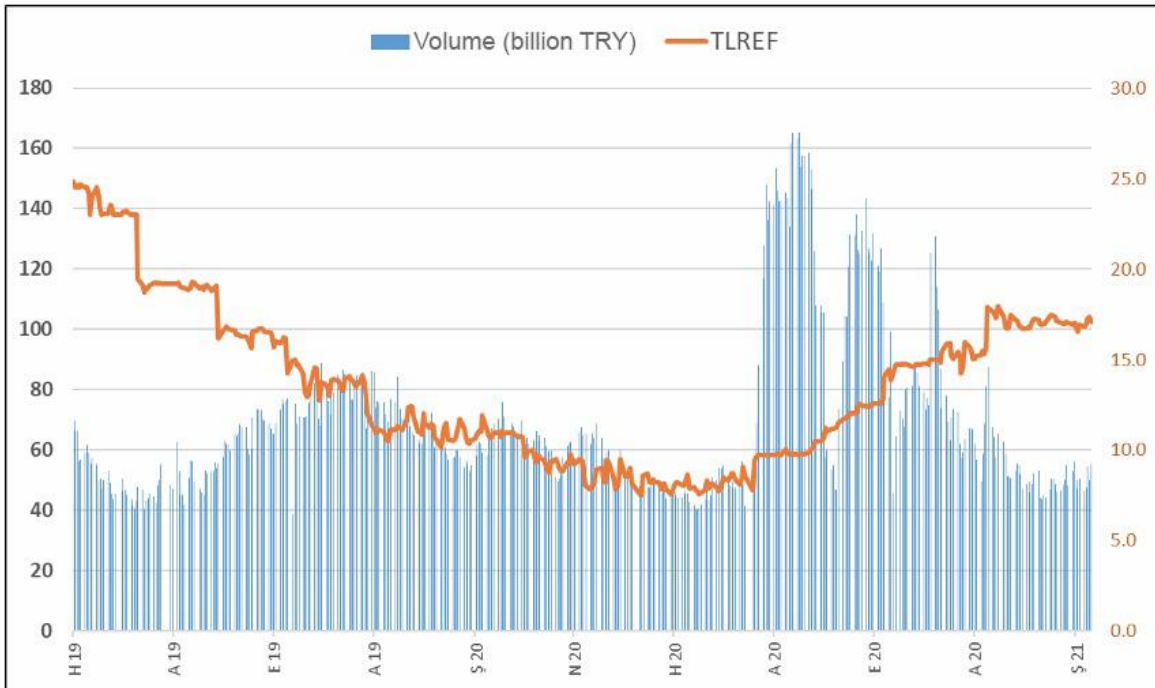
The Daily transaction volume was around TRY 70 billion from June 2019 to February 2021. The total money volume of the 2.7 million transactions realized is close to TRY 30 billion and the average transaction size is around TRY 11 million.

These transaction volume findings are summarized as follows:
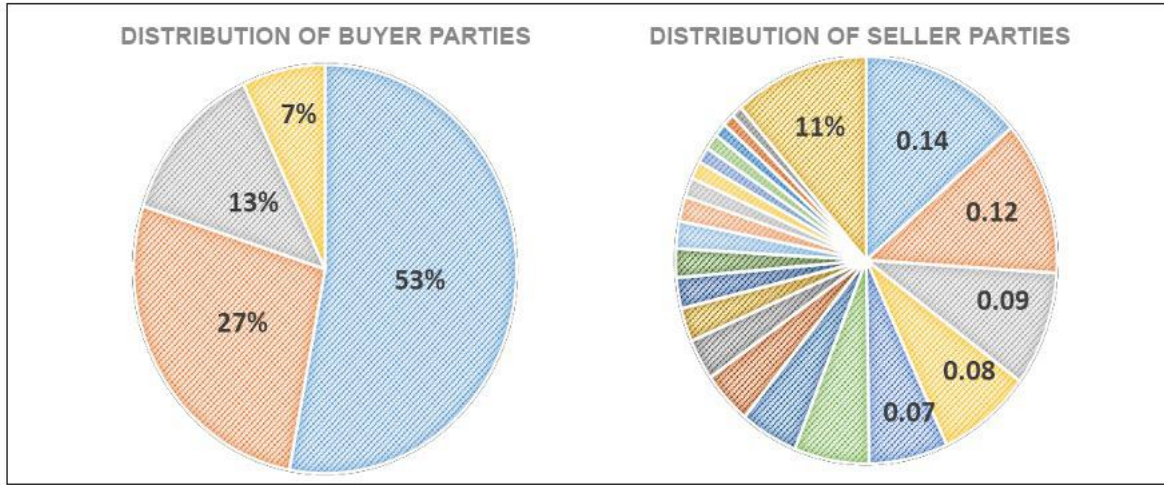
Such demand-supply asymmetry can be considered as a temporary situation specific to our country or the concerned period (2019 – 2020). Still, the effects that a future potential need and/or appetite change at the demand or supply side might have on the micro structure of the TLREF market should be taken into consideration now. Factors should be taken into consideration such as the monetary policy of the Central Bank, the fiscal policy of the Treasury, the domestic distribution of banks' overnight funding need and risks from global financial markets. The healthy sustainability of the TLREF market depends on its endurance against such external and unexpected effects.

It was previously stated that as a rate based on daily and fully secured real transactions, TLREF is a meaningful reference rate with high representation capability. The market depth and high participation also support this claim. As a matter of fact, overnight interest rates <e.g., in the US, the "federal funds rate" and "prime rate" and the OIS (overnight indexed swap) contracts and floating rate credits based on them> have been used in many financial products since long before LIBOR. TLREF-based OIS contracts traded in BIST are more recent examples.

TLREF and similar rates are daily rates and the mean of daily rates must be calculated for periods longer than one day. Using mean interest rates has two significant consequences:

- Using mean interest rates neutralizes sudden daily and temporary price fluctuations and cleans the noise in the data.
- The average of TLREF rates over a certain period of time represents both the term rates and potential trends in interest better. This fact shows the "semantic" advantage of TLREF or a similar rate over LIBOR.

The following graph shows the overnight TLREF, the one-month (backward-looking geometrical) mean TLREF and the one-month TRLIBOR rates observed during June 2019 – February 2021:
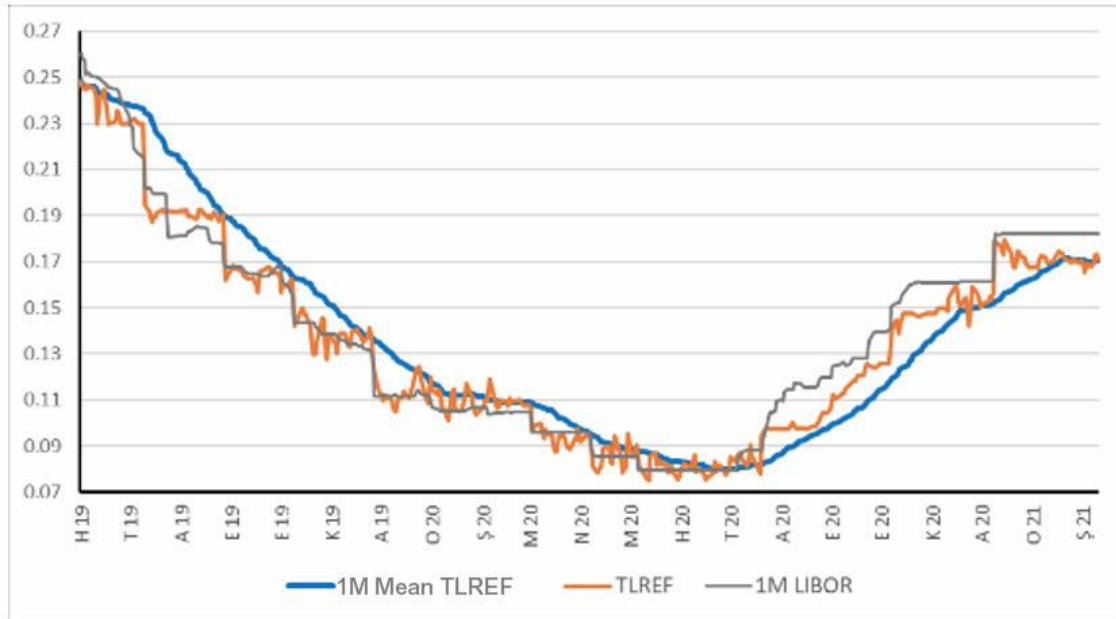
As shown in the graph, one-month mean TLREF has less volatility than both overnight TLREF and one-month TRLIBOR. The term average better shows the market expectation and the trend of the interest rates. It is therefore more meaningful to be used in credit products and derivatives and poses less risk for all parties of contracts. Financial Stability Board therefore considers that widespread use of reference rates like TLREF and SOFR will contribute to financial stability and recommends their use.

In developing countries, the TLREF market in Turkey is among the fastest growing markets. Important starts were also made in many new products other than overnight repo:

- The TLREF OIS transaction volume through the BIST Settlement and Custody Bank was TRY 47 billion between December 2019 and February 2021.
- Although it has not yet achieved sufficient demand, the TLREF forward contracts were available at BIST since August 2019.
- After the second half of 2019, banks started to loan TLREF-based credits and in addition to banks, companies also started to issue TLREF-based bonds as of early 2020. The Central Administration issued around TRY 48 billion with maturities of 2 – 5 years until February 2021 (Other non-TLREF floating rate bonds issued again by the Central Administration was around TRY 58 billion during the same period).

3.2 Assessment of TLREF's Compliance to IOSCO Criteria

The criteria recommended for financial benchmarks, published by IOSCO in the report entitled *Principles for Financial Benchmarks* in 2013 were also approved by the FSB as the standard for "best practice in financial benchmarks". The administration agencies of alternative reference interest rates such as SOFR, SONIA and €STR published their compliance declarations and/or audit reports. As TLREF is administered by the relevant public authorities and/or their delegated parties, there is no legal requirement for questioning compliance to IOSCO criteria. A similar situation is also true for SOFR and €STR. Despite this, TLREF will highly benefit from the reputation and potential collaborations in international markets resulting from compliance with the best practice standard.

The IOSCO criteria can be summarized under four main topics:

- **Governance**: Issues related to the administration of TLREF are explained in detail on the BIST website under "TLREF TURKISH LIRA OVERNIGHT REFERENCE RATE RULES". This document contains critical information such as the responsible committee's structure, meeting and decision-making rules, public disclosure procedures, benchmark calculation formulas and executive appointment.
- **Quality of the benchmark**: As specified in the mentioned document, the TLREF Overnight RfR is a realistic and reliable benchmark generated from real transactions conducted by banks and non-bank financial institutions.
- **Quality of the methodology**: TLREF is a volume-weighted average rate calculated from remaining data after the lowest and highest 15% outliers are eliminated. The TLREF is a time series generated using the compound interest rate formula from rates realized from the transactions under this scope. The document specifies issues such as its publication time, potential changes in the method and the conditions under which deviations may occur from the routine method.
- **Accountability**: The TLREF Committee also comprises government authority representatives and the daily management of the process is performed by the BIST Index Directorate. Accordingly, the accountability of the process depends on the supervision of the BIST internal oversight mechanism and the government authorities in the Committee.

For a more detailed assessment, the following table provides an item-based examination on compliance to the total of 19 IOSCO benchmark principles. It should be noted that a comprehensive IOSCA audit can be considered in the future as over time the TLREF market will deepen and the relevant product diversity will increase.

Principle	Compliance	Description
1. Overall Responsibility of the Administrator	Yes	The responsibilities of the TLREF Committee cover the whole process: a) Design and development b) Calculation and publication c) Operations d) Administration
2. Oversight of Third Parties	Not Applicable	There is no third party.
3. Conflicts of Interest for Administrators	Not Applicable	There are no conflicts of interest among the parties constituting the Committee. This does not include differences of opinion.
4. Control Framework for Administrators	Yes	a) There is no risk for conflict of interest b) Employed staff is competent c) Operational risk is low
	No	a) A "notice" and "warning" mechanism is missing to monitor the transacting party
5. Internal Oversight	Yes	a) The BIST internal oversight organization should be considered. b) Supervisory authorities are indirect and direct parties to the process.
6. Benchmark Design	Yes	a) Price set on a transaction-basis and with free market rules b) Market depth sufficient
	No	a) Other TLREF-based markets have not yet reached sufficient depth b) A "concentration" is taking place on the recipient side of the repo market (it should be considered that it could be temporary)
7. Data Sufficiency	Yes	The TLREF overnight repo market generates sufficient data in terms of both the transaction volume and the number of participants.
8. Hierarchy of Data Inputs	Yes	a) TLREF is a benchmark based on the reverse transaction of only quotation-based benchmarks. b) Articles 3.1.d and 3.2 of the rules specify the conditions and methods for determining "expert opinion".
9. Transparency of Benchmark Determinations	Yes	The calculation and publication methods can be clearly known.
10. Periodic Review	Yes	Although a regular assessment policy has not yet been published as it is a new method, it is expected to be developed in the future.

11. Content of the Methodology	Yes	The details of the method are sufficiently known. It is only considered that the method for operating the rules number 3.1 and 3.2 under stressful or crisis environments could be detailed further.
12. Changes to the Methodology	Yes	The rules document states that announcements will be made in compliance with this principle.
13. Process of Transition to Different Benchmarks	No	This issue has not yet been included in the agenda.
14. Submitter Code of Conduct	Not Applicable	A data provider of the type implied in this principle is not a part of the process.
15. Internal Controls of Data Collection	Not Applicable	There is no data collection of the type implied in this principle.
16. Complaints Procedures	No	The procedures for submitting complaints and notices should be determined.
17. Audit	No	Independent internal and external audit was not considered.
18. Audit Trail	Yes	The BIST records keep all past data.
19. Cooperation with Regulatory Authorities	Not Applicable	Regulatory authorities are already a part of the process.

The IOSCO principles do not recommend a "uniform" benchmark model and allow for flexibility in practices in various countries. The basic principle is that an acceptable benchmark should be based on prices freely set on an active market and measures are taken against market abuses. Countries may be flexible in details as long as these conditions are met.

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4 Return Calculation Methods Related to TLREF

The average of daily interest rates realized over a period of time is calculated using the "average compound interest" or "simple average interest" methods. The formula $r_t = TLREF_t \times \frac{g_t}{365}$ is used to calculate the "daily" equivalent (r_t) of the "annual" TLREF rate ($TLREF_t$) announced every business day (t). In this formula 365 is the number of days in a year. 360 can be used depending on the product or the country. The number of days ("overnight repo term") that $TLREF_t$ (the TLREF rate announced for day t) is assumed to be valid is g_t and this number is 3 for Fridays and "1 plus the number of holidays" for other holiday seasons. It will naturally be 1 for the other days.

Assuming that the interest calculation period contains calendar days and business days, the average compound interest for the period is calculated with the formula $R = \left(\prod_{t=1}^{G_{i\text{s}}} (1 + r_t) - 1 \right) \times \frac{365}{G_{takvim}}$. The number R is close to the geometric mean of the TLREFs.

The arithmetic mean formula is used for simple average interest:

$$\bar{R} = \left(\sum_{t=1}^{G_{i\text{s}}} r_t \right) \times \frac{365}{G_{takvim}}$$

The logic of the TLREF Index published by BIST is compatible with the average compound interest rate formula:

$$Endeks_t = Endeks_{t-1} \times (1 + r_t)$$

Comparing compound and simple average calculations:

1. The compound average calculated according to the aforementioned formula is always higher than simple average. This difference becomes more evident in high-interest period, longer terms and periods when volatility is higher in interest rates.

   The following graph shows the daily {R − R̄} differences for 1-month (average of 30 calendar days) and 3-month (average 91 calendar days) maturities using the TLREFs published in June 2019 – February   2021:

Compound and Simple Average Difference (6/19 - 2/21)
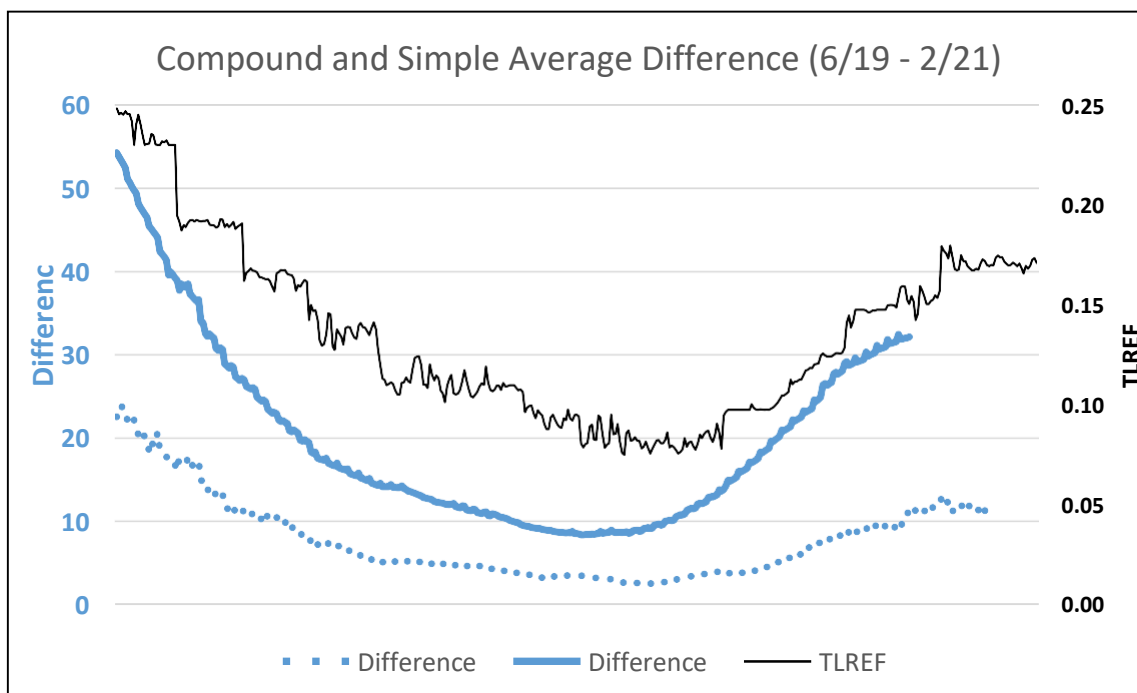
In a period when the TLREF interest rate varies between 7.5% and 25%, the mean difference is observed to be 8 bps (between 24 and 2) for monthly maturities and 20 bps (between 54 and 8) for 3-month maturities. (All of these numbers are "annualized".)

2. The compound average formula shows the "value performance" more accurately compared to the simple average formula.

3. As compound interest is used in derivative markets such as OIS, it is easier to "hedge" products using compound interest against interest risk.

4. If institution balance sheets contain different and mutual items some based on simple average and some on compound average, a new type of risk (from the difference between compound and simple) to be managed can arise.

5. Simple interest has operational convenience as it can be understood (explained) easier and settled as a traditional method in various products for years.

6. The legislative compliance of legal fallback compounding method is closely monitored by the "Legal" workshop team.
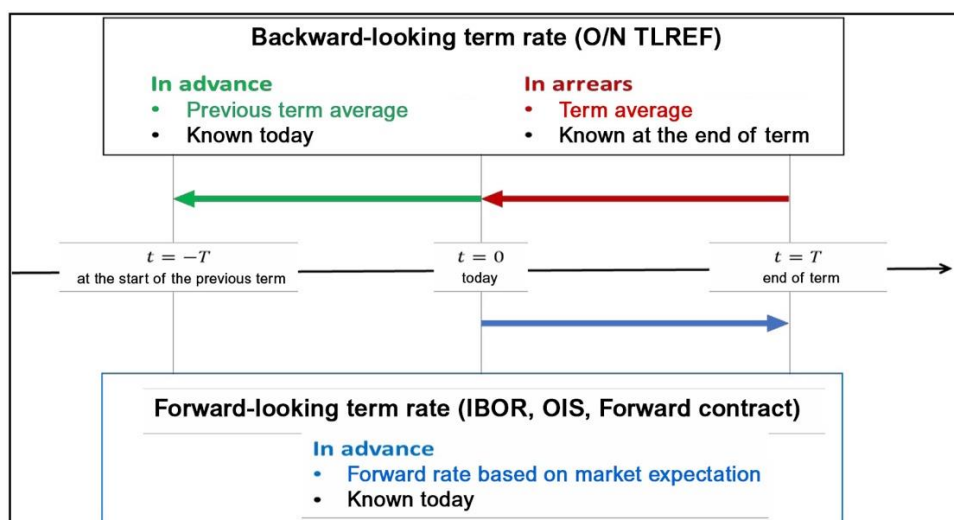
5 Term Interest Calculation Models

As a result of the many years during which LIBOR was used with global prevalence, the rates determined in IBOR (LIBOR, Ice- fix etc.) or derivative markets (swap and forward contracts) could be used as forward-looking term interest. The amount payable at the end of the term is known at the start of the term. In practice, the operational infrastructures of financial institutions were largely shaped in accordance with this mechanism.

After the decision was taken to abandon LIBOR and replace it with reference interest rates (TLREF, SOFR etc.) that comply with the IOSCO criteria, the method to calculate forward-looking term interest has not yet been clarified. Various working groups in various countries are essentially considering two different approaches:

1. The first approach is a method where term interests are determined and published such as "*forward-looking* TLREF" similar to IBOR, that form on OIS and forward contract markets based on the reference interest rate and comply with the IOSCO criteria.

2. The second approach is *backward-looking* term interest calculation. This includes two different methods:

    a. The mean of the TLREFs throughout the term are used as the term interest ("in arrears"). The payable term interest can only be known at the end of the term.

    b. The average of the TLREF rates throughout a past term that started just before the start of the term and has a suitable duration is used the term interest ("in advance"). In this case, the interest payable at the end of the term is known at the start of the term.

Before entering the details, we should first briefly assess the matter with an economic logic: The aim is to find the interest rate for the upcoming period $[0, T]$ in a contract signed today ($t = 0$). In the current LIBOR world, the interest applicable after T days is the T-day LIBOR known today. Besides its other drawbacks, this LIBOR rate is based on the market expectation and both the expectations and the real interest rates can change over the term. It is therefore likely to have consequences to the disadvantage of either the creditor or the debtor. As TLREF or a term interest calculated using a similar RfR-based and backward-looking method (preferably "in arrears") will be the average of interests realized on the market, it will not have the unnecessary risks or setup errors caused by the LIBOR mechanism.

The following figure summarizes the comparison between these two methods and IBOR:

In the figure, T is the period of time, which is usually 1 or 3 months.

5.1 Backward-Looking Interest Calculation

5.1.1 Return Calculation Method Where the Interest Payment is Known at the Start of the Interest Term (In Advance)

The "in advance" method is used where the payable term interest is required to be known at the start of the term, as in credit products. As indicated in the following figure, two different interest calculation methods are discussed in this method:
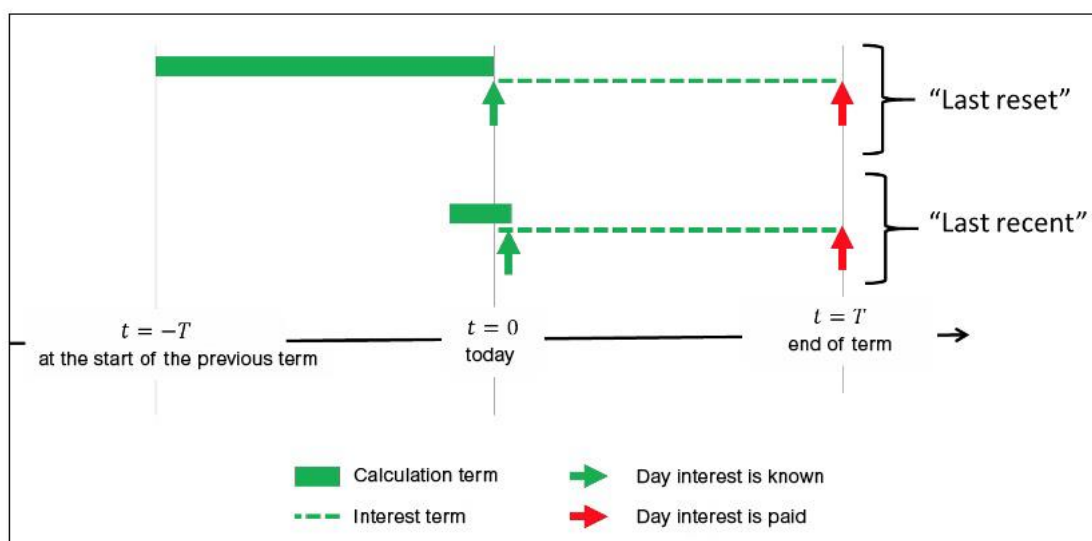
- In the "Last reset ("LR")" approach, the calculation period $[-T, 0]$ has equal length with the interest term $[0, T]$. The average of the TLREFs realized during the calculation period are determined at the start of the term ($t = 0$) and paid on the maturity date ($t = T$). In this option, despite the potential interest risk from the term difference, the term interest can be found by adding a "term premium" to the mean TLREF. This premium can be calculated using an IOS curve where there is a sufficiently active OIS market. As it will sometimes be negative and sometimes positive depending on the slope of the curve, both the creditor and the debtor will be *partially protected from their own perspective*.
- As for the "Last recent ("LRec")" approach, the TLREF on $t = 0$ or the previous TLREF or the average of TLREFs realized over a few days before or after it is used. In this option it is more difficult to protect against interest risk particularly in volatile times.

In the "in advance" calculation method:
1. It has operational convenience as the interest is known in advance and can be used without having to make many changes in structures suitable for IBOR.
2. As debtors wish to know in advance the interest they will pay especially in credit products, the relations with credit customers can be managed easier.
3. It is difficult to protect against interest risk resulting from difference in the calculation and accrual periods (mostly in current derivative products using "in arrears" calculation). The creditor will not have earned and the debtor will not have paid the current interest.

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5.1.2 Return Calculation Method Where the Interest Payment is Known at the End of the Interest Term (In Arrears)
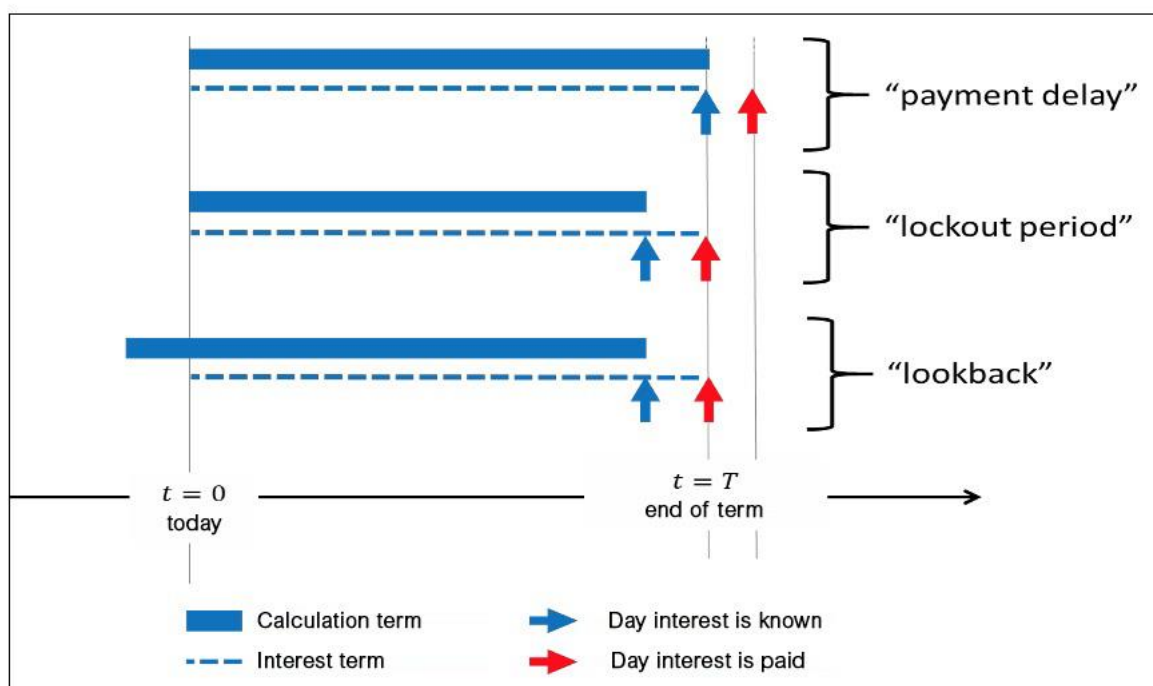
In the "in arrears" method, the calculation and payment periods fully or mostly overlap in terms of time. The average of the TLREF rates realized over the interest term are calculated and paid as backward-looking. The theoretically correct method is to calculate the average of TLREFs realized over the period [0, T] on day T and pay it on the same day. However, it is difficult to exactly implement this calculation in practice. Three different methods are discussed that contain time shifts due to certain structural facts such as the announcement time of TLREF, the swap time in OIS and other derivative products and the accounting infrastructure:

1. In the case of "Payment delay ("PD")", the payment is made in $T + g$ days with a few days of delay (to give time for swap and accounting). The product cash flows need to be aligned with the OIS cash flows for protection against the potential interest risk from the delay. This is possible by matching the date $T + g$ with the OIS (or other derivative used for hedge purposes) swap date.

   In this method, a potential cash management difficulty is observed in periods with a principal payment (maturity dates of floating rate bonds etc.). As the principal will be payable on day T and its interest on day T + g, there may be a cash flow incompatibility in terms of accounting. In this respect, it is useful to minimize the number of delayed days.

2. In the case of "Lockout period ("LP")", the applicable term interest is fixed a few days in advance to the average of TLREFS over the period [0, $T - g$] and this fixed rate is used for the remaining g days (in the US this is four days in floating rate bonds issued with the SOFR rate). A potential problem of this calculation is potential sudden in-day fluctuations in market interests as the interest rate is fixed.

3. In the case of "Lookback ("LD")", the term interest is calculated as the average of the TLREFs over the period [$-g$, $T - g$] shifted g days backwards and used until the payment date. For example, g = 5 days is used in SONIA-based bonds. This calculation method resembles "lockout period" in terms of interest risk and operational requirements.

   These three alternatives are summarized below:

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The following summary can be considered when backward-looking term interest calculation methods are compared according to three main criteria:

The Turkish translation of the methodologies have not yet been decided.

Method	Methodology*	Operational Convenience / Cash Flow Management	Calculation Convenience	Hedge Convenience	Customer Acceptance	Time Value of Money (Term Compatibility)	Used Markets	Recommendation
In Arrears	Basic Method	Operational difficulty due to calculation and payment on the same day	Simple and transparent calculation	Hedge convenience due to compatibility with the OIS market	Not suitable due to operational difficulty	Compatible	Certain derivative markets	🔴
In Arrears	Payment Delay	Operational difficulty due to payment delay	Simple and transparent calculation	Hedge convenience due to compatibility with the OIS market	Suitable for ertain asset classes and customers	Compatible	OIS derivative markets	🟢
In Arrears	Lockout Period	Convenience between rate fixing day and payment day	Not transparent due to rate fixing	Hedge transaction difficult in the rate fixing period	Limited due to non-transparent calculations	Slight incompatibility	SOFR FRN market	🟡
In Arrears	Lookback days	Convenience between rate delay day and payment day	Simple and transparent calculation	Slight difficulty due to differences caused by delay	Suitable for certain asset classes and customers	Slight incompatibility	SONIA FRN market	🟢
In Advance	Last reset	Operationally simple as payments are known in advance	Simple and transparent calculation	Hedge difficulty due to calculation basis	More suitable for personal and SME customers	Incompatible	Solution recommended for personal portfolio	🟢 (light)
In Advance	Last Recent	Operationally simple as payments are known in advance	Simple and transparent calculation	Not hedging impossible	Not suitable to incompatibility with the rate term	Incompatible	Not observed	🔴
Hybrid	Principal Correction	Operational complexity due to corrections	Complex and non-transparent calculation	Cash flow incompatibility	Complex, limited due to non-transparent calculations	Can be made compatible through corrections	Not observed	🟡
Hybrid	Interest Round-off	Operational complexity due to corrections	Complex and non-transparent calculation	Cash flow incompatibility	Complex, limited due to non-transparent calculations	Can be made compatible through corrections	Not observed	🟡

🟢 recommended   🟢 (light) recommended for specific products   🟡 has certain problems   🔴 not recommended

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The working groups in some countries are also considering "hybrid" methods that include the properties of both the "in advance" and the "in arrears" methods. However, the structures that emerge in the context of the mentioned methods are not considered in this Report as they can be very complex. This is because every complexity will have an unpredictable costs and undesired side effects.

The sample calculations for the following situations are provided in the Annexes in Section 9:
- Return calculation using in advance method on a credit
- Return calculation using in arrears method and simple interest on the same credit
- Return calculation using in arrears method and compound interest
- Return calculation using in arrears method and compound interest by applying 2 days of lookback
- Return calculation using in arrears method and compound interest by applying 2 days of lockout
- Return calculation using in arrears method and compound interest by applying 2 days of lockout and 2 days of lookback

5.2 Forward-Looking Term Interest Calculation

LIBOR is both a forward-looking and a foreknown interest and is claimed to reflect market expectations. Even today, trillions of dollars' worth of notional and spot value is directly or indirectly based on LIBOR. Rates such as TLREF and SOFR proposed for replacing LIBOR are daily rates. This is why the requirement to generate forward-looking rates based on them is being discussed in order to fully end LIBOR.

It can be said that a major problem will not occur in derivative markets as pricing is mostly based on backward-looking rates in derivative markets such as OIS and the ISDA transition methodology is mostly defined. The problem is more related to spot (cash) products such as credits. Knowing the payable term rate in advance is a common procedure and habit in personal loans such as SME loans and housing loans. It should be stressed here that the actual aim is to have the convenience of **knowing the term interest in advance** rather than the forward-looking feature of LIBOR that reflects market expectations. This priority should be kept in mind when trying to find a solution based on TLREF.

One of the alternatives being considered is a method where term interests such as "*forward-looking* TLREF" based on a reference interest rate and determined in accordance with the IOSCO criteria are calculated. In other words, a trade-based reference term interest similar to LIBOR is requested. Managed by the IBA (ICE Benchmark Administration) since 2014, LIBOR is actually a similar benchmark. However, developments in recent years showed that ICE LIBOR or a similar IBOR is unable to fully have the features required from a reliable forward-looking reference term interest:
- In stressful markets and times of crisis market actors have difficulty in setting expectations and therefore avoid futures (except for protection purposes).
- When market depth decreases and/or volatility increases, published LIBOR may become based more on expert opinions rather than trades, which has been observed with increasing frequency in ICE LIBOR.
- Institutions may refrain from giving forward prices in today's world where besides increasing global uncertainty, central banks can change policy rates frequently and follow unusual monetary policies.
- According to the IOSCO criteria, forward-looking term interests should be administered (calculated and published) with an understanding similar to administering RfRs.

A second and similar alternative is to calculate forward-looking term interests using RfR-based OIS and forward contract rates. For example, the "SOFR term rates" published by ICE are the volume-weighted average rates formed in SOFR forward contracts and OIS contracts.

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The TLREF-based OIS market has been operating in Turkey since December 2019 and is continuing to grow. Data providers such as Bloomberg publish TLREF OIS rates up to 10 years of maturity. Bloomberg calculates these rates as the volume-weighted average of both trades on the Settlement and Custody Bank OIS market and the trades through brokers on foreign markets. Sample return curves are shown in the following graph. The changes observed in the curves over time indicate that the market is showing a foresighted and prudent reaction towards the Central Bank monetary policy. For example, the OIS return curves in February and May 2020 show that market actors are not expecting any rate hikes. As for the period from August 2020 to February 2021, the 875 basis point increase in the CBRT policy rate and the interest hike expectations of market actors before the decisions were reflected onto the OIS market. Although it is a fairly new market, this is a positive course.
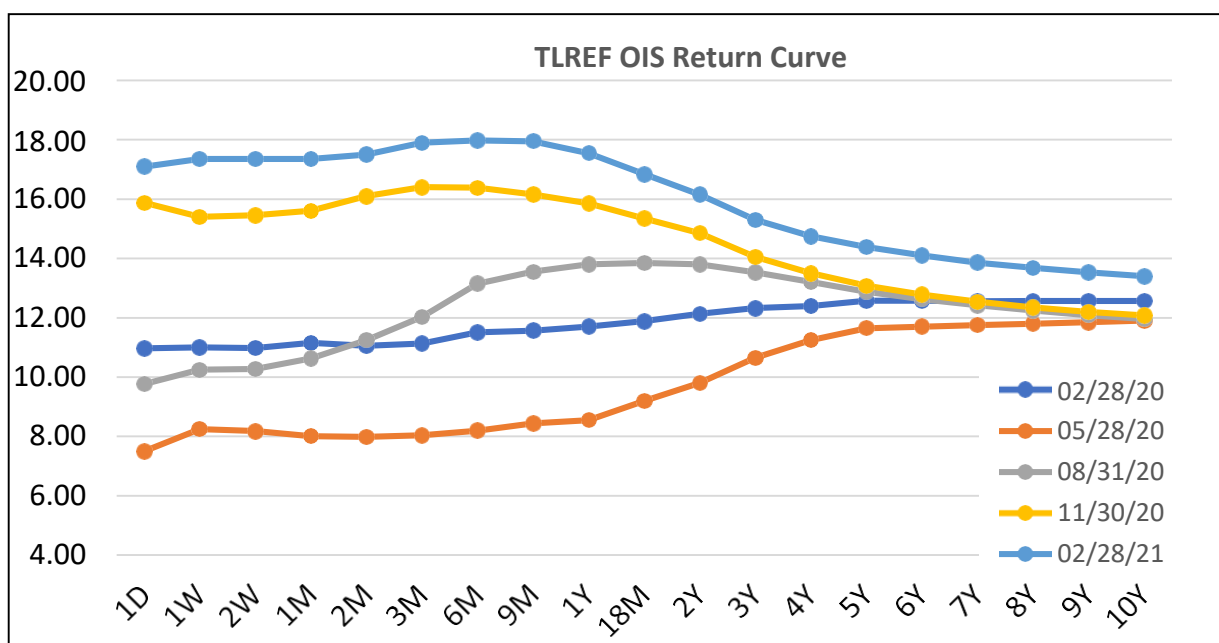
The observations made between December 2019 and February 2021 show that the pricings in the OIS market moved in accordance with the logic of finance. Namely; the "swap interest" that equates the current value of cash flows resulting from "forward rates" calculated with a forward compound interest using overnight TLREF, with the current value of the fixed rate, is equal or very close to the traded fixed interest rate. In other words, no apparent mispricing was observed to the benefit of any party of the swap. If such correct pricings and growing trading volumes continue, we can foresee that a TLREF OIS market with major benefits in risk management will be created.

Despite such positive developments, it is not yet possible to generate a forward-looking reference term interest that complies with IOSCO criteria based solely on OIS quotations:

- Theoretically, a TLREF futures market that balances the pricings in the OIS market is required. The futures in BIST have not yet drawn sufficient attention. The trade volume to date is close to zero. The reason for thus should be investigated. A "market making" policy that encourages participation may be beneficial as a first step. Development of the futures market will also be beneficial regardless of the need to generate a forward-looking "TLREF term interest".
- The OIS trades through the Settlement and Custody Bank constitute only a party of the total volume. It is not possible to manage a benchmark that satisfies IOSCO's basic criteria in such a "fragmented" market. Such fragmentation will be prevented if the Settlement and Custody Bank gains the status of a "central counterparty" recognized by ESMA.

At this stage, reconsidering the problem of calculating forward-looking term interest:

   a. Spot products such as bank credits require a definition for forward-looking term interest during the LIBOR transition process.
   b. A forward-looking term interest can be found with advanced derivative products but the development of the derivative market requires a sufficiently deep spot market!
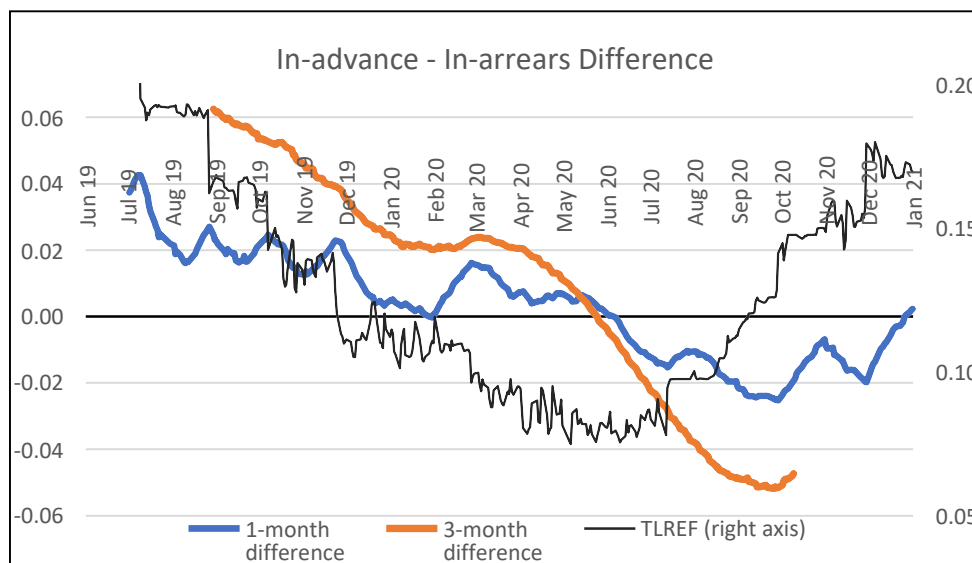
It should be noted that in order to break this vicious cycle, the problem is finding rates *known in advance* rather than finding forward-looking rates. A relatively simple approach mostly based on the overnight TLREF rate will be useful in solving the problem with such an understanding. What is ultimately sought is term interests known in advance and derived from reference interest rates calculated in accordance with the IOSCO.
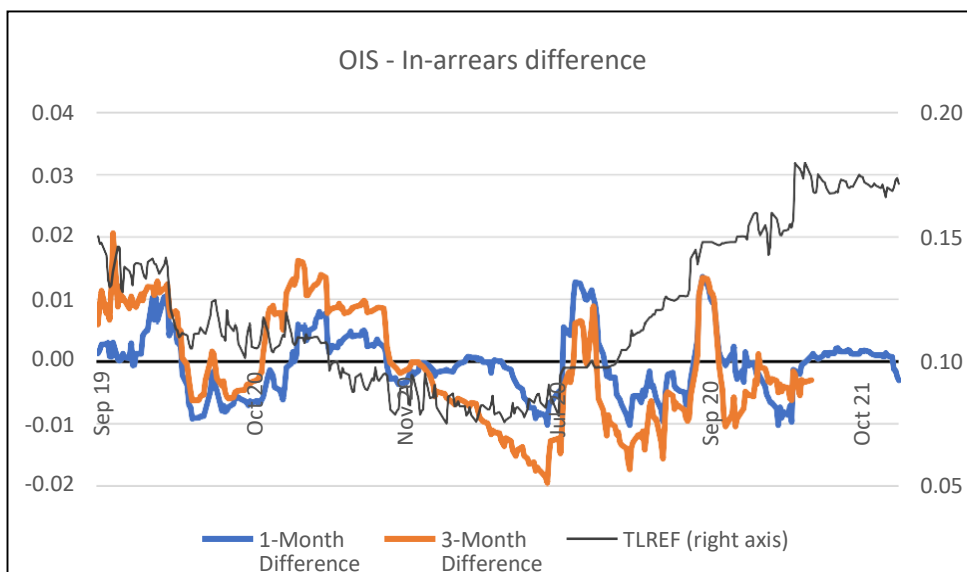
As you may recall, in the "in advance" method the term interest is determined at the start of the term and is known in advance. As for the alternative "in arrears" method, the term interest is only calculated at the end of the term and as the average of realized interest rates. The "in arrears" method is preferred both for its basic financial logic and the ease of risk management with derivatives. Therefore, a solution can be found when the foreknowledge of the "in advance" method is combined with the financial logic of the "in arrears" method (without waiting for the development of derivative markets). It may be useful to examine the history of the market before finding a potential solution.

The following table shows the TLREF rates and the in-advance - in-arrears rate differences and the OIS - in-arrear rate differences calculated for one- and three-month terms for the period December 2019 – February 2021:

|	In-advance - In-arrears difference		OIS - In-arrears difference	
	1-month maturity	3-month maturity	1-month maturity	3-month maturity
Mean	0.0030	0.0088	(0.0006)	(0.0011)
Median	0.0045	0.0206	(0.0003)	(0.0030)
Standard deviation	0.0157	0.0346	0.0051	0.0089
Min	(0.0252)	(0.0517)	(0.0103)	(0.0195)
Max	0.0424	0.0623	0.0134	0.0205

Considering that TLREF remained in the broad range of 7%-25% during the concerned period, the resulting in-advance - in-arrears differences are not surprising. OIS - in-arrears differences were at more reasonable levels. The following graphs show their course over time:

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Naturally, the in-advance rate is higher than the in-arrears rate in times when the interest rates are decreasing and lower when the interest rates are increasing. This indicates that in-advance calculation does not reflect the current reality. A correction needs to be made in the in-advance mean if a rate is sought which is known in advance but also realistic.

Let us build a simple example to explain the considered solution. The "in advance" and "in arrears" scenarios will be as follows in a credit cash flow example with floating rate and four equal payments:
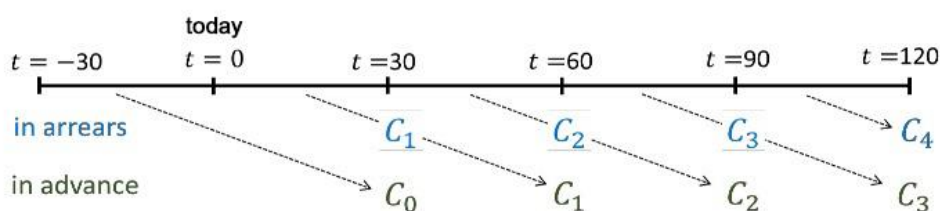

Assuming that each period is equal and 30 days long and the nominal value us TRY 1 for convenience, the cash flows will be $C_0 = \prod_{t=-30}^{0}(1 + r_t) - 1$, $C_1 = \prod_{t=1}^{30}(1 + r_t) - 1$ .... It can be seen that:

- All the cash flows have values generated from the daily $\{r_t\}$ values formed on the TLREF market. Only the timing is different.
- At any time T, C_{T-1} is a fixed amount known in advance based on TLREFs of the previous terms, whereas C_T is a variable amount to be determined by TLREFs to be formed during the term.

TLREF OIS contracts are contracts where fixed-interest payments are swapped with floating-rate payments. The floating-rate is the compound average of TLREFs formed during the term. As a requirement of the setup, the fixed-rate ("swap rate") is the rate that equates the starting value of the contract (the difference between the current values of the fixed rate and the floating rate) to zero. Therefore, the forward fixed rate in OIS contracts (known in advance) is expected to be equal to the rate expected in the upcoming term under normal circumstances (In this context, it could be considered to have forward-looking information feature.)

The following graphs provide one- and three-month in-arrears TLREF rates and OIS rates for the period October 2019 – January 2021. The series are observed to follow each other very closely and this observation supports the claim in the paragraph above.

1-month OIS and In-arrears TLREF

3-month OIS and In-arrears TLREF
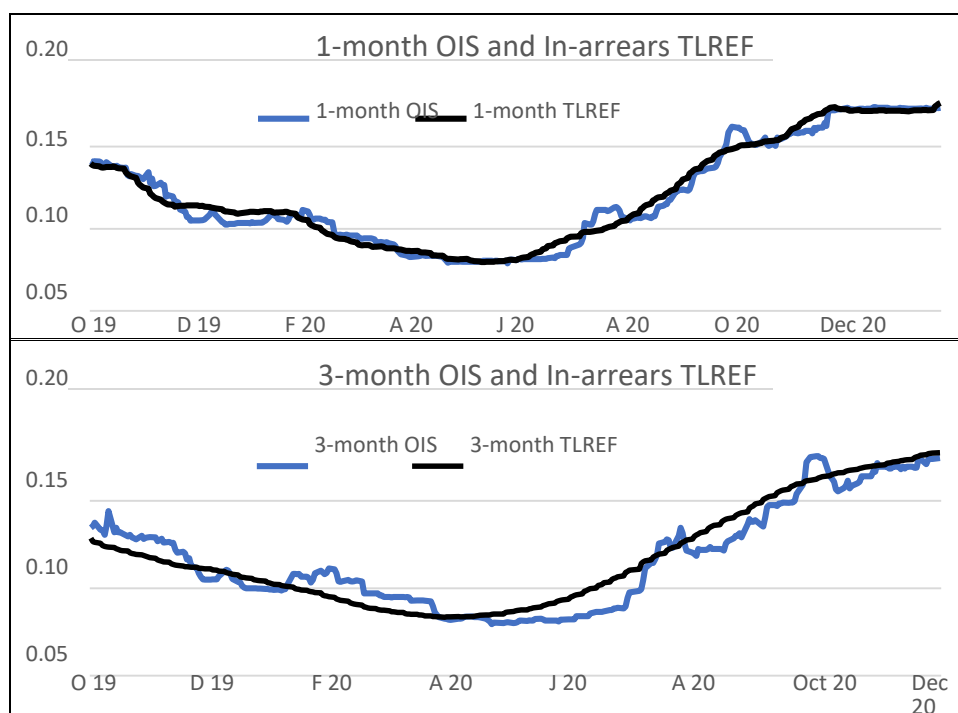
The four-term loan in the example can be considered as four separate consecutive one-term loans. If the party loaning or borrowing with fixed rate is worried that the market interests may change to their disadvantage (or the party exposed to floating rate does not wish to have interest rate uncertainty), it may use one-term OIS trades to easily protect the position at a low cost.

In conclusion, one-month, 3-month and 6-month OIS swap rates can be used significantly when interest rates known in advance are required. The TLREF Committee should consider publishing data on this matter in a using similar to the overnight TLREF calculation and publication rules. If any doubt arises regarding the OIS market or there is any worry regarding an extraordinary disruption in the market, it may become necessary to implement the suggested method. If the search for a forward-looking interest rate known in advance is accepted in this regard, it is important that the current OIS market should be further deepened and the TLREF futures market should be developed.

As an alternative approach, a "correction factor" can be periodically published to be added to the swap rate and calculated with VAR (vector autoregression) using macroeconomic variables or a similar econometric estimation method. A sample model that can be developed using macroeconomic variables is presented in the annexes section of the document.

Using such a model will eliminate the requirement to know the term interest in advance. At this stage, the TLREF Committee should consider the task of publishing a practical version of the model that is acceptable by everyone. In principle, the Committee should have an independent data publisher or a similar organization carry out this task and check the compliance of the suggested method complies with the IOSCA principles. The model presented in this document can be used as it is, its estimation power can be increased with certain developments or the possibility can be investigated of developing better models using different modeling techniques. Ultimately, the user party(ies) will be responsible for using the approaches presented in this document.

6 Product-Based Assessment and the Transition Logic

As the forward-looking term interest model cannot be foreseen yet and in order to guide subsequent works at this stage, institutions need to discuss their backward-looking calculation methods in terms of various products. Bringing up the assessments in the following table to discussion will be beneficial:

	Now	Post-transition
Corporate loan	LB, PD	LB, PD
Personal loan / SME	LR	LR, LB
Bond, bills	PD, LB	PD
Investment fund	LB	LB
Derivative	PD, LB	PD

As seen, it may not be easy to choose an in-house uniform method. Therefore, the need may arise for institutions during the transition process to leave the decision to competent authorities in certain product groups (for instance in personal loans) for which the method cannot be decided.

Reference interest rates are considered to be mostly *risk-free* when they are fully secured (TLREF, SOFR etc.). On the other hand, IBOR includes bank credit risk and maturity risk premiums. IBOR is thus expected to be greater than a forward RfR with the same maturity. Therefore, in transitioning from IBOR to RfR, a risk premium ("spread") should be calculated that does not lead to an unjust value transfer between debtors and creditors or the market to stop. The most widely accepted approach among the many alternatives considered was the idea to estimate the mean or median of the difference between IBOR and RfR from historical data and adapt it to ongoing contracts. One of the leading questions here is how long to go back in historical data. As suggested in some studies, using data from the past 5 – 10 years will be more exhaustive as a statistics technique. However, the extent to which very old data can represent the current market conditions remains as a question. In any case, this approach is the fairest one even if full correction cannot be achieved.

For this purpose, overnight RfR series were generated for the period January 2014 – March 2021. Published TLREF was used for post June 2019, TLREF calculated but not published by BIST was used for January 2019 – June 2019 and the overnight repo rates realized in two different markets at the Settlement and Custody Bank were used for 2014 – 2018. Calculation was made using the current TLREF calculation formula (volume-weighted average rate cleaned of 15% outliers) for all the periods. A "representative TLREF" was thus obtained for 2014 – 2018 and a time series consisting of standard TLREF figures was obtained for thereafter.

The following graph shows the overnight TLREF calculated using this method and the overnight TRLIBOR rates for the same period:

O/N TLREF and TRLIBOR
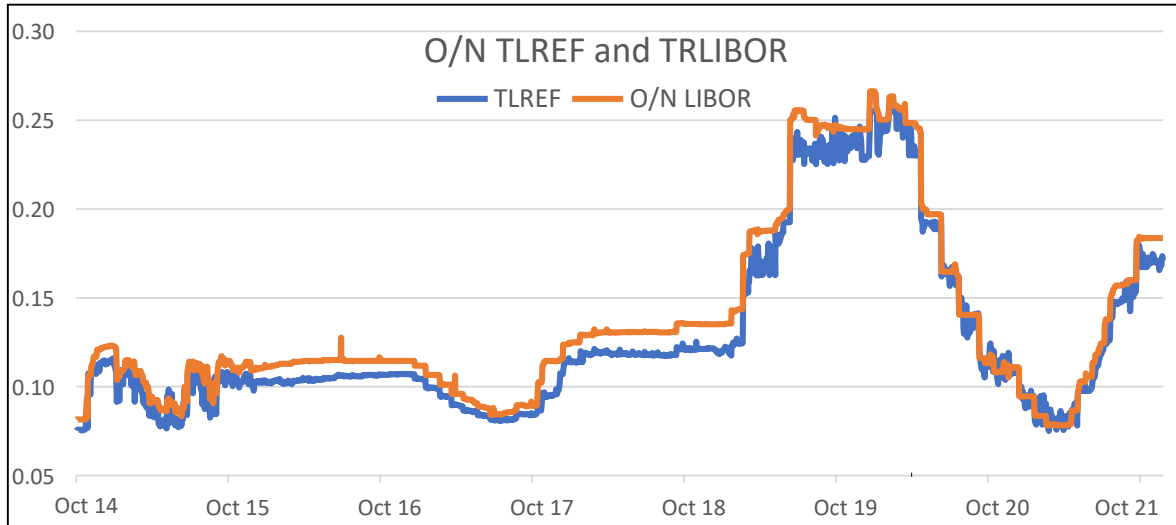
The following graph shows the TRLIBOR - TLREF (backward-looking compound average) differences in overnight, 1, 3 and 6-month maturities in the period 2014 – January 2021:

TRLIBOR - TLREF differences
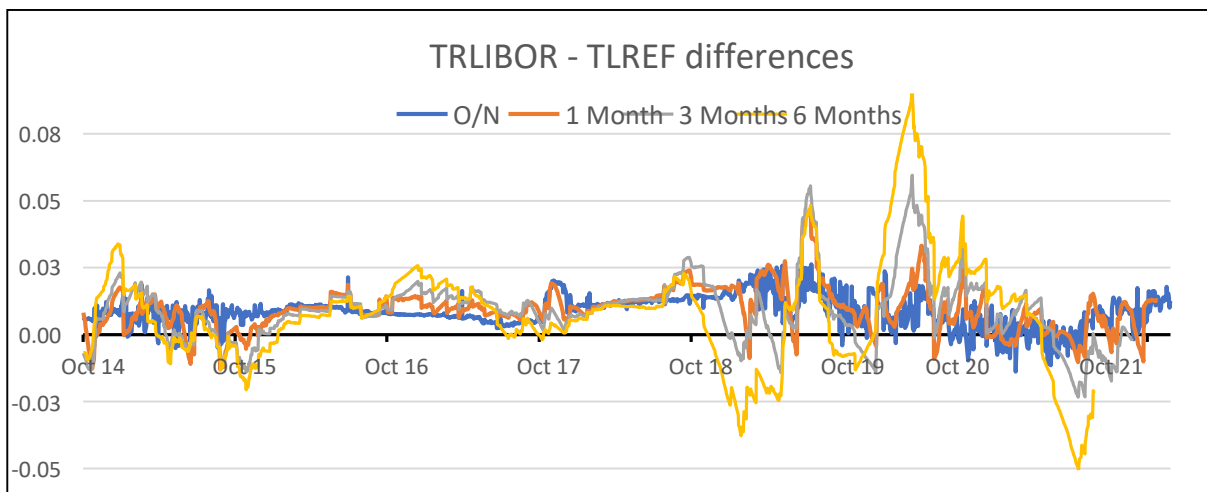
Some important observations can be summarized as follows:

1. The TRLIBOR -TLREF differences in various maturities are observed to be negative in certain periods. This anomaly becomes more apparent particularly in times with increased interest rate volatility and for long maturities such as 6 months.

2. The TRLIBOR market is relatively shallow. TRLIBOR- based loans are less than 5% of the total volume. The negative difference anomaly mentioned in item one is perhaps caused by this "market indifference". This observation should be taken into consideration in the procedure of the transition from TRLIBOR to TLREF.

The statistical findings from the data shown on the graph are summarized below:

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TRLIBOR – TLREF differences (2014 – 2021)				
	Overnight	1 month	3 months	6 months
20% cropped mean	0.0087	0.0095	0.0084	0.0072
Mean of positive differences	**0.0096**	**0.0114**	**0.0129**	**0.0167**
Mean	0.0087	0.0096	0.0088	0.0076
Median	0.0084	0.0099	0.0089	0.0083
Mean TLREF	**0.1287**	**0.1295**	**0.1310**	**0.1332**
As a percentage of mean TLREF				
20% cropped mean	6.8%	7.3%	6.4%	5.4%
Mean of positive differences (*dv*)	**7.4%**	**8.8%**	**9.8%**	**12.5%**
Mean	6.8%	7.4%	6.7%	5.7%
Median	6.6%	7.6%	6.8%	6.2%

The calculated differences have a volatile course and this volatility is observed to be higher in longer maturities. Extreme values (queues) can be removed from the calculation and the mean difference can be calculated to reduce volatility and eliminate the negative difference anomaly. Alternatively, the mean of only the positive differences can be calculated. Examining the findings on the table shows that the second alternative gives more meaningful results. Namely, a higher TRLIBOR-TLREF difference is found in longer maturities. According to this result, the following due "transition correction" can be made for a TRLIBOR with maturity *V* on date *t*:

$$TRLIBOR_{t,t+V} = TLREF_t * (1 + dV)$$

For example, if today's *TLREF* = 0.19 then *TRLIBOR*$_{0,3month}$ = 0.19 × (1 + 0.098) = 0.208. The process will be continued until existing TRLIBOR-based contracts expire. For the period 2014 – 2021, the rates shown in the following graph and generated accordingly are observed to comply with the financial logic.
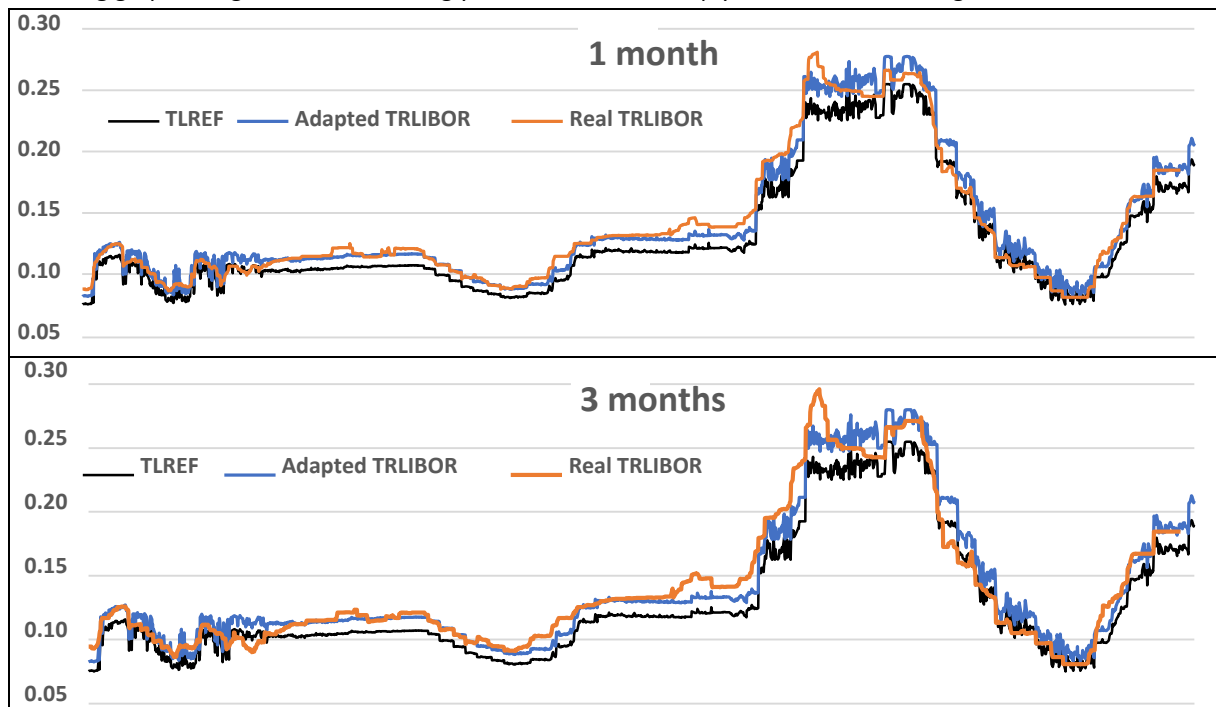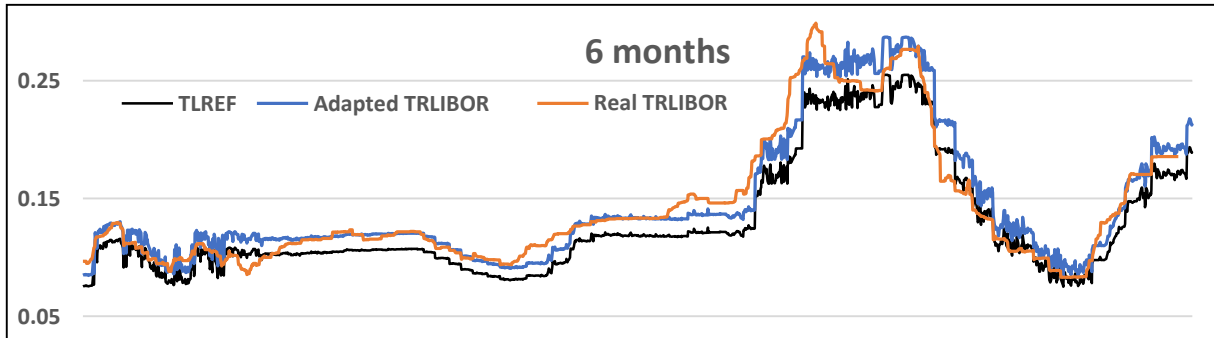
A shorter dataset may be used instead of 2014-2021 data in estimating the transition coefficient (*dv*) used in the adaptation. For example, the following findings may be examined for the period 2019-2021.

TRLIBOR – TLREF differences (June 2019 – March 2021)				
	Overnight	1 month	3 months	6 months
Mean of positive differences	0.0071	0.0094	0.0147	0.0262
Mean TLREF	0.1377	0.1349	0.1302	0.1233
Correction rate (1+ *dv*)	1.052	1.070	1.113	1.212
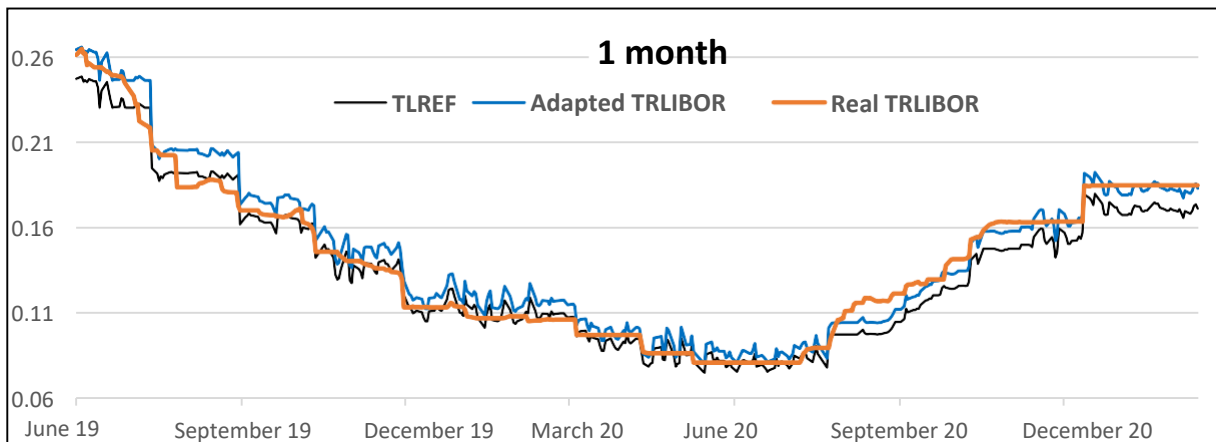
Using a long dataset will be more meaningful considering that financial conditions can be subject to high uncertainty in short terms and that the mentioned adaptation will be used only temporarily. This is because the suggested coefficient is not an absolute value and is a percentage of the latest TLREF figure.

7 Conclusion

The user guide prepared for TLREF products assessed the development of the TLREF market, the compliance of the TLREF administration model to IOSCO criteria and return calculation models related to TLREF.

The case studies we prepared for return calculation models related to TLREF were sent to the stakeholders and the comments of 10 stakeholders were taken into consideration in preparing the document. As a result of both EY, opinions on the global markets and the feedback from stakeholders, the conclusion was reached that the Lookback Return Calculation Method Where the Interest Payment is Known at the End of the Interest Term (In Arrears) is the most reasonable method.

Recommendations for EY in the upcoming period and possible actions to be taken for the development of the TLREF market have been classified as follows:

1. In addition to the daily TLREF rate and TLREF index published by BIST:
    a. Starting to publish backward-looking weekly, monthly and quarterly compound average TLREF series,
    b. Rates with various maturities realized in OIS trades conducted through the Settlement and Custody Bank and
    c. (On the condition of not being affirmative even due to their usage) Series based on simple average

2. Preparing a more comprehensive "administration text" so that the compliance of the TLREF administration principles to IOSCO principles can be understood more clearly,

3. Encouraging market making and simultaneously taking preventive measures against market abuse actions to revive the TLREF futures contract market,

4. Urgently ensuring that the Settlement and Custody Bank becomes a central clearing house recognized by ESMA, thereby ensuring that swap transactions in foreign markets are also cleared at the Settlement and Custody Bank,

5. Quickly adapting the existing infrastructures of institutions to the mathematics of a method that can be preferred by Institutions (e.g., backward-looking average compound interest) and starting works for new legal regulations in this regard, if necessary,

6. Starting the necessary works for the "Return Calculation Method Where the Interest Payment is Known at the Start of the Interest Term (In Advance)" adaptation without waiting for (or without relying on) the derivative markets to deepen sufficiently for "forward-looking term interest" and the TLREF Committee checking the IOSCO compliance of the said method,

7. Working to calculate a formula for transition to a fair TLREF in TRLIBOR-referenced products
    a. And localizing the ISDA transition rules in derivative products can ensure a smooth transition
    b. It should be noted that in cash products - as in SME and personal loans - all the parties of the loan should reach an agreement and the applicable law must be complied regardless of the adopted method.

8 References

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9 Annexes

9.1 TLREF Return Calculation Examples

TLREF Return
Calculation Examples.

9.2 National Working Committee Studies

IBOR Geçişi Ulusal
Çalışma Komitesi Sun

9.3 Forward-Looking Macroeconomic TLREF Prediction Model

This study examines the relation between Turkish Lira Overnight Rate (TLREF) and macroeconomic variables for future predictions. The purpose of the study is to form an opinion on the accuracy at which TLREF daily value predictions can be made at low frequencies (Monthly, Quarterly, Annually).
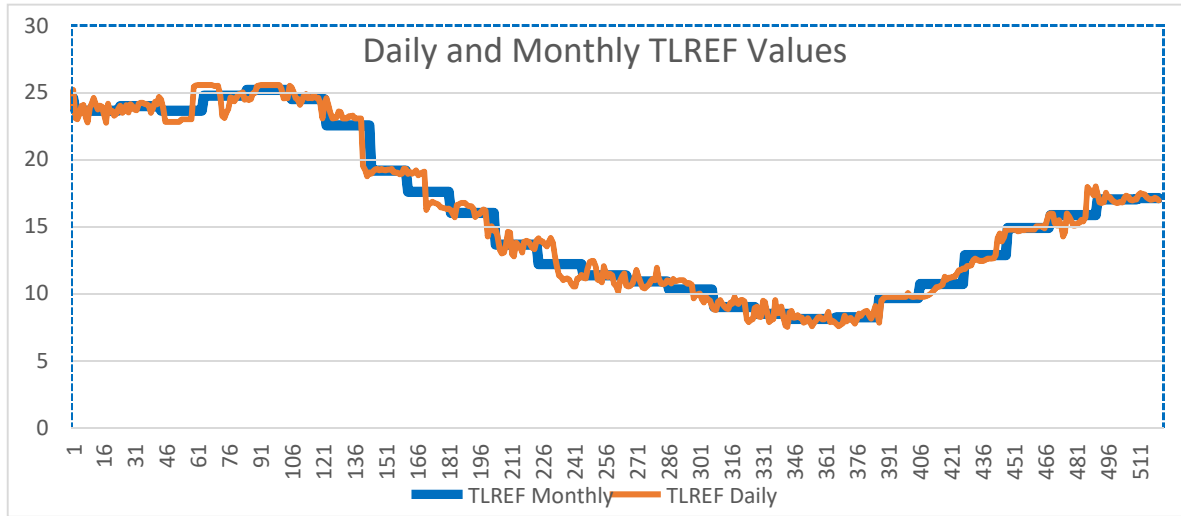
The aim is to find the relation between the dependent variable - defined as TLREF - and macroeconomic factors using linear regression models with delayed values of each variable. Additional studies were also conducted regarding the use of the ARCH, GARCH, VECM (Vector Error Correction Model) and VAR (Vector Autoregressive) models, which can potentially be used in this field, but successful models worth presenting could not be achieved. After the model was created, the expectations of the Central Bank of the Republic of Turkey (CBRT) regarding macroeconomic factors were used for future predictions.

The studies should be considered as a preliminary step for potential models for TLREF prediction. As a general rule, macroeconomic models are established with minimum 7 years of data to capture the most extreme decrease and increase points in the economy. However, this model was prepared using data between 28/12/2018 and 31/01/2021 as the history of TLREF is quite short. Each relevant party should establish the model by calculating the results and deviation ratios according to their own predictions or expectations.
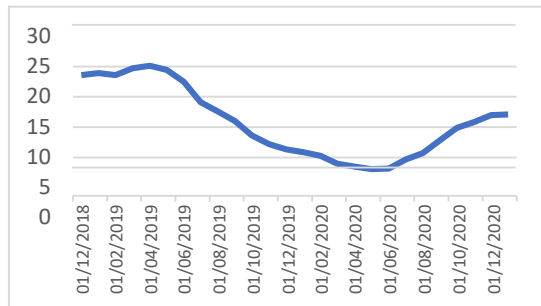
9.3.1 Used Data

The CBRT's Electronic Data Distribution System (EDDS) was used as the source for TLREF estimation. The variables Weighted Average Cost of Funding (WACF), Dollar Exchange Rate (USD/TRY) and Consumer Price Index (CPI) for which CBRT announced expectation surveys were used as independent variables in the model.
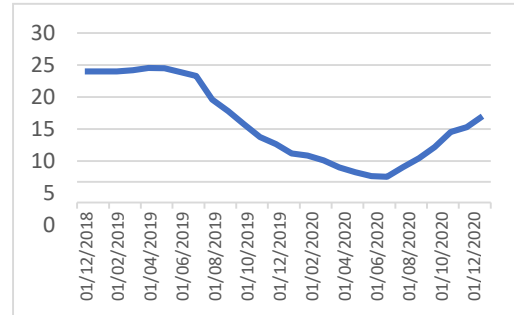
Data was received from EDDS in monthly and daily frequencies between 28/12/2018 and 31/01/2021. The variations in the monthly and daily data were examined so that the CBRT predictions can be made monthly and the delay studies based on the models can be more consistent. As seen in the following graph, the variations in the monthly data were observed to mostly cover the daily variations and using monthly data will be more suitable for prediction as macroeconomic data is not available in monthly frequency.

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Daily and Monthly TLREF Values
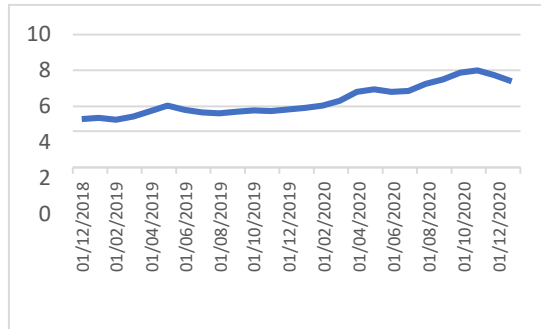
TLREF Monthly — TLREF Daily

TLREF: Turkish Lira overnight interest rate
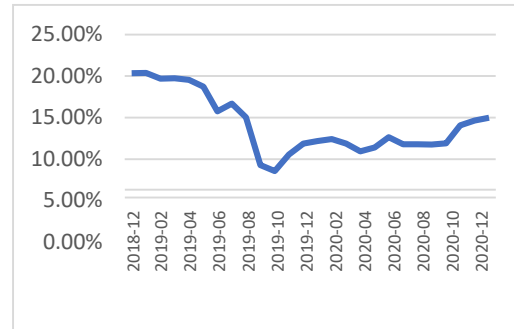

WACF: Weighted average fund cost

USD/TRY: US Dollar ND Turkish Lira exchange rate

CPI: Consumer price index (Annual Change %)

9.3.2 Methodology

A linear regression model was used to predict TLREF values. Up to 3-month delayed versions of each variable were included and used for TLREF prediction. The predictions were made with models using the coefficients of parameters from linear models and the consistency of the models were evaluated and their error terms were examined. The monthly and annual expectations values of each variable were received through EDDS, these values were used to examine how consistent predictions can be made using expectations published by the CBRT on a monthly and annual basis and a range was created for using the concerned predictions.

Last, the following model using the variables CPI, USD and WACF was developed.

$$TLREF = -25,10 + 55,86 * CPI\_D + 2,77 * USD + 0,94 * WACF\_L2$$

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Then the basic linear regression validation steps were applied on the model. The model has a prediction capability of 96% and passed the statistical tests with which we tested its normality, heteroskedasticity, stationarity, autocorrelation and multicollinearity assumptions. The test results are as follows. In applying the tests, the condition was sought to pass one of the methods commonly used for each test.

Test	Test Name	Test Statistics	P-Value	Status
Normality	Shapiro Wilk	0.97527	0.7613	Valid
Heteroskedasticity	White	6.26	0.395	Valid
Stationarity	Augmented DF	-3.3401	0.0861	Valid
Autocorrelation	Breusch-Godfrey (F)	2.2606	0.1327	Valid
Multicollinearity	VIF	1.8 / 3.2 / 4.6	N/A	Valid

After the model was developed, the predictions made using the CBRT expectation survey statistics were compared with the realization for each calculation period. The prediction studies used the CBRT's predictions for end-of-month WACF, 3 months later WACF, 1 year later WACF, end-of-month USD, one year later USD and 1 year later CPI and the CPI values realized in the relevant months. Data was created using interpolation based on the prediction ranges for months without available CBRT predictions. As the data range is short, the predicted periods had to be the same as the periods used in the model.

Data received from the CBRT's expectation surveys were used for the relevant period when making monthly, quarterly and annual predictions. The following graphs include comparisons of the predictions made using the expectation surveys and the realized values.
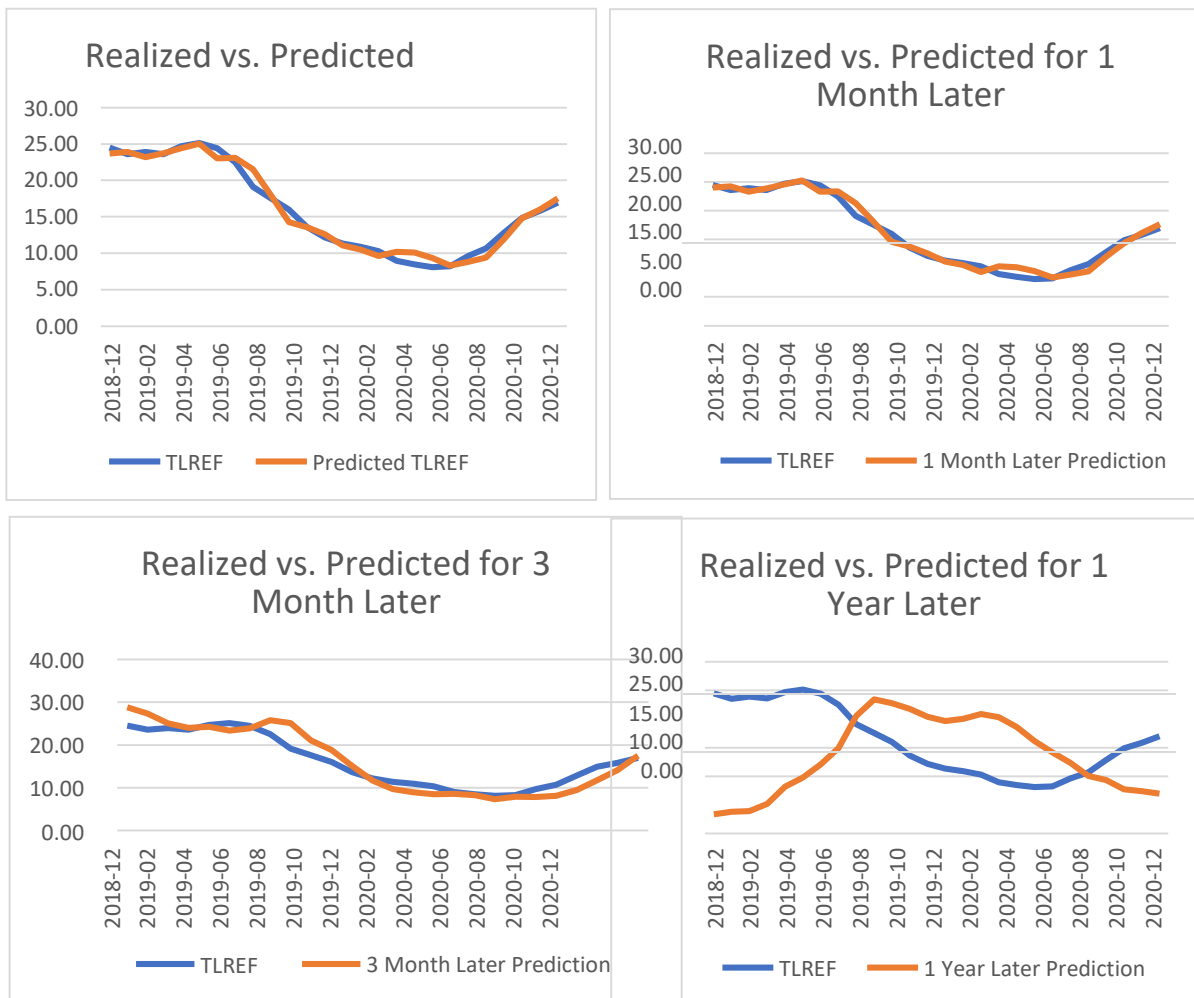
Realized vs. Predicted: Includes a comparison of realized TLREF values versus TLREF values estimated using realized macroeconomic values.

Realized vs. Predicted for 1 Month Later: Includes a comparison of TLREF calculated using CBRT's 1 month later predictions versus realized TLREF for each calculation period. (e.g., predictions dated 201905 were used for the period 201906.)

Realized vs. Predicted for 3 Month Later: Includes a comparison of TLREF calculated using CBRT's 3 month later predictions versus realized TLREF for each calculation period. (e.g., predictions dated 201903 were used for the period 201906.)

Realized vs. Predicted for 1 Year Later: Includes a comparison of TLREF calculated using CBRT's 12 month later predictions versus realized TLREF for each calculation period. (e.g., predictions dated 201806 were used for the period 201906.)

The mean absolute difference between the values obtained in the study and the realized values together with the upper and lower confidence interval values of the differences under 95% confidence interval are provided below. Examining the results, using the predictions made by the CBRT for the end of the relevant month with 95% confidence interval, the deviation ratio is realized in the range 11.91% and - %13.17, while the values are realized in the range 110.83% and -124.7% for the 1 year later predictions.

	Model Output	1 Month Later Prediction	3 Month Later Prediction	1 Year Later Prediction
Mean Difference	5.43%	5.66%	12.65%	63.68%
Upper Confidence Interval	12.13%	11.91%	27.26%	110.83%
Lower Confidence Interval	-13.17%	-13.85%	-23.16%	-124.70%

Examining the high deviation values observed in the 1 year later predictions, a significant difference was observed between the predicted macroeconomic expectations and the realizations. The deviation ratios in the table above will decrease as the predictions approach the realizations and more accurate TLREF predictions will be possible. However, in predicting TLREF, considering that monetary policy can change frequently, adding a political risk factor to the models that reflects such changes may reduce the deviation ratio of the predictions.

9.3.3 Conclusion

Some assumptions need to be used as each model developed to predict future TLREF has data for a period in which only the TRY interest rate shows significant variations. The model development data range is found to be shorter than required and future macroeconomic predictions are mostly observed to not reflect the realizations. Therefore, each model should be taken into consideration with a certain error margin when making predictions.

Examining the results reached in the light of the studies, it is observed that if daily TLREF values are used in monthly, quarterly or annual calculations, a significant correction margin should also be added to the values. However, it will be possible to reduce this correction margin for each user of the model to the extent of their own prediction accuracy and by using more complex model structures.

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