A User's Guide to Thai Overnight Repurchase Rate (THOR)

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1. Introduction

The London Interbank Offered Rate (LIBOR) scandal in 2012 exposed flaws, vulnerabilities to rate manipulation and deficiencies in regulatory oversight and governance. Regulators tried to improve the transparency in the rate calculation and regain credibility of the rate by switching from a submission-based rate to a transaction-based rate. Although regulators have tried to make significant improvements to LIBOR, these efforts were not very successful due to the significant decline in volume of term borrowing and lending transactions after the Global Financial Crisis. Subsequently, the Financial Conduct Authority, the regulator of LIBOR, announced that they will no longer compel or persuade panel banks to submit quotes for LIBOR post 2021.

Central banks, regulators, and market participants are collaborating to minimize the effects of LIBOR discontinuation. Many countries chose to develop an alternative reference rate as a replacement or as an additional reference rate in the financial market. In the earlier stages, these new rates are overnight rates because transactions are concentrated in the overnight market. Moreover, there are insufficient term transactions to build a reliable term benchmark on a daily basis.

Table 1 Reference rates in foreign markets

|	LIBOR	Overnight rate to replace LIBOR				
		SOFR	SONIA	SARON	ESTR	TONA
Currency	5 major currencies[1]	US Dollar (USD)	Sterling Pounds (GBP)	Swiss Francs (CHF)	Euro (EUR)	Yen (JPY)
Rate type	unsecured interbank rate	secured treasury repo rate	unsecured wholesale rate	secured interbank repo rate	unsecured wholesale rate	uncollateralized overnight call rate
Rate origin	survey-based	transaction-based				
Term	O/N, 1 week, 1/2/3/6 months and 1 year	O/N				

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[1] LIBOR is currently published across 5 currencies which are United States dollar (USD LIBOR), British pound sterling (GBP LIBOR), European euro (EUR LIBOR), Japanese yen (JPY LIBOR), and Swiss franc (CHF LIBOR)

2. Compounded Overnight Rate Calculation Methodology

For financial products referencing overnight rates, daily interest settlement is time- consuming and operationally- taxing for the parties involved. Therefore, counterparties usually settle payment periodically on a monthly, quarterly or annual basis. In doing so, counterparties agree upon the "compounded overnight rate". This is calculated from compounding daily overnight rates on business days (compound average) and taking the simple average on non-business days for the period of interest[2].

There may be multiple terms calculated from the compounded overnight rate. Such terms may include 1 month or 3 months. Since these term rates are calculated from the compounded overnight rate, the term rates are backward- looking term rate. This is different from the forward-looking nature of LIBOR term rates.

Figure 1 Forward-looking term rate and backward-looking term rate
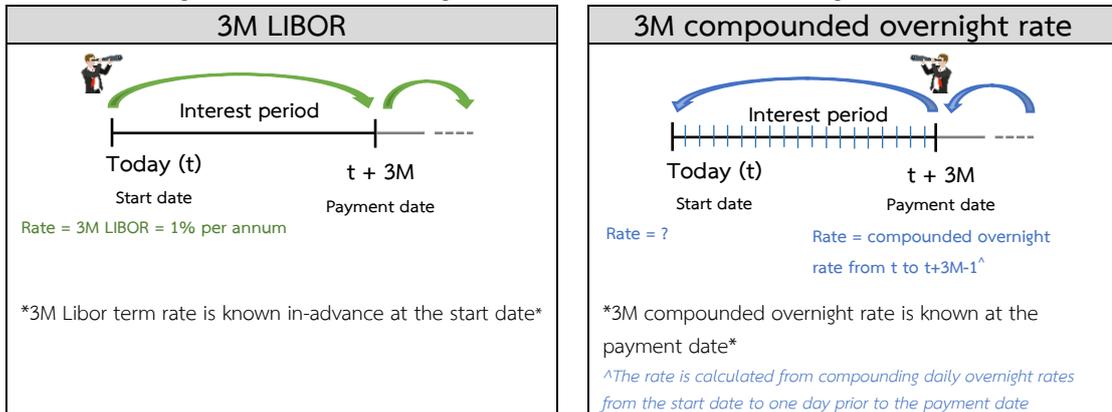
In general, overnight rates have low volatility. Users are able to approximate the compounded overnight rate for the period without the need to wait until the last day of the period. This is possible because the occurrences that would cause sudden volatility in the overnight rates are infrequent. Such occurrences may include monetary policy rate change and unusual liquidity strains in the market. The impact of these occurrences on the overall compounded overnight rate are so minimal that we may not observe any significant difference in the compounded rate. In order to allow sufficient time for operational matters before the payment date, parties may also choose to use other interest calculation and settlement- related market conventions (more details in section 4).

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[2] The compounded overnight rate is obtained by compounding the daily overnight rates in the period, not by compounding the interest due. Thus, this does not violate Section 655 of the Thailand Civil and Commercial Code which states that interest should not bear interest.

3. Development of Thai Interest Rate Benchmark Reform

The financial market conditions in Thailand is similar to that of other countries, particularly with respect to the concentration of transactions in the overnight market. Term transactions in the market are sparse due to excess liquidity in money market which allows day-to-day liquidity management. Thus, there are insufficient term transactions to build a reliable term benchmark on a daily basis. The majority of the money market transactions in the Thai financial market are private repurchase transactions (PRP). The daily volume for overnight PRP transactions in 2019 totaled to greater than 100 billion baht. High liquidity in the PRP market, particularly in the overnight interbank PRP market, makes it a suitable new alternative reference rate. It reflects the domestic money market liquidity conditions and is not sensitive to USD liquidity constraints. It also moves correspondingly with the monetary policy rate, which allows it to support the monetary policy transmission mechanism.

Figure 2 Private Repurchase Market
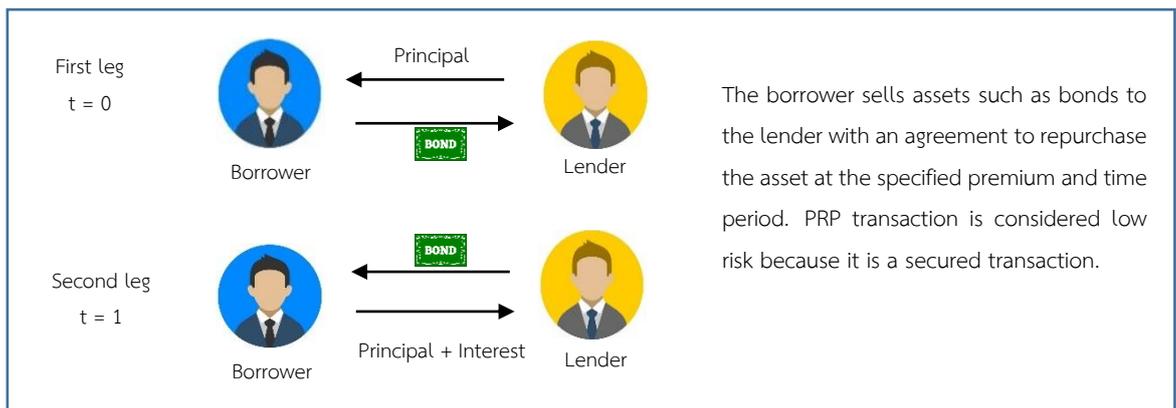
Therefore, the Thai Overnight Repurchase Rate (THOR) is developed as the new reference rate for the Thai financial market. THOR[3] is the interbank overnight private repurchase rate. The Bank of Thailand (BOT) is the rate administrator and the Thai Bond Market Association (ThaiBMA) is the calculation agent. THOR is published on the BOT's website[4] and ThaiBMA's website every Bangkok business day at 5.00 pm.

THOR differs from other existing reference rates such as the Thai Baht Interest Rate Fixing (THBFIX) and the Bangkok Interbank Offered Rate (BIBOR) in terms of the

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[3] THOR metadata https://www.bot.or.th/App/THOR/SharedFiles/FM_RT_013_ENG.PDF

[4] THOR publication page https://www.bot.or.th/App/THOR/en
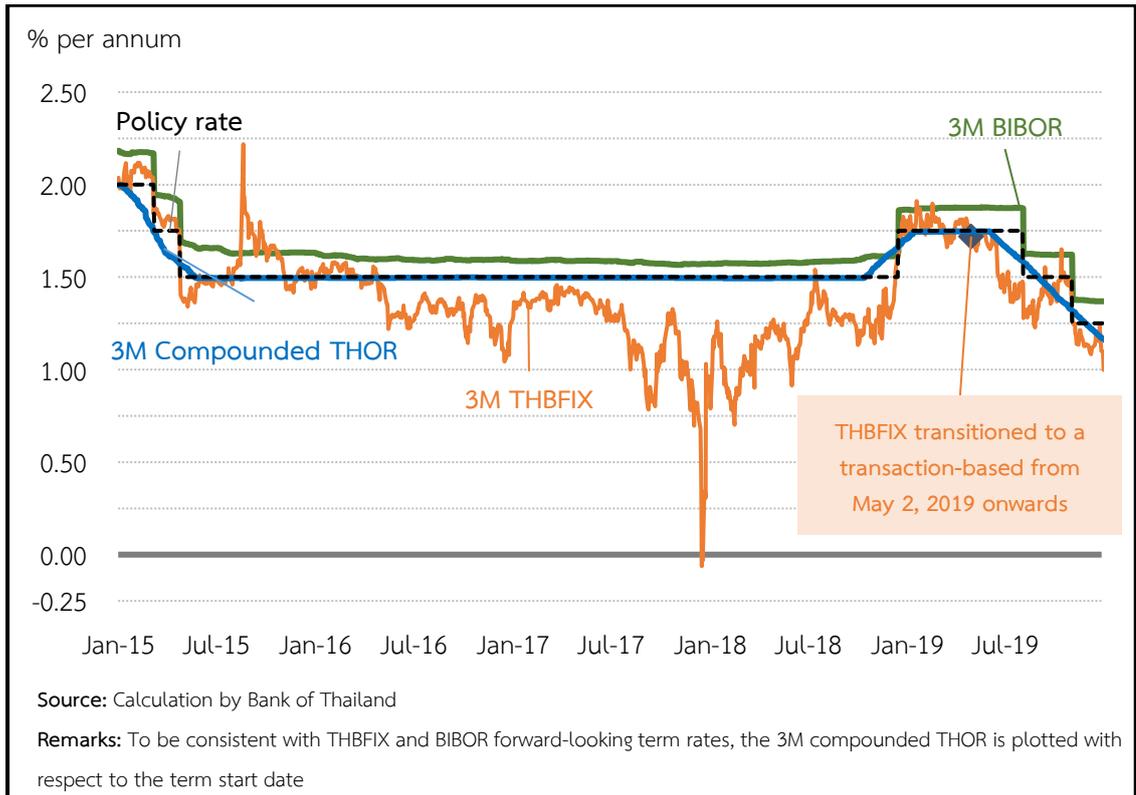
  Historical THOR data publication page
https://www.bot.or.th/App/BTWS_STAT/statistics/BOTWEBSTAT.aspx?reportID=945&language=Eng

underlying market. The underlying market for THBFIX is the USDTHB interbank swap market. THBFIX is the synthetic cost of borrowing the Thai Baht, obtained by borrowing US dollar for the same maturity, and swapping out the US dollar in return for the Thai Baht. USD is used as collateral for the FX swap transactions which causes the THBFIX to be sensitive to the USD liquidity condition. Additionally, LIBOR permanent cessation puts THBFIX at risk as LIBOR is a component in the calculation of THBFIX. BIBOR is an uncollateralized interbank lending rate which is vulnerable to low volume of underlying transactions.

Table 2 The characteristics of interest rate benchmarks in the Thai financial market

	THOR	THBFIX	BIBOR
Status	New reference rate	THBFIX will cease publication once LIBOR cessation event occurs. "Fallback THBFIX" will be published as the fallback rate for THBFIX.	Remains unchanged
Underlying market	interbank private repurchase	USDTHB swap	unsecured interbank
Data collection	transaction-based	transaction-based (since 2019)	survey-based
Term	O/N (compounded overnight rate is used as a backward-looking term rate)	O/N, 1 week, 1/3/6 months and 1 year (Fallback THBFIX will only have 1/3/6 month term rates)	O/N, 1 week, 1/2/3/6 months and 1 year
Movement in correlation with policy rate	☑	☒ Impacted by USD liquidity	☑ Term rates do not reflect future rate expectations due to low transaction volume.

Figure 3 Reference rates in the Thai financial market

% per annum

Policy rate

3M BIBOR

3M Compounded THOR

3M THBFIX

THBFIX transitioned to a transaction-based from May 2, 2019 onwards

Source: Calculation by Bank of Thailand

Remarks: To be consistent with THBFIX and BIBOR forward-looking term rates, the 3M compounded THOR is plotted with respect to the term start date

4. THOR as a reference rate for financial products

Using overnight rates as reference for financial products is not uncommon in the Thai financial market. The Minimum Lending Rate (MLR) that is commonly used in loan contracts has similar characteristics to THOR. MLR is also a floating rate that can change over the duration of the contract. However, MLR does not fluctuate as often as overnight rates, making it easier to forecast the interest payment due at the settlement date for MLR-linked.

For financial contracts referencing THOR or other overnight rate benchmarks, the interest rate is calculated from compounding the daily overnight rates of the interest period, excluding the payment date. Thus, the interest due is only known on the last day of the interest period. In order to allow for sufficient time for parties involved in the contract to prepare for payment settlement, users of the THOR or other overnight rate benchmarks can explore interest calculation and settlement-related market conventions as described in the following table.

Table 3 Interest calculation and settlement-related market conventions for THOR-linked financial contracts[5]

Approaches	Advantages	Disadvantages
In-arrears Approach - Plain THOR / Interest period / payment date THOR compounding period used to calculate compounded THOR (observation period) matches the interest period	- THOR compounding period perfectly matches the interest period	- There is no buffer time to prepare for the settlement of interest payments
- Payment Delay THOR / Interest period THOR compounding period used to calculate compounded THOR matches the interest period but interest payment is due a number of days following the interest period	- THOR compounding period perfectly matches the interest period - Some buffer time to prepare for the settlement of interest payment	- Increased counterparty credit risk
- Lookback THOR / Interest period Compounded THOR calculated from THOR for the period beginning and ending a certain number of days before the interest period (typically 1-5 days). There are 2 sub-approaches under this method. (1) **Lookback with observation shift (Backward shift)** Compounded THOR is calculated from the daily THOR and the actual number of calendar days (weight) in the observation period. (2) **Lookback with no observation shift** Compounded THOR is calculated from the daily THOR in the observation period. The actual number of calendar days (weight) aligns with the interest period .	- Some buffer time to prepare for the settlement of interest payment	- THOR compounding period does not exactly match the interest period
- Lockout or Suspension period THOR / Interest period	- Some buffer time to prepare for the	- The final THOR observed at the start of the lockout period

[5] Example of compounded interest calculation in each convention:
https://www.bot.or.th/English/FinancialMarkets/Documents/Overnight%20rate%20convention%20example%20eng.xlsx

Approaches	Advantages	Disadvantages
THOR is not updated for the final few days (lockout period of typically 1-5 days) of the interest period. Daily compounding of THOR begins at start of the interest period and the final observed THOR is used in the calculation throughout the lockout period	settlement of interest payment	may not be a representative rate for the entire lockout period
In-advance Approach Compounded THOR is calculated from THOR observed before the current interest period	- Compounded THOR is known at the beginning of the interest period	- THOR compounding period does not match the interest period - Difficult to hedge interest rate risk

To assist commercial banks to start developing loans referencing THOR, BOT has conducted a survey across banks in Thailand and issued a THOR Pilot Lending Practice[6] based on the majority views. Most commercial banks viewed that the backward shift approach is the suitable convention for THOR-linked loans. In any case, commercial banks and their clients should negotiate the terms of financial contract to mutually agree upon a convention. Issuers of both corporate bonds and government bonds also have the liberty to set the appropriate conventions for their bonds. For instance, the Bank of Thailand THOR Floating Rate Note (BOT TFRN) uses a backward shift approach as well. Parties of the financial contract that are looking to hedge against interest rate risk through derivatives should also take into account the derivative market conventions.

To facilitate market adoption of THOR, BOT has published THOR Index and THOR Calculator. Market participants can use these tools to calculate the compounded THOR for any given tenor.

THOR Index[7] represents the cumulative value of compounding THOR over time, with an initial value of 100 on April 1, 2020. THOR Index reflects the effect of compounding THOR each business day and taking the simple average on non-business day. THOR Index is published by rounding to eight decimal places. Although THOR

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[6] https://www.bot.or.th/Thai/FinancialMarkets/Documents/THOR_pilot_lending_practice.pdf

[7] THOR Index publication page https://www.bot.or.th/App/THOR/en
  Historical THOR Index data publication page
https://www.bot.or.th/App/BTWS_STAT/statistics/BOTWEBSTAT.aspx?reportID=946&language=Eng
THOR Index metadata https://www.bot.or.th/App/THOR/SharedFiles/FM_RT_014_TH.PDF

Index is calculated daily, BOT publishes THOR Index only on business days at 9.30 am. The Index for non-business days will be published on the following Bangkok business day.

THOR Index can be used to obtain the compounded rate for the THOR compounding period or observation period. The calculation method is as follows:

$$\text{Compounded THOR per annum} = \left(\frac{\text{THOR Index}_{t+n}}{\text{THOR Index}_t} - 1\right) \times \frac{365}{n}$$

where t is the start date of the observation period

n is the number of calendar days in the observation period

This calculation method works even if the start or end date falls on a non-business day. However, it does not work for contracts that employ the Lookback with no observation shift convention and the Lockout or Suspension period convention.

In general, the result from this method will be equal to the compounded THOR obtained by compounding the daily THOR from the start date (t) until the final day prior to the end date (t + n − 1). However, these two calculation methods may sometimes result in slightly different final rates due to rounding differences.

Example for calculating the compounded THOR using the THOR Index
To illustrate the calculation method, we refer to this example of a 1 year loan contract, with interest settlement at the final business day of every 3 months using a 5 business day backward shift approach.

Figure 4 Example for calculating the compounded THOR using the THOR Index
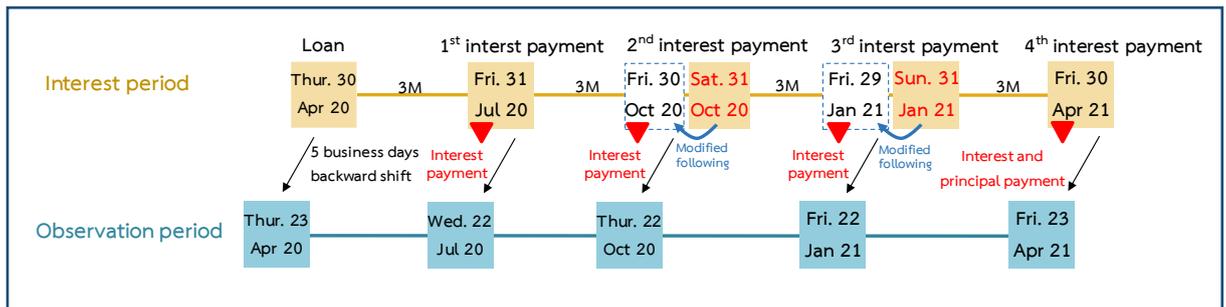
Using the 5 business day backward shift approach, the observation period for the first interest period is from April 23, 2020 to July 22, 2020. The compounded THOR per annum for first interest period is $\left(\frac{\text{THOR Index}_{22\ July\ 20}}{\text{THOR Index}_{23\ Apr\ 20}} - 1\right) \times \left(\frac{365}{90}\right)$

For the other interest periods,

$$\text{Compounded THOR}_{\text{interest period 2}} = \left(\frac{\text{THOR Index }_{22\ Oct\ 20}}{\text{THOR Index}_{22\ July\ 20}} - 1 \right) \times \left(\frac{365}{92} \right)$$

$$\text{Compounded THOR}_{\text{interest period 3}} = \left(\frac{\text{THOR Index }_{22\ Jan\ 21}}{\text{THOR Index }_{22\ Oct\ 20}} - 1 \right) \times \left(\frac{365}{92} \right)$$

$$\text{Compounded THOR}_{\text{interest period 4}} = \left(\frac{\text{THOR Index }_{23\ Apr\ 21}}{\text{THOR Index}_{22\ Jan\ 21}} - 1 \right) \times \left(\frac{365}{91} \right)$$

THOR Calculator[8] is a tool for calculating the compounded THOR for a specified period, which is obtained from THOR Index. Similarly, THOR Calculator is compatible with all THOR-linked financial contract conventions except for <u>Lookback with no observation shift</u> and <u>Lockout or Suspension period</u> conventions.

The 2 models of THOR Calculator are as follows:

1) **Observation Period Model** is recommended when the period referencing THOR is known.

By selecting April 23, 2020 as the start date and July 22, 2020 as the end date, we can calculate the compounded THOR of the first observation period for the example in Figure 4. The compounded THOR obtained is equivalent to $\left(\frac{\text{THOR Index}_{22\ July\ 20}}{\text{THOR Index}_{23\ Apr\ 20}} - 1 \right) \times \left(\frac{365}{90} \right)$.

2) **Interest Period Model** is recommended when interest period indicated in the contract is known. Lookback with observation shift (Backward shift) may be applied in order to calculate compounded THOR for the specified observation period.

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[8] THOR Calculator https://www.bot.or.th/App/THORCalculator/en

THOR calculator manual https://www.bot.or.th/app/thorcalculator/sharedFile/THOR_Calculator_Manual_EN.PDF

The following steps illustrate how to calculate the compounded THOR for the first interest period in Figure 4:

1. Select the start date *(April 30, 2020)* and end date *(July 31, 2020)* of the interest period as indicated in the contract
2. Select the business day convention *(Modified Following)*
3. Select the number of business days applicable for the backward shift approach *(5 business days)*
4. Users may input principal amount and spread over compound THOR, if applicable

THOR Average is the term rate obtained from compounding the daily values of THOR (compound setting in arrears method) for the following tenors: 1 month, 3 months and 6 months. It is published on the BOT and ThaiBMA website[9] at 9.30 am every Bangkok business day. The start date[10] for each THOR Average tenor is determined by referring to the corresponding numerical dates and the modified

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[9] THOR Average publication page https://www.bot.or.th/App/THOR/en
Historical THOR Average data publication page
https://www.bot.or.th/App/BTWS_STAT/statistics/BOTWEBSTAT.aspx?reportID=945&language=Eng
[10] For example, the 3 month THOR Average published on July 22, 2020 has a start date of April 22, 2020. For start date that falls on a non-business day, THOR for that day would equal to THOR on the preceding business day.

preceding[11] business day convention is applied to the start date if the start date falls on a non- business day. THOR Average is calculated using the compounding methodology (as outlined in section 2) of daily THOR from the start date until the final business day prior to the publication date.

      Example for calculating the interest payment using the THOR Average Figure 5 illustrates the calculation method of interest payment using 3 months THOR Average (3M THOR Average) for a 1-year loan contract, with interest settlement at the final business day of every 3 months using a 5 business day backward shift approach.

Figure 5 Example for calculating the Compounded THOR using the 3M THOR Average
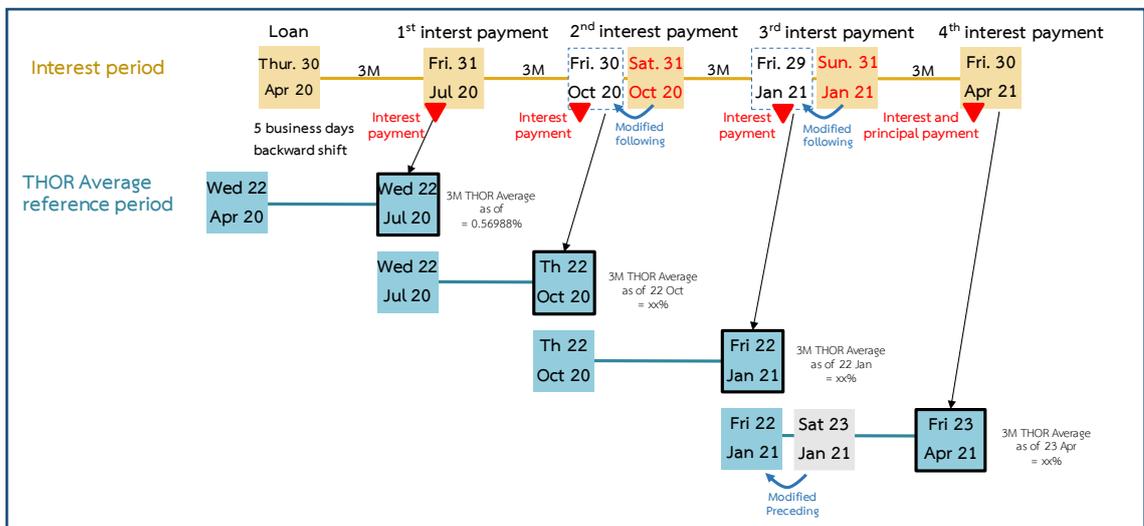
      As shown in Figure 5, the first interest settlement date is July 31, 2020. Interest payment for the first interest period can be calculated by multiplying the 3M THOR Average on July 22, 2020 (applying the 5 business day backward shift convention) with the number of calendar days in the interest period[12]. 3 M THOR Average on July 22, 2020 was calculated by compounding the daily values of THOR from April 22, 2020 to July 21, 2020. For the following interest periods, the relevant 3M THOR Average rates are published on October 22, 2020, January 22, 2021, and April 23, 2021 respectively.

      Table 4 shows the advantages and disadvantages of using THOR and THOR Average to calculate compounded THOR.

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[11] If the start date falls on a non-business day, the date will be the first preceding day that is a Business Day, unless the first preceding Business Day is in the previous calendar month, in which case that date will be the first following day that is a Business Day.

[12] Interest payment for the interest period $= \dfrac{\text{Principal} \times \text{THOR Average} \times \text{Number of calendar days in the interest period}}{365}$

Table 4 Advantages and disadvantages of using THOR and THOR Average

|	Advantages	Disadvantages
THOR	1. Flexibility to calculate compounded THOR from any given tenor, even odd tenors such as 14-days or 2 months. 2. The start date of the compounding period may fall on a non-business day. This is suitable for financial contracts that do not apply business day adjustment conventions. 3. Applicable to all Interest calculation and settlement-related market conventions.	Users must individually compound the daily THOR to obtain the compounded THOR for the interest period.
Tools - THOR Index - THOR calculator	These tools facilitate the calculation of compounded rates for any given tenor.	Not applicable for financial contracts that employ the Lookback with no observation shift and Lockout or Suspension period conventions.
THOR Average	THOR Average rates are ready-to-use term rates for calculating interest payment.	1. THOR Average rates are standardized and not customizable. For example, THOR Average has no tenors other than 1, 3, and 6 months and there are no rates published on non-business days. Therefore, THOR Average may not be suitable for some financial contracts. 2. The reference periods for THOR Average may be different from the interest period of derivatives. Therefore, users may not perfectly hedge their financial contracts with derivatives.

5. Hedging instruments to manage overnight interest rate risk

Although THOR moves in line with the policy rate and experiences low volatility, market participants may still face rate volatility, especially for long term contracts. To hedge against overnight interest rate risk, BOT and market participants have started developing the "overnight index swaps" (OIS).

OIS is an interest rate swap agreement where a fixed rate is swapped against a floating rate, which is an index of an overnight reference rate. The floating leg is obtained from compounding the overnight interest rate. The BOT, on behalf of the Steering Committee on Commercial Banks' Preparedness on LIBOR Discontinuation, has issued a guideline for the conventions of OIS and USDTHB Cross-Currency Swap (CCS) referencing THOR for the Interbank market[13]. According to the guideline, the net settlement for the floating leg and fixed leg is two days after the end date (payment delay) to allow for sufficient time to prepare for payment. For long term contracts, interest will be settled every 3 months, using the modified following business day convention.

To effectively hedge the overnight rate risk for THOR-linked loans using OIS, we should match the observation periods of the two contracts as closely as possible. Nevertheless, the payment dates can still differ no matter how closely the observation period of loans matches the OIS interest period. This is because OIS uses a 2 business day payment delay convention. Meanwhile, loan contracts may use other conventions and a different length of buffer time to prepare payment settlement. To illustrate this point, Figure 6 provides an example of a 6-months loan contract from January 24, 2020 to July 24, 2020, using 5 business day backward shift convention. The observation period is from January 17, 2020 to July 17, 2020. By matching the OIS interest period to the loan's observation period, the OIS settlement is 3 days before the loan payment date.

Figure 6: OIS hedging for loan referencing THOR Average
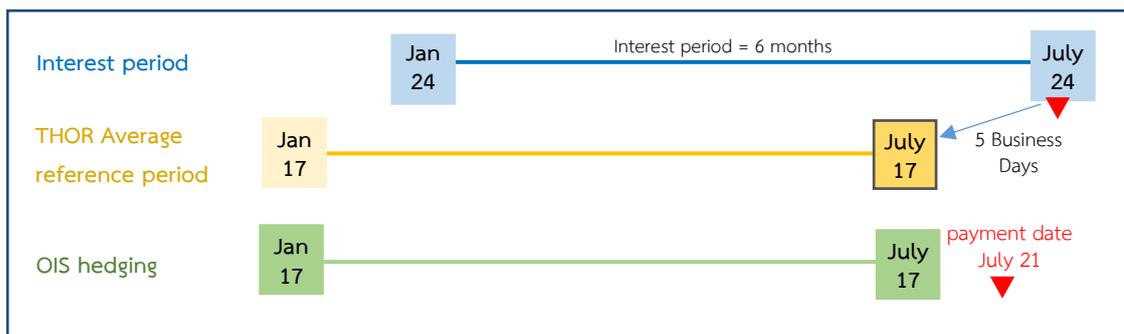
6. Future developments for THOR

The Steering Committee on Commercial Banks' Preparedness on LIBOR Discontinuation, involving BOT, the Thai Bankers' Association and the Association of International Banks, is committed to promoting market adoption of THOR. The

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[13] https://www.bot.or.th/Thai/FinancialMarkets/Documents/THOR%20derivative%20conventions%20for%20Interbank.pdf

Committee's key tasks are to ensure smooth and fair transition by establishing market conventions and infrastructure, building liquidity in the THOR market, and engaging market players.