Annexes: Selected Issues

1. Integrating Financial Stability Considerations into R-Star Estimates[54]

The neutral rate of interest (r-star) provides insights into monetary policy stance, but the Holston-Laubach-Williams (HLW) model—a workhorse for r-star estimation—does not account for financial factors crucial to the Bank of Thailand's monetary policy formulation. Given the Bank's objective to facilitate the deleveraging of still-elevated household debt, we refine r-star estimation by incorporating an additional credit gap variable into the original HLW model. This aims to draw more practical policy implications from estimated r-star. We also explore model variations using potential output estimates from a production function approach, seeking an r-star estimate more reflective of underlying economic fundamentals. Results show that including the credit gap increases Thailand's estimated r-star, but it remains below the actual policy rate. Furthermore, our model variations show persistent negative output gap in recent period. This suggests current monetary policy stance may be slightly tight, even accounting for credit situations. Thailand's policy rate exceeds the range of r-star estimates from all model variations, indicating room for monetary policy easing if growth continues to underperform.

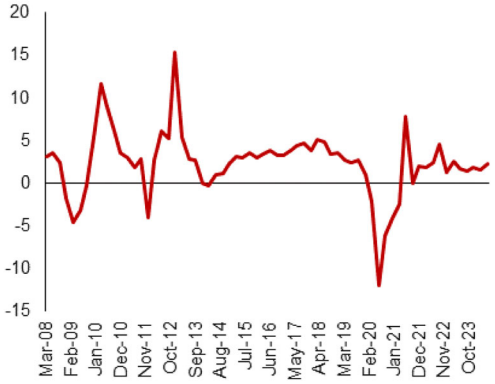
1. The neutral rate of interest is a critical benchmark for monetary policy, but its estimation is challenging in the context of Thailand. The neutral rate of interest (r-star) is the short-term real interest rate that would prevail in the absence of business cycle shocks, consistent with economic growth converging to its potential and prices remaining stable (Borio 2021). It serves as the equilibrium real interest rate closely monitored by central banks to guide monetary policy implementation. While the concept of r-star is intuitive, it is empirically unobservable, and its estimation is highly dependent on the model specification. In estimating r-star at low frequencies, the Laubach-Williams (LW) model has become the workhorse approach. However, the HLW model is primarily designed for advanced economies where data aligns well with the New Keynesian model over extended periods. This limits its applicability to emerging market economies (Barrett and others 2023). In the context of Thailand for instance, financial factors such as private sector leverage is an important consideration in the monetary policy formulation framework, yet it is not explicitly accounted for in the LW model.

Rationale for Integrating Financial Factor into R-star Estimation

2. Thailand has experienced sluggish growth and persistently low inflation since 2023, intensifying debates over whether the current policy rate is above its neutral level. Thailand's economy has been underperforming expectation, with growth of just 1.9 percent in 2023 and less than 2.0 percent year-on-year in the first half of 2024 (Figure A1.1). These figures not only miss the government's 3.0–5.0 percent target but also fall well below the pre-pandemic trend growth of about 3.0 percent. The lack of a sustained rebound has resulted in a persistent negative output gap. Inflation has also been weak, turning negative in Q4 2023 and Q1 2024, and although positive in Q2 2024, it remains below the BOT's target range (Figure A1.2).

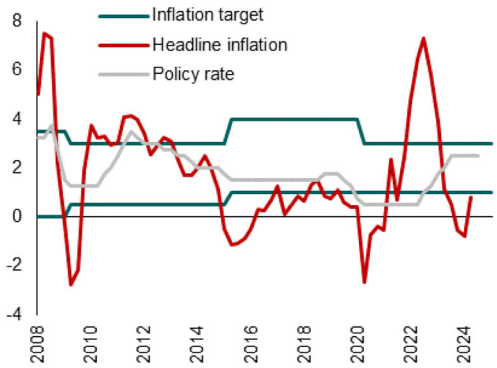
[54] Prepared by Haobin Wang, Michael Wynn and Yuhong Wu.

Figure A1.1. GDP Growth, 2008–Q2 2024
(Year-on-year, Percent)



Source: National authorities via CEIC.

Figure A1.2. Policy Rate and Headline Inflation versus Inflation Target, 2008–Q2 2024
(Percent)



Source: National authorities via Haver Analytics.

3. While the traditional HLW and Taylor Rule model both suggest room for monetary easing, high household debt calls for more nuanced consideration for the case of Thailand. Based on the Holston, Laubach, and Williams (HLW) 2023 model, Thailand's current policy rate is above its neutral level, suggesting the current monetary policy stance that may be restrictive (AMRO 2024). Similarly, the policy rate generated from the Taylor Rule model is also lower than actual policy rate. However, the BOT has been cautious in lowering interest rate despite sluggish growth and subdued inflation due in part to concerns about high household debt.[55] The high household debt, accumulated during the low-interest-rate environment following the GFC and exacerbated by the pandemic, reached a peak of 95.5 percent of GDP in Q1 2021. The BOT faces a dilemma: lowering rates might encourage unproductive loan growth and hinder deleveraging, while keeping rates high could increase the debt servicing burden, especially for low-income households.

4. The debt situation not only requires more nuanced monetary policy considerations but also has broader implications for potential growth and the trajectory of r-star. High leverage exerts a drag on consumption and trend growth (Mian and others 2015; Dynan 2012), with Mian and others (2021) illustrating that debt shifts resources from borrowers to savers, leading to persistently low interest rates. Supply-side effects of debt (Cecchetti and Kharroubi 2015; Juselius and others 2016) show that credit booms misallocate resources and slow potential growth, potentially creating a negative feedback loop (Lo and Rogoff 2015). These findings suggest that household debt and the credit cycle are endogenous factors influencing r-star dynamics. To address this, Borio and others (2017) establish a "finance-neutral" natural rate estimate, yielding a higher r-star estimate that falls less than in the LW model since 2000. Krustev (2019) further models the financial cycle as a deviation from long-run credit equilibrium, suggesting that LW estimates of r-star have a slight upward bias after 2000 due to overestimated trend output growth masked by credit boom and failure to account for persistent tailwinds during 2001–2007's financial leverage build-up.

[55] See, for example, the Bank of Thailand's Monetary Policy Committee (MPC) press release on June 12. The Committee expressed concerns about high household debt levels and stated that credit growth should align with ongoing debt deleveraging efforts to promote long-term financial stability.

Estimation Approaches

5. To align r-star assessment closer to Thailand's monetary policy goals, we incorporate other considerations into the baseline HLW model. The HLW model, which primarily ties r-star estimates to trend output growth, does not account for other critical factors such as demographic shifts, risk appetites, fiscal deficits, and financial imbalances. A wide literature (Kiley 2015; Cukierman 2016; Taylor and Wieland 2016; Borio and others 2017; Krustev 2019) suggests that omitting financial imbalances in the LW framework leads to biased estimates of r-star. Given Thailand's high household debt and the BOT's goals of maintaining inflation, growth, and financial stability, it is essential to revisit the HLW model by incorporating financial conditions to generate r-star estimates with more practical policy implications.

6. We extend the HLW model by incorporating the credit-to-GDP gap as a proxy for financial cycle dynamics. To better capture r-star trends under high leverage, we extend the HLW model to include the credit cycle variable. Similar to Krustev (2019), we use the Bank for International Settlements (BIS) credit-to-GDP gap data as a proxy for financial cycle dynamics. We explicitly model the linkage between the credit-to-GDP gap and r-star, as well as the output gap, in the HLW framework. This approach, following Borio and others (2017), allows for a more nuanced distinction between long-term trends and temporary deviations in the natural rate caused by financial headwinds or tailwinds.[56]

7. We further extend the HLW model by imputing a production-function-estimated potential output. The output gap estimates from the LW model faced controversies as they showed substantial deviation from results derived from production-function approaches (Kiley 2015; Pescatori and Turunen 2016). To get a r-star estimate that is more reflective of underlying economic fundamentals and less susceptible to certain limitations of statistical smoothing methods, we incorporate the potential output from the production function approach into the HLW model.

Model Results[57]

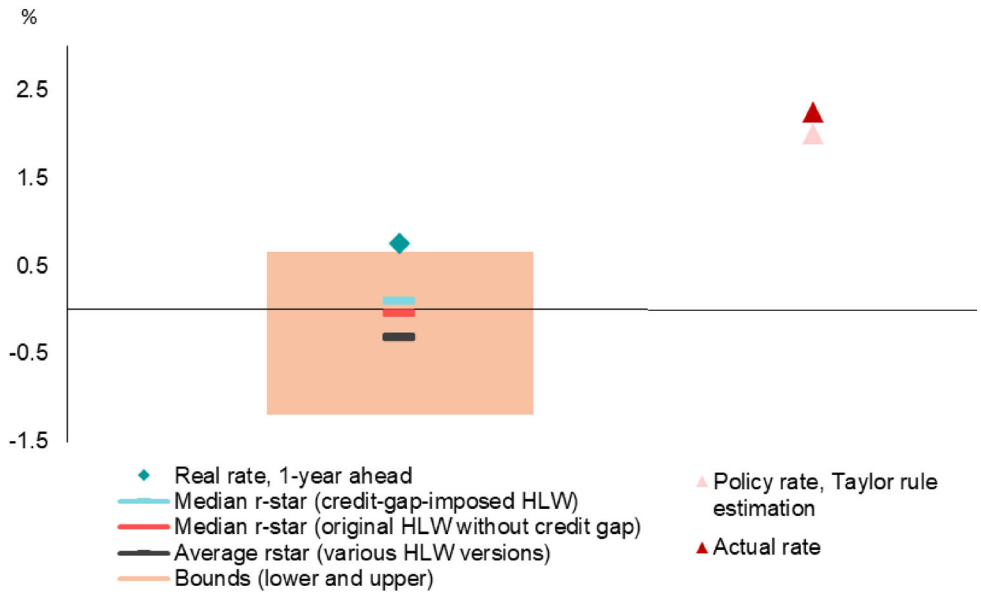
8. The incorporation of the credit gap slightly increases r-star estimates, but it remains below current policy rate. Our r-star estimates with credit gap yield a median estimate close to zero in early 2024. This is lower than Thailand's current real policy rate of about 0.75 percent. R-star estimate with credit gap saw a quick drop from second half of 2022 to early 2024, driven in part by the narrowing positive credit gap, widening negative output gap, and falling inflation over this period. The credit-gap model produces generally higher r-star estimates than the original HLW model (Figure A1.3), consistent with the rising credit gap during most of the estimation period (Figure A1.4). However, estimates across all four model variations remain in a narrow range (Figure A1.7), suggesting that the credit gap's impact on Thailand's r-star estimates is relatively limited (Figure A1.4). Possible

[56] Borio and others (2017) uses a vector autoregressive system to pin down a sustainable level of the credit-to-GDP ratio, which is jointly determined by the leverage gap—deviations from the long-run equilibrium between the credit-to-GDP ratio and asset prices—and the debt service gap. However, during booms, asset prices often outpace the rise in credit-to-GDP ratio, leading to A decline in the leverage gap despite a rising credit-to-GDP ratio, which could mask the buildup of financial imbalances. To keep the model more tractable, we omit the interactions between credit-to-GDP ratio and asset prices or debt service burden.

[57] Estimation period for the original and credit-gap imposed HLW runs from Q1 1994 –Q1 2024, while the estimation period for the remaining two approaches incorporating production function potential output runs from Q1 1992–Q1 2024.

reasons include a relatively weak relationship between credit and output gaps in Thailand over the estimation period.[58]

Figure A1.3: Models estimates suggest that current policy rate in Thailand may be above the neutral interest rate.
(Percent)



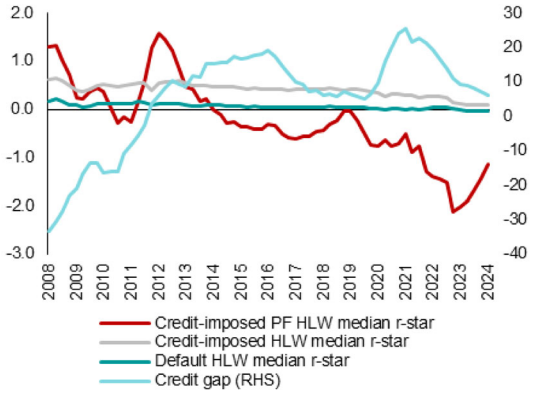
Source: National authorities via Haver Analytics; and AMRO staff calculations.
Note: The neutral rate of interest is estimated using the Holston, Laubach, and Williams (HLW) (2023) model. We adopt a similar but simplified approach to include credit gap in the modeling process, as in Juselius, Borio, Disyatat and Drehmann (2016).

9. Using the potential output from production function approach leads to higher variability in r-star estimate (Figure A1.5). The potential output derived from the production function approach takes into account the trends and relationship between capital, labor, and total factor productivity (TFP), which could undergo significant changes after crises. The HLW framework and the HP filter used to obtain potential output both seek to smooth out cyclical fluctuations, which could mask the structural shifts in the economy. When incorporating both credit gap and production function approach, the r-star estimates are higher during the Asian Financial Crisis and the period 2011–2012 (Figure A1.6). This suggests that there could be interactions between the credit cycle and structural changes during periods of rapid leveraging or deleveraging.

10. There is higher uncertainty in r-star and output gap estimates around major crisis periods. Economic shocks and rapid changes in leverage during these times can lead to fluctuations in trend output growth and r-star. Although the HLW model introduces time-varying variability by applying variance scale parameters to downweigh extreme outliers, the estimates still show a much larger range during the Global Financial Crisis and COVID-19 across different model variations. Interestingly, periods of household debt build-up, such as during the first-car scheme and historic flood in 2011–2012, also show greater estimate ranges. This suggests that incorporating the credit gap yields significantly different estimates during periods of increasing leverage, underscoring the importance of incorporating financial imbalances in r-star estimation and monetary policy making.

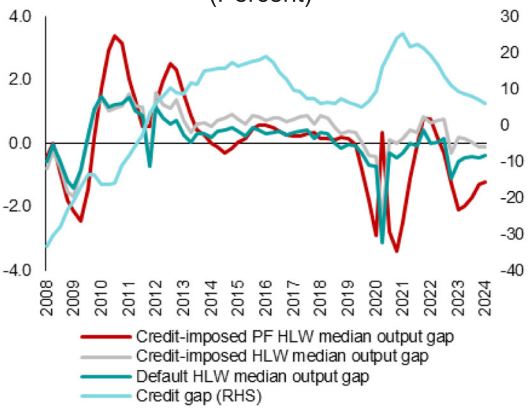
[58] In our models, the dynamics of r-star are more strongly influenced by output gaps than by credit gaps.

Figure A1.4. Neutral Rate Estimates: Default vs Variation Models
(Percent)



Source: National authorities via Haver Analytics; BIS; and AMRO staff estimates.
Note: PF = Production function; Figure shows estimated period from 2008 to Q1 2024. The r-star estimates are derived from three different model variations of the HLW model, namely the default HLW; the credit-gap imposed HLW, and the credit-gap imposed PF HLW.

Figure A1.5. Output Gap Estimates: Default vs Variation Models
(Percent)

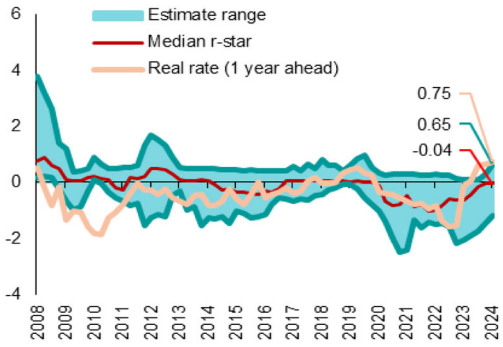


Source: National authorities via Haver Analytics; BIS; and AMRO staff estimates.
Note: PF = Production function; Figure shows estimated period from 2008 to Q1 2024. The output gap estimates are derived from three different model variations of the HLW model, namely the default HLW; the credit-gap imposed HLW, and the credit-gap imposed PF HLW.

11. The persistent negative output gap indicated by the model results suggests there is room for monetary policy easing. The output gap estimates derived from our models point to a negative output gap that has persisted over recent quarters (Figure A1.7). It is worth noting that compared to HP-filtered potential output, production-function-based potential output yields a larger and more persistent output gap.[59] The persistence of a negative output gap is consistent with Thailand's continued weaker-than-expected growth performance in recent quarters, which has been hampered by both domestic and external factors. This suggests that the current monetary policy stance may be restrictive, given the economy's position relative to its potential.

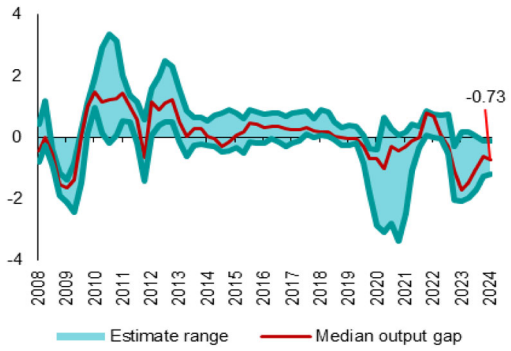
[59] HP-filtered potential output tends to track actual output more closely compared to fundamental-based potential output due to smoothing techniques.

Figure A2.6. Estimated R-Star, 2008–Q1 2024
(Percent)



Source: National authorities via Haver Analytics; and AMRO staff estimates.
Note: PF = Production function; Figure shows estimated period from 2008 to Q1 2024. The range of estimates is derived from four different model variations of the HLW model, namely the default HLW; the credit-gap imposed HLW, the PF HLW, and the credit-gap imposed PF HLW.

Figure A2.7. Estimated Output Gap, 2008–Q1 2024
(Percent)



Source: National authorities via Haver Analytics; and AMRO staff estimates.
Note: PF = Production function; Figure shows estimated period from 2008 to Q1 2024. The range of estimates is derived from four different model variations of the HLW model, namely the default HLW; the credit-gap imposed HLW, the PF HLW, and the credit-gap imposed PF HLW.

12. Overall, our analysis suggests that there is room for monetary policy easing should growth continue to underperform. Policy rate in Thailand remains above the r-star estimates from all our model variations, reflecting persistent negative output gap, sluggish inflation, and fast-narrowing credit gap. Our model results suggest that a lower policy rate would be more consistent with a neutral stance of monetary policy. Should economic growth continue to underperform baseline expectation and inflation remains below the inflation target, there is room for the Bank of Thailand to ease the policy rate.

13. The uncertainty surrounding the r-star highlights the critical need for a flexible and forward-looking monetary policy framework. Going forward, the trajectory of r-star can be increasingly uncertain. As illustrated in the BIS quarterly review (2024), the downtrend in potential growth, population aging, and greater risk aversion would continue to weigh on r-star. Additionally, prolonged deleveraging might dampen growth and r-star (Krustev 2019). On the other hand, rising dependency ratio and ballooning fiscal deficits post-pandemic could drive r-star higher. New developments and public investments in green transition and AI technologies also offer potential for productivity gains. The evolving complexities of r-star necessitate a robust monetary framework that can account for and adapt to a multitude of factors.

Technical Appendix

Estimation Process

The original structure of the HLW process is maintained for all four variations. In addition, for each estimation approach, a range of model parameters (particularly, the constraints for the slopes of the IS and Phillips curves and the coefficient of the COVID-19 variable) are tested. Derived estimates are subject to model convergence and screened based on economic judgment. It is important to note that the results are indicative only and not exhaustive of the findings from all model iterations that yield plausible results.

Incorporation of Credit Gap into IS curve

We build on the HLW (2023) model as the baseline model and keep the adjustment as little as possible to ensure tractability. In the IS equation, we include the credit-to-GDP gap to reveal more information about the linkage between the output gap and financial cycle. The changes to the baseline model are highlighted in red.

$$\tilde{y}_t = a_{y,1}\tilde{y}_{t-1} + a_{y,2}\tilde{y}_{t-2} + \frac{a_r}{2}\sum_{j=1}^{2}(r_{t-j} - r^*_{t-j}) + a_c c_t + \varepsilon_{\tilde{y},t}$$

$$\pi_t = b_\pi \pi_{t-1} + (1 - b_\pi)\pi_{t-2,4} + b_y \tilde{y}_{t-1} + \varepsilon_{\pi,t}$$

Where $\tilde{y}_t$ is the output gap defined by $\tilde{y}_t = 100 * (y_t - y_t^*)$, in which y_t and y_t^* are logarithms of real GDP and the unobserved natural rate of output respectively. r_t and r_t^* are the real short-term interest rate and natural interest rate, π_t is the core consumer price inflation, $\pi_{t-2,4}$ is the average of the second to fourth lags of the core inflation rate. c_t is the newly added credit-to-GDP gap, defined as the difference between the credit-to-GDP ratio and its long-run trend. The sources of the variables can be found below.

Inclusion of Credit-to-GDP Gap Equation

We include an equation to capture the dynamics of the credit-to-GDP gap:

$$c_t = b_c c_{t-1} + b_r(r_t - r^*) + \epsilon_{c,t}$$

The law of motion for the latent variables remains unchanged:

$$r_t^* = k \cdot g_t + z_t$$

$$y_t^* = y_{t-1}^* + g_{t-1} + \epsilon_{y^*,t}$$

$$g_t = g_{t-1} + \varepsilon_{g,t}$$

$$z_t = z_{t-1} + \epsilon_{z,t}$$

Where g_t is the trend growth rate of the natural rate of output, and z_t captures the remaining determinants of r_t^*. We assume that the disturbances $\varepsilon_{i,t}$ in all the equations are normally distributed with standard deviations $\sigma_{i,t}$ respectively and are serially and contemporaneously uncorrelated with all other disturbances. Following HLW (2023), we keep the COVID-19 adjustments including the variance scale parameters κ_t and the COVID-19 indicator d_t. As the Asian Financial Crisis (AFC) has affected Thailand's output gap more severely than COVID-19, we also include the variance scale parameters for the AFC period.

Inflation Expectations

The real short-term interest rate r_t is computed as the difference between the nominal short-term interest rate and inflation expectation. Instead of using the four-quarter moving average of past inflation—which could be more volatile and provide limited forward-looking information—as a proxy for inflation expectations, we use the one-year-ahead inflation expectations from the survey conducted by Consensus Economics.

Methodology Towards Backfilling Policy Rate

An ordinary least squares linear regression was used to estimate and backfill missing policy rates from periods before Q2 2000. The approach is justified based on observed

lending rates typically exhibiting strong correlation with the observed repurchase rates, through a reasonably high R square statistic of 78.0 percent (see Table A1.1). Hence, assuming the relationship remains consistent prior to that period, the regression equation can be expressed as follows:

$$\tilde{\imath}_t = \beta_0 + \beta_1 x_t + \varepsilon_{\tilde{\imath},t}$$

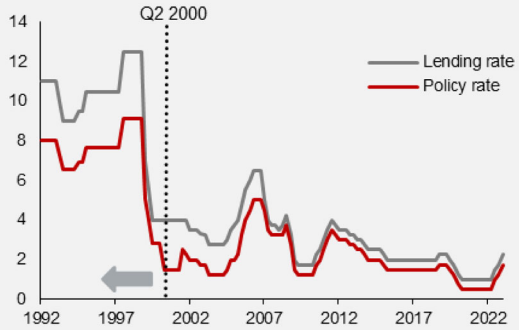
Where $\tilde{\imath}_t$ represents the estimated policy rate at time t, β_0 is the constant term, β_1 is the coefficient for the lending rate, x_t is the observed lending rate, and $\varepsilon_{\tilde{\imath},t}$ is the associated error term.

Table A1.1. Regression Summary Output

Statistics	
R Square	0.781
Standard Error	0.495
Observations	94
Coefficients	
Intercept	-0.105 (0.127)
Lending Rate	0.739*** (0.041)

Source: AMRO staff estimates.
Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Figures are rounded to 3 decimal placing where relevant.

Figure A1.8. Estimated Policy Rate Versus Lending Rate



Source: Haver Analytics; and AMRO staff estimates.

List of Variables Used

No.	Variable	Source	Haver Code	Transformation
1	Gross domestic product (GDP)	Haver	H578NGPC@EMERGEPR	Log transformation
2	COVID-19 indicator	Haver	THOWSTI@GLSECTOR	Quarterly mean aggregated[60]
3	Core CPI	Haver	H578PCXG@EMERGEPR	Annualised quarter-on-quarter log transformation
4	1-day repurchase rate	Haver	N578RTAR@EMERGEPR	Quarterly mean aggregated (percent, end of period)
5	Lending facility rate	Haver	N578RD@EMERGEPR	Quarterly mean aggregated (percent, end of period)
6	Inflation expectations	Consensus Economics	-	Year-on-year growth rate
7	Credit-to-GDP gap	BIS	-	Percent of GDP

Source: Authors' compilations.
Notes: Both GDP and headline core CPI series are seasonally adjusted.

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[60] Given that the Oxford COVID-19 Government Response Tracker (OxCGRT) project suspended data collection at the end of 2022, we adopted a similar approach as in Holston, Laubach and Williams (2023), by assuming that the Thailand COVID-19 indicator declines linearly beginning in Q1 2023, reaching zero in Q4 2023. For more details on OxCGRT, see Hale and others (2021).

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