ECONOMICS OF DEVELOPMENT

Journal homepage: https://ecdev.com.ua/

ISSN: 1683-1942
E-ISSN: 2304-6155

Vol. 24, No. 4, 2025

UDC 338.1
DOI: 10.63341/econ/4.2025.67

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The impact of financial intermediation efficiency on Thailand's total factor productivity

Abstract. This study aimed to measure Thailand's total factor productivity and also investigate the impact of financial intermediation efficiency on it during 2001-2024. The financial intermediation efficiency in this study was measured by three indicators, including interest rate spread, business sector credit ratio and non-performing loans ratio. Additionally, the growth accounting equation was applied to calculated the total factor productivity growth rate, whereas Autoregressive Distributed Lag model was employed to examine the impact of financial intermediation efficiency on it. The findings revealed that Thailand's total factor productivity growth was volatile over the study period, with several years of negative performance, and that its average growth rate was only 0.15% per year. The long-run results from Autoregressive Distributed Lag model indicate that financial intermediation efficiency significantly affects total factor productivity growth in the long run as business sector credit has a positive effect on total factor productivity growth, while non-performing loans exert a negative impact on it. However, the interest rate spread does not affect total factor productivity growth in the long run. In the short run, the results further confirmed that total factor productivity growth is significantly determined by financial intermediation efficiency. Specifically, the change in business sector credit has the positive effect on the change in total factor productivity growth whereas the change in interest rate spread has the negative impact on it. Nevertheless, the change in non-performing loan does not have any effect on the change in total factor productivity growth in the short run. The findings provide practical guidance for policymakers and financial regulators in improving credit allocation and supporting productivity-driven economic growth

Keywords: economic growth; macroeconomic performance; efficiency; interest rate spread; credits; non-performing loans

INTRODUCTION

Thailand is currently facing a rapid shift toward an aged society. That is, it is now recording the total fertility rate as low as 1.21 children per woman in 2023, while life expectancy at birth rises to 76.41 years. The continuous decline in fertility and rise in life expectancy cause old-age population to grow faster than working-age population. That is, the proportion of old-age population increased from 7.48% in 2005 to 15.36% in 2024, while the proportion of working-age population decreased from 70.37% to 69.89% during the same period (World Bank, 2025). Such a demographic transition poses critical challenges to Thailand's competitiveness and long-run economic growth as it put detrimental pressure on public finances, social welfare systems, and labour supply. Such trends could erode Thailand's productivity, reduce its ability to sustain dynamic growth, and weaken its competitiveness in the global markets (World Bank, 2021). To cope with this situation, enhancing total factor productivity (TFP) is needed as a strategic imperative for Thailand to counterbalance demographic drag and preserve sustainable growth over the long term. To promote TFP growth, efficient financial intermediation is necessary to ensure that financial resources are allocated efficiently to their most productive uses. However, Thailand's financial intermediation efficiency may be exposed to numerous risk factors that could weaken its positive impact on TFP. Among these risks are credit misallocation caused by sectoral concentration, weak risk governance and regulatory arbitrage in shadow banking or

Article's History: Received: 11.06.2025; Revised: 30.10.2025; Accepted: 23.12.2025; Published: 12.01.2026

Suggested Citation:
Chansarn, S. (2025). The impact of financial intermediation efficiency on Thailand's total factor productivity. *Economics of Development*, 24(4), 67-77. doi: 10.63341/econ/4.2025.67.

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fintech, high non-performing assets, and structural inefficiencies arising from oligopolistic banking markets or ownership networks. Moreover, external shocks, such as global financial crises or interest rate volatility, may worsen the inefficiency by raising funding costs or forcing suboptimal credit allocation. In Thailand's case, OECD (n.d.) states that high market concentration and limited banking competition may reduce dynamism in credit allocation, which may dampen the beneficial effect of financial efficiency on its productivity.

Beside financial intermediation efficiency, TFP is also determined by other factors. S. Bibi *et al*. (2024) noted that human capital raises TFP by enhancing workforce's capability, leading to the greater production efficiency. Educated and skilled workers improve countries' capacity to adopt and create new technologies and innovations, which raise productivity. Furthermore, trade openness and foreign direct investment (FDI) also positively affect TFP promoting technology diffusion, competition, and resource reallocation toward more efficient firms, which was the topic of Y. Li *et al*. (2021) study. Capital formation enhances TFP as higher capital accumulation raises output by deepening capital per worker, leading to the greater TFP (Ma *et al*., 2022). Real wages also positively affect TFP. When real wages rise in line with productivity, they can enhance worker motivation, reduce turnover and encourage firms to invest in human capital and technology, leading the higher TFP. Based on the literature review, there are several studies which investigate TFP growth in various countries. For instance, M. Ahmed & T.T. Chowdury (2019) examined the TFP growth in Bangladesh during 1981-2014 by utilising the growth accounting framework. G. Cette *et al*. (2021) also employed the growth accounting framework with two types of capital, including ICT capital and non-ICT capital, to measure TFP growth in 30 developed countries over the period 1960-2019. In addition, O. Siddique (2022) measured TFP growth of Pakistan during 1997-2021, while F. Ataev (2024) examined TFP growth in six countries in Central Asia during 1991-2019, by employing growth account framework.

In the case of Thailand, studies on TFP and on the impact of financial intermediation efficiency on TFP are still limited. J.W. Lee & N. Suwimol (2018) examined Thailand's TFP growth during 1975-2016 as proxied by ratio of value added to GDP and ratio of tax to total revenue, and found that product innovation and development policy are positively related to TFP growth while N.Z. Abidin *et al*. (2020) utilised Malmquist productivity index to measure TFP growth of Thailand, including seven ASEAN+3 countries over the period 1981-2014, and examined the effects of capital formation, human capital and FDI on TFP growth by employing panel VAR. Based on existing studies on Thailand's TFP, several research gaps remain to be addressed. Studies on Thailand's TFP growth need to be updated, as the existing ones are considerably outdated. Empirical studies on the impact of financial intermediation efficiency on TFP growth remains scarce in the context of Thailand. Previous studies commonly used the number of workers as a proxy for the labour input in TFP growth. However, this approach may not fully reflect reality, as the labour supply is constrained by the size of the working-age population and does not capture the cost or quality dimension of labour input, potentially leading to inaccuracies in the estimation of TFP growth. Due to the demographic constraints and Thailand's need to shift toward productivity-driven growth, this study aimed to investigate the impact of financial intermediation efficiency on Thailand's TFP over the period 2001-2024 with the primary objective of shedding more light on the appropriate policies to reform the financial sector in order to boost Thailand's TFP.

MATERIALS AND METHODS

Growth accounting framework to measure TFP growth

This study employed the growth accounting framework to measure Thailand's TFP growth over the period 2001-2024. Output was measured by real GDP, capital input is represented by two indicators, including (1) real gross fixed capital formation in construction and (2) real gross fixed capital formation in machinery and equipment, while labour input is measured by the real cost of labour, calculated as employment multiplied by the average wage. This study relied on Thailand's quarterly economic data, totally 96 quarters, obtained from secondary sources. The data utilised in this study include real GDP and real gross fixed capital formation, which are obtained from the National Economic and Social Development Council (NESDC, n.d.), labour force, employment rate, average real wage, and mean years of schooling of employed workers, which are obtained from the National Statistical Office (NSO, n.d.), as well as interest rate spread, total loans, business sector credits, non-performing loans, and exports and imports, which are obtained from the Bank of Thailand (n.d.). The growth accounting equation utilised to calculate TFP growth is somewhat modified from R.M. Solow (1957) as the following:

$$\frac{\Delta Y}{Y} = \frac{\Delta A}{A} + \alpha\frac{\Delta Kc}{Kc} + \beta\frac{\Delta Kme}{Kme} + \delta\frac{\Delta L}{L}, \tag{1}$$

where Y – real GDP; Kc – real gross fixed capital formation in construction; Kme – real gross fixed capital formation in machinery and equipment; L – real cost of labour; A – TFP; α – elasticity of real GDP with respect to real gross fixed capital formation in construction, indicating percentage change in real GDP as real gross fixed capital formation in construction changes by one percent; β – elasticity of real GDP with respect to real gross fixed capital formation in machinery and equipment, indicating percentage change in real GDP as real gross fixed capital formation in machinery and equipment changes by one percent; δ – elasticity of real GDP with respect to real cost of labour, indicating percentage change in real GDP as real cost of labour changes by one percent. Based on the equation (1), growth of real GDP is caused by (1) the growth of inputs, including real gross fixed capital formation in construction, real gross fixed capital formation in machinery and equipment and real cost of labour $\left(\alpha\frac{\Delta Kc}{Kc} + \beta\frac{\Delta Kme}{Kme} + \delta\frac{\Delta L}{L}\right)$ and (2) the TFP growth $\left(\frac{\Delta A}{A}\right)$. Therefore, the TFP growth rate can be calculated by the following equation:

$$\frac{\Delta A}{A} = \frac{\Delta Y}{Y} - \alpha\frac{\Delta Kc}{Kc} - \beta\frac{\Delta Kme}{Kme} - \delta\frac{\Delta L}{L}. \tag{2}$$

The growth rate of output (real GDP) and three inputs can be calculated from the available of Thailand. However, the elasticity of real GDP with respect to three inputs (α, β

and δ) can be calculated by employing the Cobb-Douglas production function as the following:

$$Y = AKc^{\alpha}Kme^{\beta}L^{\delta}. \quad (3)$$

The Cobb-Douglas production function is linearised by converting it into its natural logarithmic form. Moreover, quarterly dummy variables are included in the equation to capture seasonal variations. The equation to be estimated is presented as follows:

$$lnY = lnA + \alpha lnKc + \beta lnKme + \delta lnL + \Sigma_{i=1}^{3}\gamma_i Q_i + \mu, \quad (4)$$

where Q_i – quarterly dummy variables; i – 1, 2, 3. Quarter 4 is assigned as the base quarter. After estimating equation (4), the elasticity of real GDP with respect to three inputs will be obtained as the regression coefficients. Thereafter, the TFP growth rate for each period was calculated using equation (2) presented above.

Econometric model to examine the impact of financial intermediation efficiency

Model specification to examine the impact of financial intermediation efficiency on Thailand's growth was as follows:

$$TFP_t = \alpha + \beta_1 INT_t + \beta_2 BUS_t + \beta_3 NPL_t + \\ + \beta_4 CAP_t + \beta_5 SCL_t + \beta_6 TRD_t + \mu_t, \quad (5)$$

where TFP – TFP growth rate (%); INT – interest rate spread (%); BUS – business sector credit (% of total credit); NPL – non-performing loan (% of total credit); CAP – gross fixed capital formation (% of GDP); SCL – mean years of schooling of employed workers (years) in natural logarithms; TRD – export and import (% of GDP); μ – residual term. It should be noted that INT, BUS and NPL represent financial intermediation efficiency, CAP – represents capital formation, SCL represents human capital and TRD represents trade openness. Augmented Dickey-Fuller (ADF) unit root test for all variables under specifications with and without a deterministic trend was used. The Breusch-Godfrey LM test statistic and the White's test statistic were also used. An Autoregressive Distributed Lag (ARDL) model was chosen for this study because it is a flexible econometric approach capable of analysing both short-run and long-run relationships among variables in time-series data (Pesaran *et al.*, 2001). The ARDL model for bound testing is specified as follows:

$$\Delta TFP_t = \alpha_0 + \Sigma_{i=1}^{p} \alpha_{1i}\Delta TFP_{t-i} + \Sigma_{j=0}^{q1} \beta_{1j}\Delta INT_{t-j} + \Sigma_{j=0}^{q2} \beta_{2j} \\ \Delta BUS_{t-j} + \Sigma_{j=0}^{q3} \beta_{0j}\Delta NPL_{t-j} + \Sigma_{j=0}^{q4} \beta_{4j}\Delta CAP_{t-j} + \Sigma_{j=0}^{q5} \beta_{5j}\Delta SCL_{t-j} + \\ + \Sigma_{j=0}^{q6} \beta_{6j}\Delta TRD_{t-j} + \delta_1 TFP_{t-1} + \delta_2 INT_{t-1} + \delta_3 BUS_{t-1} + \delta_4 \\ NPL_{t-1} + \delta_5 CAP_{t-1} + \delta_6 SCL_{t-1} + \delta_7 TRD_{t-1} + \\ + \gamma_1 Q_1 + \gamma_2 Q_2 + \gamma_3 Q_3 + \varepsilon_t, \quad (6)$$

where denotes the first difference operators; p, q_1, q_2, q_3, q_4, q_5, q_6, are optimal lag lengths; δ_1 to δ_7 represent the long run relationship; β_1 to β_6 describe the short run dynamic; Q_1, Q_2 and Q_3 are dummy variables of quarter 1, 2 and 3, respectively. The analysis began with unit root tests to determine the stationarity of each variable and to ensure that none are integrated of order two. After it was confirmed that all variables are either I(0) or I(1), the ARDL bounds testing procedure developed by M.H. Pesaran *et al.* (2001) was employed to examine the existence of a long-run relationship between TFP growth and explanatory variables. If cointegration did exist, the unrestricted Error Correction Model (ECM) was estimated to examine the short-run dynamics and the speed of adjustment towards long-run equilibrium. The ECM model was specified as follows:

$$\Delta TFP_t = \varphi_0 + \Sigma_{i=1}^{p} \varphi_{1i}\Delta TFP_{t-i} + \Sigma_{j=0}^{q1} \psi_{1j}\Delta INT_{t-j} + \Sigma_{j=0}^{q2} \\ \psi_{2j}\Delta BUS_{t-j} + \Sigma_{j=0}^{q3} \psi_{3j}\Delta NPL_{t-j} + \Sigma_{j=0}^{q4} \psi_{4j}\Delta CAP_{t-j} + \Sigma_{j=0}^{q5} \\ \psi_{5j}\Delta SCL_{t-j} + \Sigma_{j=0}^{q6} \psi_{6j}\Delta TRD_{t-j} + \lambda ECM_{t-1} + \\ + \vartheta_1 Q_1 + \vartheta_2 Q_2 + \vartheta_3 Q^3 + \mu_t, \quad (7)$$

where ECM represents the error correction term which should be negative to reflect the convergence toward the long-run equilibrium.

RESULTS AND DISCUSSION

Table 1 presents descriptive statistics of output and input data of Thailand. The findings revealed that the value of annual output as measured by real GDP increased from 5,435.36 billion baht in 2001 to 11,179.50 billion baht in 2024. As looking at annual inputs, the value of real cost of labour equalled 7,354.97 billion baht in 2004 whereas the value of real gross fixed capital formation equalled 2,637.31 billion baht, consisting of 899.64 billion baht for construction and 1,737.67 billion baht for machinery and equipment.

Table 1. Descriptive statistics of Thailand's output and inputs, billion baht

Statistics	Real GDP	Real gross fixed capital formation			Real cost of labour
		Construction	Machinery & equipment	Total	
M	2,181.72	177.12	357.86	534.98	1,455.76
SD	449.10	41.29	78.20	110.00	306.86
Q1/2001	1,378.08	110.08	182.75	292.83	927.56
Year 2001	5,435.36	449.49	741.10	1,190.58	3,988.11
Q4/2024	2,920.67	214.22	481.61	695.83	1,881.67
Year 2024	11,179.50	899.64	1,737.67	2,637.31	7,354.97

Source: prepared by the author based on NSO (n.d.) and NESDC (n.d.)

According to the results of OLS regression analysis shown in Table 2, all input variables, including gross fixed capital formation for construction and for machinery and equipment and cost of labour, significantly determine Thailand's real GDP. Thus, the elasticities of real GDP with respect to each input can be summarised as follows:

- elasticity of real GDP with respect to real gross fixed capital formation in construction (α) is 0.2345. That is, 10 percent increase in real gross fixed capital formation in construction will lead to 2.345 percent increase in real GDP;
- elasticity of real GDP with respect to real gross fixed capital formation in machinery and equipment (β)

is 0.2333. That is, 10 percent increase in real gross fixed capital formation in machinery and equipment will lead to 2.333 percent increase in real GDP;

- elasticity of real GDP with respect to real cost of labour (δ) is 0.5040. That is, 10 percent increase in real cost of labour will lead to 5.040 percent increase in real GDP.

Moreover, sum of the elasticities of real GDP with respect to three inputs ($\alpha+\beta+\delta$) are 0.9718, indicating that Thailand's production exhibits nearly constant return to scale.

Table 3 reports the annual growth rates of Thailand's real GDP and TFP over the period 2001/02-2023/24. The data show that real GDP growth fluctuated considerably, ranging from a peak of 7.51% in 2009/10 to a sharp contraction of -6.05% in 2019/20 during the COVID-19 crisis, with an overall average growth rate of 3.23% per year. In contrast, TFP growth exhibited even greater volatility, with several years of negative performance, including substantial declines in 2004/05, 2007/08, and 2019/20, while its highest growth occurred in 2016/17 at 4.41%. Over the study period, Thailand's average TFP growth rate was only 0.15% per year, indicating relatively weak productivity gains compared with output growth. The pattern of positive GDP growth alongside negative TFP growth in multiple years suggests that economic expansion was driven primarily by input accumulation rather than productivity improvements.

Table 2. Estimate of Cobb-Douglass production function

Variable	Coefficient	Std. error	*t* stat	*p* value
Constant	1.6576***	0.2208	7.5100	0.0000
lnKc	0.2345***	0.0445	5.2700	0.0000
lnKmc	0.2333***	0.0276	8.4500	0.0000
lnL	0.5040***	0.0439	11.4700	0.0000
Q_1	0.0323***	0.0112	2.8800	0.0050
Q_2	-0.0443***	0.0125	-3.5300	0.0010
Q_3	-0.1063***	0.0163	-6.5200	0.0000
Adjusted R^2 = 0.9788, *F* statistic = 731.73, *p* value = 0.0000, observations = 96				

Note: *** indicates statistical significance at 1% level
Source: prepared by the author

Table 3. The annual growth rates of Thailand's real GDP and TFP

Year	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13
GDP	6.15	7.19	6.29	4.19	4.97	5.44	1.73	-0.69	7.51	0.84	7.24	2.69
TFP	2.57	0.73	-1.49	-3.88	2.25	3.20	-1.78	2.41	0.26	-2.60	-2.36	0.07
Year	**13/14**	**14/15**	**15/16**	**16/17**	**17/18**	**18/19**	**19/20**	**20/21**	**21/22**	**22/23**	**23/24**	**Mean**
GDP	0.98	3.13	3.44	4.18	4.22	2.11	-6.05	1.55	2.58	2.02	2.54	3.23
TFP	-0.94	-1.64	1.15	4.41	1.77	0.78	-6.04	0.25	0.88	1.15	2.25	0.15

Note: GDP – real GDP growth rate (% per year); TFP – TFP growth rate (% per year)
Source: prepared by the author

Table 4 presents the descriptive statistics for the key determinants of TFP employed in this study. The interest rate spread exhibits a mean value of 1.10%, with relatively low standard variation of 0.14, ranging from 0.92% to 1.46%. Business sector credit averages 54.88% of total credit, with a standard deviation of 9.11. Its values span from 44.85% to 75.57%. Non-performing loan shows a mean of 6.50% of total credit and a standard deviation of 4.71, with a minimum of 2.56% and a maximum of 22.35%. Gross fixed capital formation records a mean of 24.55% of GDP, with relatively limited standard deviation of 1.94 and values ranging between 20.25% and 29.54%. The average years of schooling has a mean of 7.46 years, with a standard deviation of 1.19, reflecting gradual progression in educational attainment over time. Its range extends from 5.44 to 9.41 years. Finally, trade openness, as measured by the share of exports and imports relative to GDP, averages 108.08%, with a standard deviation of 10.87, and ranging from 81.97% to 136.53%. Overall, the descriptive results highlight substantial variation across macroeconomic and financial indicators, particularly in credit quality and trade openness, suggesting notable shifts in economic structure over the sample period.

Table 4. Descriptive statistics of determinants of TFP

Variable	Description	Unit	*M*	*SD*	Max	Min
INT	Interest rate spread	%	1.10	0.14	1.46	0.92
BUS	Business sector credit	% of total credit	54.88	9.11	75.57	44.85
NPL	Non-performing loan	% of total credit	6.50	4.71	22.35	2.56
CAP	Gross fixed capital formation	% of GDP	24.55	1.94	29.54	20.25
YSCL	Mean years of schooling	Years	7.46	1.19	9.41	5.44
TRD	Export and import	% of GDP	108.08	10.87	136.53	81.97

Note: mean years of schooling in natural logarithm (SCL) will be used in the ARDL model instead of YSCL
Source: prepared by the author based on NSO (n.d.), NESDC (n.d.) and Bank of Thailand (n.d.)

Table 5 presents the results from ADF unit root test for all variables under specifications with and without a deterministic trend. The findings reveal that *TFP* and *CAP* are stationary at level under at both specifications, while the remaining variables (*INT*, *BUS*, *NPL*, *SCL*, and *TRD*) fail to reject the null hypothesis of a unit root at level. However, all variables become stationary after first differencing, as evidenced by statistically significant ADF statistics at the 5 percent level across both model specifications, with and without trend. These results confirm that the variables are integrated of order one, I(1), supporting the suitability of cointegration and ARDL approaches for subsequent empirical analysis. Table 6 reports the results of the ARDL bounds test for cointegration. The computed *F* statistic is 4.662, which is greater than the upper-bound critical values at the 1%, 5%, and 10% significance levels (4.43, 3.61, and 3.23, respectively). Since the *F* statistic is higher than the I(1) critical values for all significance levels, the null hypothesis that there is no long-run relationship can be rejected. Consequently, the results confirm the existence of a long-run cointegrating relationship between TFP and its determinants in the ARDL model.

Table 5. Results from ADF test for stationarity

Variable	Constant without trend				Constant with trend			
	Level		First difference		Level		First difference	
	t stat	*p* value	*t* stat	*p* value	*t* stat	*p* value	*t* stat	*p* value
TFP	-4.479***	0.0002	-8.343***	0.0000	-4.459***	0.0018	-8.292***	0.0000
INT	-1.720	0.4210	-6.203***	0.0000	-1.652	0.7713	-6.214***	0.0000
BUS	-2.065	0.2588	-8.197***	0.0000	-1.431	0.8515	-8.332***	0.0000
NPL	-2.220	0.1992	-5.585***	0.0000	-1.978	0.6136	-5.648***	0.0000
CAP	-3.203**	0.0198	-3.869***	0.0023	-3.372*	0.0552	-3.980***	0.0094
SCL	-2.323	0.1646	-2.944**	0.0405	-1.323	0.8822	-3.509**	0.0384
TRD	-2.157	0.2223	-4.451***	0.0002	-2.245	0.4643	-4.414***	0.0021

Note: *, **, *** indicate 10%, 5% and 1% significance level, respectively
Source: prepared by the author

Table 6. Results from ARDL bound test for cointegration

F bound test		Bound critical value		
Test statistic	Value	Significance level	I(0)	I(1)
F statistic	4.662	1%	3.15	4.43
		5%	2.45	3.61
		10%	2.12	3.23

Source: prepared by author

The optimal ARDL(4,1,2,1,4,0,1) model, determined according to the minimum AIC criterion, is estimated, and the results are reported in Table 7. The findings reveal that the Breusch-Godfrey LM test statistic and the White's test statistic are not statically significant at any level, showing that there are no serial correlation and heteroskedasticity problem in the ARDL model. In addition, the adjusted R^2 of 0.9046 suggests that 90.46 percent of the total variation in TFP growth can be explained by the explanatory variables the model. These results confirm that the ARDL model is statistically robust, stable and suitable for interpreting both short- and long-run dynamics of Thailand's TFP growth.

The long-run results clearly reveal that financial intermediation efficiency significantly affects TFP growth in the long run, as two out of three indicators of financial intermediation efficiency have statistically significant impacts of TFP growth. Specifically, business sector credit (*BUS*) has a significant positive effect on TFP growth. Its regression coefficient of 1.1342 suggests that a one percent increase in credit extended to the business sector leads to a 1.1342 percent rise in the TFP growth rate. In contrast, *NPL* exert a significant negative impact on TFP growth, with a coefficient of -1.4411, indicating that the TFP growth rate is likely to decline by 1.4411 percent if the ratio of non-performing loans to total credit increases by one percent. However, the *INT* has the insignificant long-run effect on TFP growth, implying that financial cost differentials do not directly influence long-term productivity once other factors are controlled for.

Beside business sector credit, *CAP* and the *SCL* also have the significant positive effect on TFP growth rate. The regression coefficient of *CAP*, which equals 0.4947, indicates that TFP growth rate will increase by 0.4947 percent if the ratio of gross fixed capital formation to GDP rises by one percent. Furthermore, the coefficient of *SCL*, which is 27.8461, suggests that a one percent increase in the mean years of schooling of employed workers will lead to 0.2785 percent increase in TFP growth rate. Nevertheless, the findings indicate that *TRD* does not have any significant impact of TFP growth.

Table 7. Estimated long-run and short-run coefficients of the ARDL model

Variable	Coefficients	Std. error	*t* stat	*p* value
Long-run estimates: ARDL(4,1,2,1,4,0,1) based on AIC **Dependent variable:** *TFP(t)*				
INT	-0.7945	5.1262	-0.1500	0.8770
BUS	1.1342**	0.4986	2.2700	0.0260

Table 7. Continued

Variable	Coefficients	Std. error	*t* stat	*p* value
Long-run estimates: ARDL(4,1,2,1,4,0,1) based on AIC **Dependent variable:** *TFP(t)*				
NPL	-1.4411**	0.6034	-2.3900	0.0190
CAP	0.4947*	0.2643	1.8700	0.0650
SCL	27.8461**	13.7607	2.0200	0.0460
TRD	-0.0869	0.0626	-1.3900	0.1690
Short-run estimates ARDL(4,1,2,1,4,0,1) based on AIC **Dependent variable:** Δ*TFP*				
Δ*TFP*(*t*-1)	0.0682	0.2575	0.2600	0.7920
Δ*TFP*(*t*-2)	-0.1676	0.1799	-0.9300	0.3550
Δ*TFP*(*t*-3)	-0.4266***	0.1045	-4.0800	0.0000
Δ*INT*(*t*)	-22.6769**	10.79863	-2.1000	0.0390
Δ*BUS*(*t*)	2.6202**	1.0933	2.4000	0.0190
Δ*BUS*(*t*-1)	-1.7573*	0.9657	-1.8200	0.0730
Δ*NPL*(*t*)	0.5932	1.2249	0.4800	0.6300
Δ*CAP*(*t*)	-9.1659***	0.6624	-13.8400	0.0000
Δ*CAP*(*t*-1)	-4.6996***	1.0069	-4.6700	0.0000
Δ*CAP*(*t*-2)	-1.4901	1.0558	-1.4100	0.1620
Δ*CAP*(*t*-3)	-3.7363***	0.9099	-4.1100	0.0000
Δ*SCL*(*t*)	23.0883**	10.3784	2.2200	0.0290
Δ*TRD*(*t*)	-0.2902*	0.1714	-1.6900	0.0950
ECM(*t*-1)	-0.7998***	0.1604	-4.9863	0.0000
Quarterly dummy variables				
Q_1	-9.5758*	4.9792	-1.9200	0.0580
Q_2	-1.2897	5.0285	-0.2600	0.7980
Q_3	-9.4477**	4.6927	-2.0100	0.0480
Observation		91 Quarters		
Adjusted R^2		0.9046		
Breusch-Godfrey LM test for autocorrelation		$\chi^2 = 6.4480$, *p* value = 0.1681		
White's test for heteroskedasticity		$\chi^2 = 92.0000$, *p* value = 0.4510		

Note: *, **, *** indicate 10%, 5% and 1% significance level, respectively
Source: prepared by the author

In the short run, the results shed light on how temporary shocks and lagged effects influence TFP adjustments. The short-run results further confirm that TFP growth is significantly determined by financial intermediation efficiency. Specifically, the change in business sector credit (Δ*BUS*) has the positive and statistically significant effect on change in TFP growth whereas the change in interest rate spread (Δ*INT*) has the significantly negative impact on the change in TFP Growth. These findings imply that the short-term expansion in business credit help boost output and productivity through increased working capital and production activity while the higher interest rate spread reduce firms' incentives to invest efficiently in the short term. Anyway, the change in non-performing loan (Δ*NPL*) does not have any significant effect on the change in TFP growth in the short run.

Additionally, the three quarter-lagged changes in TFP (ΔTFP_{t-3}) are significantly negative, indicating that a rise in TFP three quarters earlier leads to a slowdown in the current quarter, likely due to diminishing short-run returns or cyclical fluctuations. As looking at the other short-run determinants, the change in capital formation (Δ*CAP*) and its lag terms are significantly negative, indicating that the excessive capital expansion in the short run is likely to cause a decline in TFP growth due to the inefficiencies in utilising new capital stock. Likewise, the change in trade openness (Δ*TRD*) is also negative and significant, implying that the expansion of export and import in the short run leads to the decline in TFP growth. On the other hand, the change in mean years of schooling (Δ*SCL*) has a positive and significant short-run effect on the change in TFP growth, implying that the improvement in education immediately benefits TFP growth. According to Table 7, the error correction term (ECM_{t-1}) is significantly negative, confirming the existence of a stable long-run equilibrium relationship among TFP growth and its determinants. Its coefficient of -0.7998 indicates a strong adjustment, indicating that deviation from the long-run equilibrium is corrected by approximately 80% within one quarter. Specifically, when TFP growth deviates from its long-run equilibrium due to short-run shocks, the system will adjust rapidly toward its long-run equilibrium.

This study fills the research gap regarding Thailand's production performance and TFP. Specifically, this study found that the country's production exhibits nearly constant return to scale, implying the optimal scale of production of the economy. In addition, labour and capital factors contribute similarly to overall production, reflecting balanced production structure within Thai economy. In terms of TFP growth, this study found that Thailand's average TFP growth rate over the study period (2001-2024) was low (0.15% per year), implying that Thailand's economic expansion was driven mainly by capital and labour accumulation rather than productivity improvements. These results bridge the gap left by the studies of J.W. Lee & N. Suwimol (2018) and N.Z. Abidin *et al.* (2020), which mainly examined the determinants of TFP growth rather than measuring the actual TFP growth rate.

This study provides the significant evidence that financial intermediation efficiency affects Thailand's TFP growth in both the long run and the short run. In the long run, TFP growth is positively influenced by business sector credit, suggesting that an expansion in business credit enhances the country's overall productivity by facilitating investment, innovation and operational efficiency among business firms. These findings are consistent with those of F. Manaresi & N. Pierri (2018) and S.M. Cakici (2024). Furthermore, non-performing loans have the adverse impact on TFP growth in the long run, implying that the greater level of bad debt limits business credit provision, causes resource misallocation, and eventually reduces the country's overall productivity. These results are consistent with the findings of A.S. Serrano (2022).

Unlike S. Gilchrist *et al.* (2012), this study found that the interest rate spread does not significantly influence overall productivity in the long run. This is because Thailand's financial system maintains relatively stable spreads, while long-term productivity tends to be influenced more by other factors such as business credit provision and loan quality rather than interest rate differentials. Specifically, Thailand's interest rate spread ranged from 0.92% to 1.46%, with the average value of 1.10%, showing a relatively stable spread over the 24-year period.

Figure 1 illustrates the changes in Thailand's TFP growth rate, business sector credit, and non-performing loans. It shows that both business sector credit and non-performing loans exhibited a downward trend, causing TFP to grow slowly over the study period. More specifically, while financial institutions in Thailand were able to efficiently manage loan quality and reduce non-performing loans, they were likely to extend more credit to households rather than to the business sector. It should be noted that greater business sector credit tends to increase TFP growth, whereas a higher level of non-performing loans leads to a decline in TFP growth.

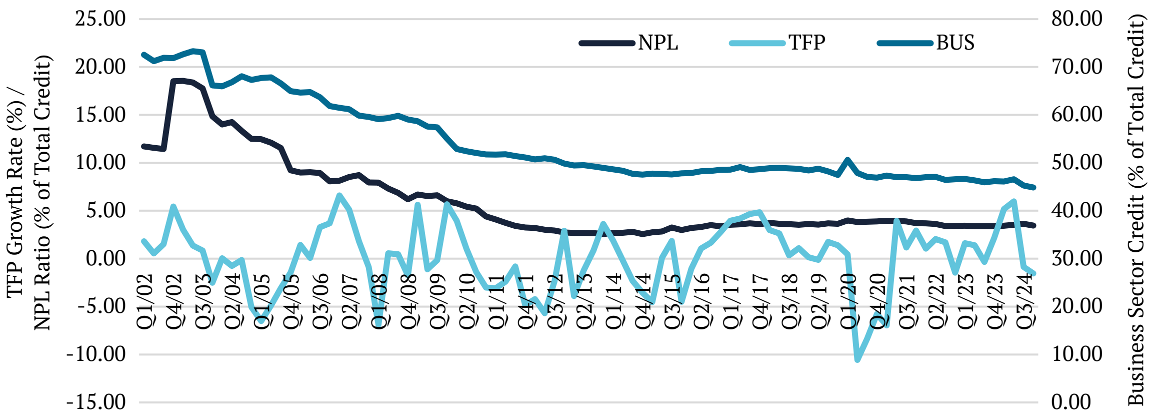

Figure 1. TFP growth rate, business sector credit and non-performing loans in Thailand

Source: made by the author

In the short run, business sector credit also positively influences TFP growth. However, non-performing loans do not affect TFP growth in the short run, probably because financial institutions can still operate relatively normally despite some bad debt, as they may temporarily absorb losses or roll over debts. As a result, the greater non-performing loans in short run do not immediately affect the country's TFP growth. In contrast, the interest rate spread does not affect TFP growth in the long run but it does in the short run. It is because the interest rate spread reflects short-term fluctuations in financial intermediation costs rather than structural efficiency. In the short run, changes in the spread are likely to immediately influence borrowing costs and investment decisions, affecting TFP growth temporarily.

As looking at the remaining determinants of TFP growth, human capital, as measured by mean years of schooling of employed workers, positively influences TFP growth in both the long run and the short run, confirming the crucial role of education and human capital accumulation in improving labour productivity, which, in turn, leads to greater overall productivity. These findings are consistent with S. Bibi *et al.* (2024). However, capital formation negatively affects TFP growth in the short run while it positively affects TFP growth in the long run. This is because, in the short run, the new capital stock tends to be underutilised, causing inefficient resource reallocation and the lower TFP growth, before it becomes fully utilised in the long run and positively influences TFP growth. This long-run relationship between capital formation and TFP growth is consistent with L. Ma *et al.* (2022).

According to the findings from this study, several policies are recommended to boost Thailand's TFP growth. Policies should focus on expanding business sector credit through efficient financial intermediation to support productive investment and innovation, particularly for SMEs and technology-driven industries, while controlling personal loan provision, which is non-productive. Furthermore, policies to strengthen credit risk assessment and promote prudent lending standards are required to reduce non-performing loans in the long run while measures to support efficient debt restructuring are also essential to prevent NPL accumulation and financial instability in the short run. In addition, the Bank of Thailand should manage short-term interest rate movements to avoid abrupt fluctuations in borrowing costs which could be harmful to TFP growth.

Additionally, policies to enhance human capital through continuous investment in education, vocational training and digital skills development should be consistently implemented, to improve labour productivity and, thereby, the country's overall productivity. Meanwhile, policies should focus on the full utilisation of new capital stock and workforce upskilling to mitigate transitional inefficiencies in the short run and on promoting productive capital formation in high-technology and green sectors in the long run. Finally, international trade policy should focus on promoting export quality and value addition through industrial upgrading and technology adoption to ensure that export expansion in the short run positively contributes to the country's overall productivity.

Trade openness adversely affects TFP growth in the short run. This finding contradicts Y. Li *et al*. (2021). The negative impact in the short run arises because greater imports are likely to cause an immediate disruption to domestic production while greater exports tend to have firms prioritise meeting external demand over efficiency gains, leading to short-run inefficiency. In addition, the negative impact of export is also stemming from the dominance of low value-added and labour-intensive industries in the country's export structure. Therefore, export expansion does not necessarily translate into productivity improvement.

TFP represents the portion of output growth which is not explained by the accumulation of observable inputs such as capital and labour. It reflects improvements in technological progress, efficiency, human capital, and institutional quality that enable an economy to produce more output with the same resources (Solow, 1957). In other words, TFP captures how effectively a country transforms inputs into economic output, encompassing both innovation and the diffusion of knowledge (Hulten, 2001).

TFP serves as a vital measure of an economy's efficiency in utilising inputs (capital, labour, technology, etc.) to generate output. In growth accounting frameworks, TFP is often regarded as the "residual" that captures improvements in technologies, managerial practices, institutional quality, and resource allocation beyond mere accumulation of inputs (Cardarelli & Lusinyan, 2015). The greater TFP implies that a country is deriving more output from the given amount of input, which is needed when input boosts become limited – as is the case in aging societies. Empirical studies have consistently found that over the long run, differences in living standards and growth trajectories across countries are largely explained by variations in TFP rather than input accumulation alone (OECD, n.d.). Therefore, promoting TFP growth is crucial for Thailand to achieve the sustainable development in an environment of demographic headwinds.

Financial intermediation efficiency refers to how well financial institutions mobilise savings, allocate credit, manage risks, and facilitate transactions, all at minimal cost and friction. According to T. Philippon (2015), there are several key indicators of financial intermediation efficiency, including the interest rate spread (difference between lending and deposit rates), non-performing loan (NPL) ratios, operating cost to total assets, and the share of private sector credit to GDP. A highly efficient financial intermediation system will reduce transaction costs, mitigate information asymmetries, and support better risk assessment, thereby improving capital allocation and encouraging innovation (Liu & Li, 2022). Accordingly, the higher financial intermediation efficiency can foster faster technology diffusion, firm-level upgrading, and ultimately raise the aggregate TFP of the economy (Han & Shen, 2015).

Malmquist productivity index (MPI) is one of the most commonly used techniques for measuring TFP. Such index measures changes in TFP over time by comparing the efficiency of production across two periods. It decomposes productivity change into efficiency change (catching up to the frontier) and technological change (shifts in the frontier). MPI is widely used because it can be applied in both cross-sectional and panel settings using Data Envelopment Analysis (DEA). This technique was utilised to examine TFP changes in various countries by several studies such 30 OECD countries during 1971-2011 (Shen *et al*., 2017), East Asian countries during 2002-2010 (Le *et al*., 2019), Middle East and North African countries during 1995-2016 (Fathi & Ghorbanian, 2021) and 49 African countries during 2000-2019 (Myeki *et al*., 2023). Note that MPI gives the relative TFP changes, not the absolute level. This is because it is computed as distance to a best-practice frontier built from the sample group via DEA, so each country's productivity is measured relative to peers and reference periods.

Stochastic frontier analysis (SFA) is another frontier-based analytic technique commonly adopted to measure TFP changes. SFA, introduced by D.J. Aigner *et al*. (1977) and W. Meeusen & J. van den Broeck (1977), is a parametric econometric approach that estimates a production frontier while distinguishing random noise from inefficiency. It assumes that output deviations from the frontier are partly due to statistical noise and partly to inefficiency, modeled as a composed error term with a symmetric random error and a non-negative inefficiency component. SFA decomposes TFP growth into technical change (frontier shifts), efficiency change (movement toward or away from the frontier), and scale or allocative efficiency effects (Kumbhakar & Lovell, 2000; Coelli *et al*., 2005).

There are several studies which employ stochastic frontier analysis (SFA) to measure TFP in many countries worldwide such as 15 former Soviet Union countries (Arazmuradov *et al*., 2014), 36 Sub-Saharan African countries (Garzarelli & Liman, 2019), Middle East and North African countries (Malik & Masood, 2021) and Turkiye (Yiğiteli & Şanlı, 2024). Nevertheless, efficiency from SFA measures technical efficiency, showing how well inputs are used relative to the best-practice frontier, while TFP reflects both efficiency and technological progress over time. Hence, SFA efficiency is only a component of TFP, not equivalent to it (Kumbhakar & Lovell, 2000).

Another technique which is widely adopted to measure TFP changes is the growth accounting framework. It is an economic method used to decompose the sources of economic growth into the contributions of capital, labour, and TFP. The growth account framework is generally based on a production function, often a Cobb-Douglas function or a translog function, where the growth in output is explained by growth in inputs, and the residual, or TFP, accounts for growth not explained by factor inputs, reflecting the improvement in technology, efficiency and organisation (Solow, 1957; Hulten, 2001). Unlike MPI, TFP growth which is derived from the growth accounting framework represents absolute or aggregate TFP growth. It measures the change in the economy's overall productivity level over time, after accounting for the weighted contributions of labour and capital growth.

Furthermore, there are also numerous studies which focus on the determinants of TFP. Among various determinants of TFP, financial intermediation efficiency is considered as one of the most important determinants of TFP. Financial intermediation efficiency refers to how effectively the financial system channels savings into productive investment at minimal cost and risk. Greater efficiency reduces transaction costs, mitigates information asymmetries, and enhances credit allocation, enabling capital to flow toward more productive firms and innovation, thereby raising. Several empirical studies (Yao, 2011; Philippon, 2015; Gupta *et al.*, 2021) consistently find that countries are likely to experience the higher TFP growth with the greater financial intermediation efficiency. In other words, a more efficient financial sector decreases the cost of capital and increases aggregate TFP, since resources are efficiently utilised in production rather than intermediation.

In accordance with T. Philippon (2015) who investigated how efficiently the U.S. financial system transforms savings into productive investment by estimating the unit cost of financial intermediation, the ratio of the financial sector's income to the value of intermediated assets, there are presumably three major indicators of financial intermediation efficiency, including (1) interest rate spread which represents cost of intermediation, (2) credit to business sector which represent volume of productive intermediation and (3) non-performing loans (NPLs) which represents credit quality and risk. High interest spread, inefficient credit allocation and excessive NPLs reflect intermediation inefficiency which detrimentally affect TFP growth.

A higher interest rate spread, indicating higher intermediation costs or financial frictions, can negatively affect TFP. Since it raises firms' cost of borrowing, discouraging productive investment and leading to capital misallocation. It also signals inefficiencies in financial intermediation, where savings are not efficiently channelled to the most productive firms (Gilchrist *et al.*, 2012). Additionally, credit provided to the business sector positively affects TFP by enabling firms to invest in technology and innovation. As credit flows easily to productive firms, it supports capital deepening and innovation adoption, thereby raising aggregate TFP (Manaresi & Pierri, 2018; Cakici, 2024). High NPLs reduce TFP by weakening banks' balance sheets, limiting credit to productive firms, and causing resource misallocation. This restricts investment, innovation, and technological upgrading (Serrano, 2022).

Hence, this study measured Thailand's TFP growth during 2001-2024 and investigated the impact of financial intermediation efficiency on it to fill these research gaps. The cost of labour, rather than the labour force, is employed to measure TFP growth, thereby capturing the role of augmented labour in production. Furthermore, this study utilised two types of capital formation, including construction and machinery and equipment, to calculate TFP growth, instead of using overall capital formation, in order to enhance the accuracy of TFP estimates, as different types of capital assets exhibit distinct productivity contributions. In terms of measurement, this study employed the growth accounting framework to measure Thailand's TFP growth because it provides a transparent decomposition of output growth into contributions from capital, labour, and productivity without imposing strong functional form assumptions or frontier estimations required by the Malmquist index or SFA. Unlike the Malmquist index, which measures relative productivity changes based on benchmark comparisons across decision-making units, the growth accounting framework yields absolute TFP levels over time, making it suitable for national-level analysis. Meanwhile, SFA was not appropriate in this context, as it is primarily designed to estimate firm or industry level technical efficiency rather than aggregate productivity at the national level.

CONCLUSIONS

This study measured Thailand's TFP growth during 2001-2024 by employing the growth accounting framework and finds that Thailand's TFP growth was highly volatile, with several years of negative performance, including substantial declines in 2004/05, 2007/08, and 2019/20, while its highest growth occurred in 2016/17 at 4.41%. Over the study period, Thailand's average TFP growth rate was only 0.15% per year. This study also examined the impact of financial intermediation efficiency on TFP growth using ARDL model. The findings reveal that financial intermediation efficiency significantly affects TFP growth in the long run as business sector credit has a positive effect on TFP growth, while non-performing loans exert a negative impact on it. However, the interest rate spread does not affect TFP growth in the long run.

In the short run, the results further confirm that TFP growth is significantly determined by financial intermediation efficiency. Specifically, the change in business sector credit has the positive effect on the change in TFP growth whereas the change in interest rate spread has the negative impact on it. Nevertheless, the change in non-performing loan does not have any effect on the change in TFP growth in the short run. Regarding the other factors, the findings reveal that human capital positively affects TFP growth in both the long run and the short run while capital formation positively affects TFP growth in the long run but negatively affects it in the short run. Furthermore, trade openness negatively affects TFP growth in the short run but has no impact on it in the long run. Further research could extend the analysis by incorporating institutional quality, digital financial inclusion, and regional disparities to better explain productivity dynamics in emerging economies.

ACKNOWLEDGEMENTS

None.

FUNDING

None.

CONFLICT OF INTEREST

None.

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Вплив ефективності фінансового посередництва на сукупну факторну продуктивність Таїланду

Анотація. Метою цього дослідження було оцінити сукупну факторну продуктивність Таїланду та проаналізувати вплив ефективності фінансового посередництва на неї у період 2001-2024 років. Ефективність фінансового посередництва у дослідженні вимірювалася за допомогою трьох показників: процентної маржі, частки кредитування бізнес-сектору та рівня проблемних кредитів. Для розрахунку темпів зростання сукупної факторної продуктивності застосовано метод обліку зростання, тоді як модель авторегресії з розподіленими лагами використано для оцінювання впливу ефективності фінансового посередництва. Отримані результати свідчать, що зростання сукупної факторної продуктивності в Таїланді впродовж досліджуваного періоду було нестабільним, із кількома роками від'ємної динаміки, а середній річний темп зростання становив лише 0,15 %. Довгострокові оцінки моделі авторегресії з розподіленими лагами показали, що ефективність фінансового посередництва істотно впливає на зростання сукупної факторної продуктивності: кредитування бізнес-сектору має позитивний вплив, тоді як проблемні кредити негативний. Водночас процентна маржа не чинить значущого довгострокового вплив. У короткостроковому періоді результати також підтвердили, що зростання сукупної факторної продуктивності суттєво визначається ефективністю фінансового посередництва. Зокрема, зміна обсягів кредитування бізнес-сектору позитивно впливає на зміну темпів зростання сукупної факторної продуктивності, тоді як зміна процентної маржі має негативний ефект. Разом із тим зміна рівня проблемних кредитів не чинить впливу на зміну темпів зростання сукупної факторної продуктивності у короткостроковому періоді. Отримані результати мають практичне значення для формування політики покращення розподілу кредитних ресурсів та підтримки продуктивно орієнтованого економічного зростання

Ключові слова: економічне зростання; макроекономічна результативність; ефективність; процентна маржа; кредитування; проблемні кредити