



Production Factors and Technological Change in Driving Economic Growth in Thailand's Service Sector

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Abstract

This research article investigates the impact of labor, capital, and technology on economic growth in Thailand's service sector. Utilizing time-series data from 1993 to 2023, the study applies the Cobb-Douglas production function alongside the Solow Residual method to isolate the contribution of technological change beyond traditional inputs.

The results indicate that capital significantly influences the service sector's output, with a regression coefficient of 0.6971. In contrast, labor's contribution is minimal and statistically insignificant (0.0862), suggesting a gap between labor skills and the demands of the modern economy. The Solow Residual value of 1.1128 confirms that technological progress has been the dominant driver of output growth over the past three decades.

These findings underscore the critical role of technology in boosting productivity and reshaping the structural trajectory of the service sector. As such, investment strategies should emphasize digital transformation through automation, Enterprise Resource Planning (ERP) systems, and digital platforms rather than labor expansion. Additionally, businesses should strengthen digital and data competencies to better capture technological gains and support long-term competitiveness. This study contributes to the theoretical discourse on production economics by validating the relevance of Solow's framework in the context of a service-based economy, while also offering practical insights for business leaders and policymakers focused on sustainable and innovation-driven growth.

Keyword: 1) Cobb-Douglas production function 2) economic growth 3) service sector 4) total factor productivity (TFP)

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Introduction

At present, technology and innovation are key mechanisms driving Thailand's economy, especially during the transition toward a knowledge-based economy. Developments in various areas such as digital communication, artificial intelligence, biotechnology, and modern production systems have contributed to enhancing competitiveness and improving the quality of life for the population. According to data from the National Statistical Office (2023, p. 31), 87.6 percent of Thai people aged six and above use the internet, and 94.7 percent use mobile phones, reflecting the widespread access to information and communication technologies. Meanwhile, Thailand's investment in research and development (R&D) and information and communication technology (ICT) accounts for 16 percent of GDP, ranking second among ASEAN countries, behind only Singapore (Amarase, 2025, pp. 1-2). However, Thailand's overall productivity during 2015–2022 grew at an average rate of only 0.2 percent per year, which is lower than neighboring countries such as Vietnam (1.8 percent) and Singapore (1.1 percent) (Bank of Thailand, 2025). One contributing factor is that most Thai businesses still focus on innovation in management and marketing rather than in high value-added product or process development (Thai Publica, 2021). In addition, the service sector represents an important component of Thailand's economy. According to the Office of the National Economic and Social Development Council (NESDC, 2026, pp. 6-11), Thailand's GDP at current prices amounted to 18,683.9 billion baht in 2025. The same report

also noted that accommodation and food service activities expanded by 2.5 percent during the year, underscoring the continued importance of service-related activities in the Thai economy.

Technology plays a significant role in many aspects of modern life and society, as it facilitates various activities to be conducted more efficiently and conveniently while also creating new opportunities for people. Technology can enhance productivity in sectors such as manufacturing, communication, and data management through automation systems, which help reduce errors and save time. It also contributes to improving quality of life, particularly in the field of health, for instance, telemedicine or health-related applications that allow for quicker medical treatment. Although technology promotes learning and access to information by enabling everyone to learn anytime and anywhere, it also serves as the foundation for innovation, including artificial intelligence (AI) and blockchain technologies, which give rise to new businesses and ideas. However, according to a report by the Digital Economy Promotion Agency (Digital Economy Promotion Agency, 2019), despite Thailand's high level of internet access, the digital skills of the workforce remain relatively low, which presents a significant obstacle to maximizing the benefits of technology in the service sector. This issue is particularly important in Thailand's service economy, where productivity increasingly depends on technology adoption and the effective use of knowledge-based and digital capabilities.



Despite the growing importance of technology in Thailand's economy, a clear empirical gap remains in the literature. While previous studies have examined economic growth, human capital, and technological change in broader national, cross-country, or regional contexts, limited empirical research has systematically investigated the relative roles of labor, capital, and technological change specifically within Thailand's service sector over a long-term period. This gap provides the motivation for the present study.

Objectives

1. To examine the effects of labor and capital on economic growth in Thailand's service sector.

2. To analyze the rate of technological change and its impact on economic growth in Thailand's service sector.

Literature Review

The Solow growth model has long served as a foundational framework for explaining economic growth through the interaction of labor, capital, and exogenous technological progress. Subsequent studies have extended the model to better reflect real-world conditions. For example, (Yerznkryan, Gataullin and Gataullin, 2021, pp. 117-119) modified the labor growth assumption from an exponential to a linear form and showed that the model could still reach long-run equilibrium while improving its applicability to workforce and investment planning. Similarly, (Wickremeratne, 2020, pp. 1-4) incorporated human capital into the augmented Solow model and found that human capital exerts a stronger effect on GDP per capita than physical capital in several

Asian countries. These studies suggest that the explanatory power of the Solow model can be strengthened when labor is interpreted not only as a quantitative input but also as a qualitative one.

In service-based economies, the quality of labor may be particularly important. (Chomtohsuwan, 2016, pp. 65-68) emphasized that labor should not be assessed solely in terms of headcount, but also through education, skill formation, and returns to human capital. This argument is especially relevant to the service sector, where digital literacy, communication ability, and knowledge-intensive competencies can substantially affect productivity. Therefore, an empirical model using aggregate labor alone may understate labor's actual contribution when workforce quality is uneven across time.

Empirical studies on technological change also indicate that technology often plays a more decisive role in long-run growth than traditional factor accumulation. (Tran, Pavelková and Homolka, 2022, pp. 200-201), in their study of Vietnam, found that technological progress had a stronger long-term effect on GDP growth than either labor or capital. Likewise, (Kasrisom, 2024, pp. 145-146) reported that technological change positively affected economic growth in Chonburi Province, with capital having a greater impact than labor across sectors. These findings are consistent in showing that productivity growth increasingly depends on innovation, technology adoption, and efficiency gains rather than on labor expansion alone.

Across the literature, several common patterns can be observed. First, capital remains an important input for growth, particularly in sectors requiring infrastructure, digital systems, and logistics support. Second, labor quantity alone often appears insufficient to explain output growth unless labor quality is also taken into account. Third, technological progress repeatedly emerges as a major driver of long-run productivity. However, prior studies differ in their geographical scope, model specifications, and sectors of analysis. Many focus on cross-country comparisons, manufacturing, or regional economies, while relatively few directly examine Thailand's service sector over a long time horizon.

This creates an important research gap. Although previous studies have demonstrated the significance of capital, human capital, and technological progress, limited empirical research has systematically estimated their relative contributions within Thailand's service sector using a unified Cobb-Douglas production function and Solow residual framework. Accordingly, this study addresses that gap by examining the effects of labor and capital on service-sector output and by estimating technological change through Solow's residual for the period 1993–2023. In doing so, the study provides more direct empirical evidence on the drivers of structural transformation and productivity growth in Thailand's service economy.

Methods

1. Data collection: This study employed secondary time-series data spanning 31 years from 1993 to 2023. The data used in

the analysis were collected as follows: Gross Domestic Product (GDP) at current prices (Y): Data were obtained from Office of the National Economic and Social Development Council, the Bank of Thailand, and the National Statistical Office (unit: million baht). Total labor force employed in the production of goods (L): Data were sourced from Office of the National Economic and Social Development Council, the National Statistical Office of Thailand, and the Ministry of Labor (unit: persons). Capital stock used in the production of goods (K): Data were acquired from Office of the National Economic and Social Development Council, the Bank of Thailand, and the National Statistical Office of Thailand (unit: million baht).

2. Scope of industry studied: The classification of industrial sectors as defined by Office of the National Economic and Social Development Council exhibits discrepancies when compared to the classification used in the Labor Force Survey conducted by the National Statistical Office of Thailand under the Ministry of Digital Economy and Society. The NESDB adopts the International Standard Industrial Classification of All Economic Activities (ISIC) as a framework for sectoral classification. In contrast, the NSO's Labor Force Survey employed its own classification system from 1993 to 2000. Subsequently, from 2001 to 2009, it aligned with ISIC Revision 3.1 (ISIC Rev.3.1), and from 2011 onwards, it has been following ISIC Revision 4 (ISIC Rev.4). To ensure consistency with the study period, this research adopts the sectoral classification used in the NSO's Labor Force Survey (Employed Persons). A comparative grouping is established based on



the guidelines provided by the Labor Statistics Division of the NSO. Furthermore, to align with existing research, the industrial sectors are cat-

egorized into three broad groups: agriculture, industry, and services, as depicted in Figure 1, 2 and 3

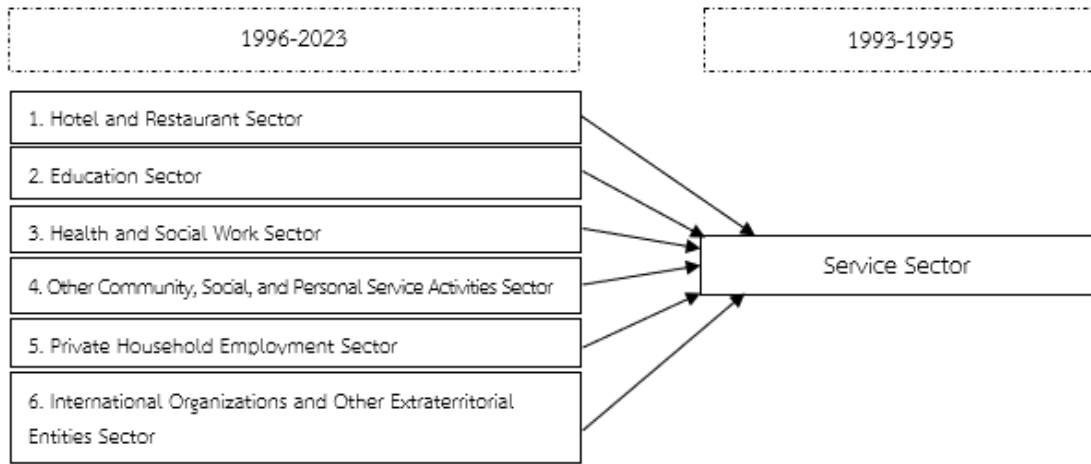


Figure 1 Classification of Production Sectors by the National Economic and Social Development Council

Source: Researcher's Study

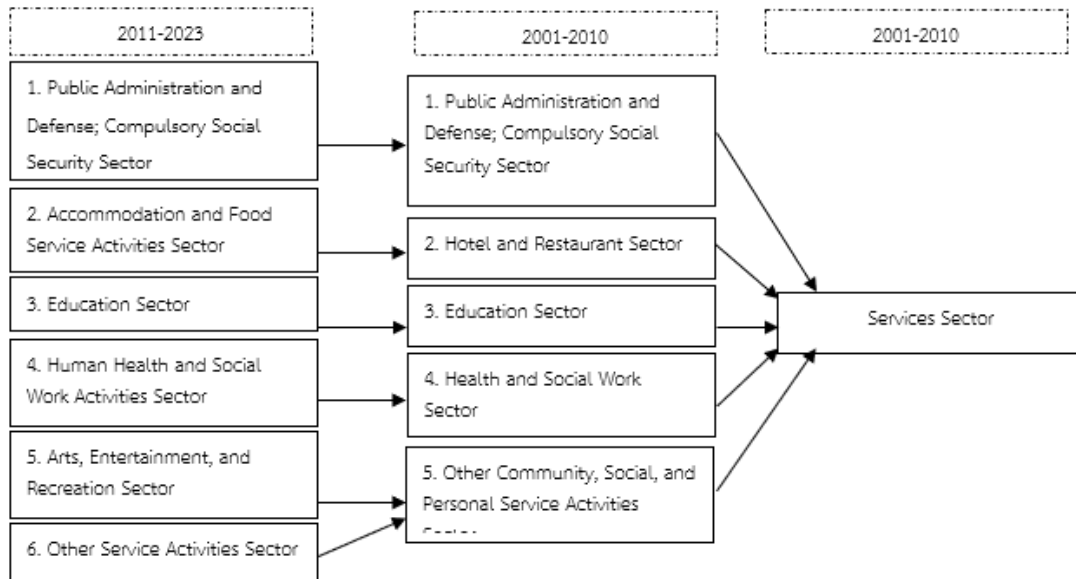


Figure 2 Classification of Production Sectors by the National Statistical Office

Source: Researcher's Study

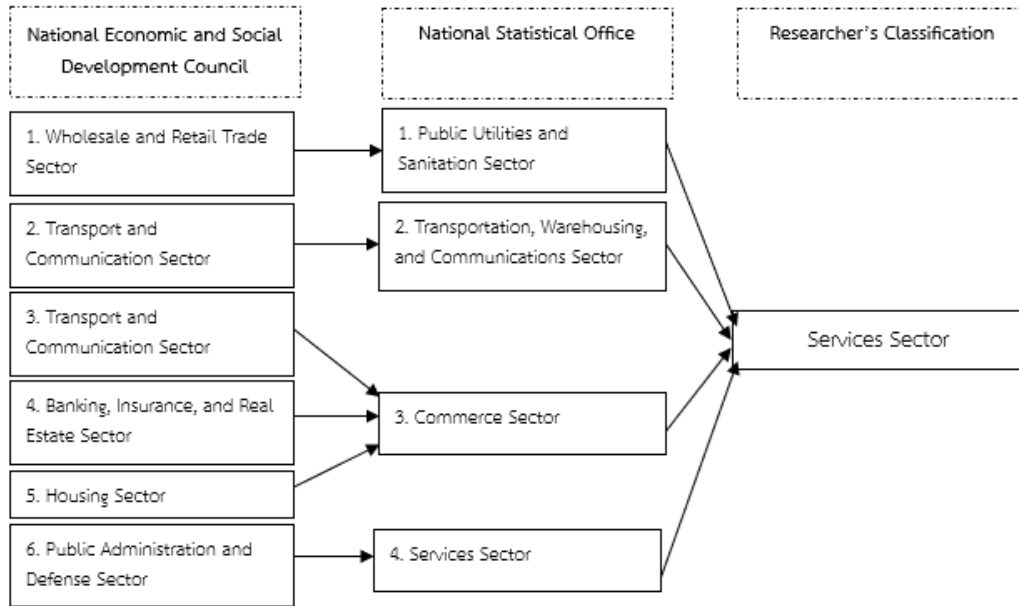


Figure 3 Classification of Production Sectors

Source: Researcher's Study

The three classification figures are presented to clarify the differences among the sectoral groupings adopted by the Office of the National Economic and Social Development Council (NESDC), the National Statistical Office (NSO), and the researcher-defined classification employed in this study. Their inclusion is intended to enhance transparency in industrial classification and to facilitate a clearer understanding of the grouping framework applied, rather than to present separate analytical findings.

3. Scope of the study: This study analyzes technological change through the framework of Solow's production function, expressed in natural logarithmic form. The analysis focuses on the growth rates of key production factors, namely labor, capital, and technology, that influence the production process. Particular attention is given to the impact of technological change and the inter-relationship between output and production

inputs within Thailand's service sector, aiming to understand how these dynamics contribute to overall economic performance. Prior to model estimation, the time-series properties of the variables were examined using standard econometric procedures, including unit root and cointegration tests, together with diagnostic checks for multicollinearity, heteroskedasticity, and autocorrelation. The results indicated that the data satisfied the required conditions for estimation, and no serious econometric problems were detected. These procedures were undertaken to reduce the risk of spurious inference and to strengthen the robustness of the estimated results. To preserve the readability of the manuscript, the detailed test statistics are not reported in the main text.

Based on the research framework, the production function is specified in natural logarithmic form in accordance with the Solow method. The Cobb-Douglas functional form



was selected because it provides a parsimonious and theoretically grounded representation of the relationship among output, labor, and capital, and it is widely used in empirical growth analysis. The assumption of constant returns to scale is maintained in line with the standard Solow framework and for comparability with prior studies. The present study intentionally retains the standard Cobb-Douglas and Solow framework in order to maintain consistency with the study's objectives and to focus on the comparative roles of labor, capital, and technological change. Alternative specifications, including models incorporating human capital or more flexible functional forms, may provide further insights and are therefore suggested for future research.

The production function is set to be in the form of Cobb-Douglas

$$Y = T L^{\alpha} K^{\beta} \quad (1)$$

Where Y is the gross national products of the Service Sector (million baht)

T is the technology that is used in the production of products.

K is capital assets used in product production in the Service Sector (million baht)

L is the total labor force used in producing products in the Service Sector (people)

α is the elasticity of output per labor.

β is the elasticity of output per capital.

As for changes in technology that affect the economic growth of the Service Sector in the manufacturing industry (i is each the Service Sector), it is shown in this equation.

$$Y_i = T_i L_i^{\alpha} K_i^{\beta} \quad (2)$$

From Equation (2), it can be in logarithmic form as follows

$$\ln Y = \ln T + \alpha \ln L + \beta \ln K \quad (3)$$

Find the derivative of equation (3) with respect to time.

$$\frac{1}{Y} \frac{dY}{dt} = \frac{1}{T} \frac{dT}{dt} + \alpha \frac{1}{L} \frac{dL}{dt} + \beta \frac{1}{K} \frac{dK}{dt} \quad (4)$$

when giving $\frac{dY}{dt} = \dot{Y}$, $\frac{dT}{dt} = \dot{T}$, $\frac{dL}{dt} = \dot{L}$, $\frac{dK}{dt} = \dot{K}$ will get

$$\frac{\dot{Y}}{Y} = \frac{\dot{T}}{T} + \alpha \frac{\dot{L}}{L} + \beta \frac{\dot{K}}{K} \quad (5)$$

$$\text{or } \frac{\Delta Y}{Y} = \frac{\Delta T}{T} + \alpha \frac{\Delta L}{L} + \beta \frac{\Delta K}{K} \quad (6)$$

$$\text{or } r_Y = r_T + \alpha r_L + \beta r_K \quad (7)$$

$$r_T = r_Y - \alpha r_L - \beta r_K \quad (8)$$

Where r_Y is Rate of change in output or total income of the Service Sector ($\Delta Y/Y$)

r_T is the rate of change in technology and other factors besides L and K of the Service Sector Also known as "Solow's Residual" ($\Delta T/T$)

r_L is the labor change rate ($\Delta L/L$) of the Service Sector.

r_K is the capital change rate ($\Delta K/K$) of the Service Sector.

From Equation (1), when α and β are known at the least squares analysis technique. Then, substitute the values obtained in Equation (8) to be able to measure the rate of technological change that affects the change in output of the overall economic sector and output of the production sector. Due to the rate of change in total output is known or the output in each branch of production (r_Y), the rate of change in the number of workers (r_L), and the rate of change in capital (r_K) of the overall economic system and each production sector in Service Sector it will make able to calculate the rate of technological change (r_T) of Service Sector. In terms of analyzing the

factors that determine changes in technology in the Service Sector able to use econometric models in the model of a complex multiple regressive equation, as follows.

Results

1. To examine the effects of labor and capital on economic growth in Thailand's service sector.

This study aims to analyze the role of labor and capital factors in driving economic growth in Thailand's service sector. The analysis is based on the Cobb-Douglas production function framework, which illustrates the relationship between output and key production input, namely labor (L) and capital (K). The model was transformed into a natural logarithmic form and estimated using multiple linear regression techniques.

The model demonstrates strong explanatory power, with an R-squared value of 0.9929 and an adjusted R-squared of 0.9909. This indicates that labor and capital together explain approximately 99.29% of the variation in service-sector output. Furthermore, the statistically significant F-statistic confirms the overall appropriateness of the model in explaining the dependent variable. These estimates are interpreted together with the diagnostic procedures reported in the Methods section, which did not indicate serious econometric problems affecting the estimation results.

The econometric results indicate that the capital variable has a regression coefficient of 0.6971, with a t-statistic of 3.3663, which is statistically significant at the 1% level. This suggests that capital is a significant determinant of

growth in the service sector. Specifically, a 1% increase in capital input is associated with an approximate 0.70% increase in service sector output. This finding aligns with the structure of Thailand's service sector, which relies heavily on capital investment in various sub-sectors such as information technology, telecommunications, and logistics systems. In contrast, the labor variable has a regression coefficient of 0.0862 and is statistically insignificant ($t = 0.1861$). From an economic perspective, the estimated elasticity of capital suggests that service-sector growth in Thailand is more closely associated with capital deepening than with labor accumulation. By contrast, the small and statistically insignificant labor coefficient implies that an increase in labor quantity alone does not translate proportionately into output growth within the estimated framework. (Table 1)



Table 1 Analysis of labor (L) and capital (K) factors affecting economic growth in Thailand's service sector.

Constant/Independent variable	Regression coefficient
	Service sector
Constant	2.2915 (0.4023)
Capital (K)	0.6971 (3.3663)***
labor (L)	0.0862 (0.1861)
R ²	0.9929
Adjust R ²	0.9909
F	651.791***
D.W.	1.5000
N	31

Source: From calculation

Note: Numbers in parentheses are t-statistics values.

***, **, * is statistical significance at the 99, 95, and 90 percent levels, respectively.

2. To analyze the rate of technological change and its impact on economic growth in Thailand's service sector.

The analysis of the role of technology was conducted through the computation of Solow's Residual, which reflects the rate of technological change that cannot be explained by changes in the traditional production factors namely, labor and capital. This residual component captures the contribution of technology and other unobserved factors to output growth.

Based on the results of the analysis covering the period from 1993 to 2023, Thailand's service sector exhibited an average output growth rate of 1.7651 per year. This indicates a consistent expansion of the sector over the past three decades. Such growth has

been driven by multiple factors, including capital accumulation, labor input, and most notably technological advancement.

When examining each factor individually, the findings are as follows: (1) Capital recorded an average annual growth rate of only 0.0718, indicating a relatively limited contribution to output growth. This suggests that investment in physical capital or infrastructure was not the primary driver of growth in the service sector during the study period. (2) Labor exhibited an average growth rate of 0.5805 per year. While labor contributed to the sector's expansion, its impact was secondary when compared to the influence of technological progress. (3) Technology, represented by Solow's Residual, had a computed value of 1.1128. This substantial figure underscores

the critical role of technology as a driving force behind economic growth in the service sector. The positive and significant rate of technological change confirms that advancements in technology played a decisive role in enhancing productivity and expanding output through-

out the study period. From an economic standpoint, this result suggests that growth in Thailand's service sector has been driven not only by factor accumulation, but also by productivity-enhancing improvements associated with technology and efficiency gains. (Table 2)

Table 2 Results of the analysis of the rates of change in labor capital and technology affecting the rate of change in output in Thailand's service sector during 1993–2023.

Rate of change	Service sector
Output or Total Income	1.7651
Capital	0.0718
labor	0.5805
Technology	1.1128

Source: From calculation

Note: From the calculation, Equation (8) the rate of change in technology and other factors besides L and K of the service sector Also known as "Solow's Residual" ($\Delta T/T$)

Conclusions and Discussion

This study investigates the effects of labor, capital, and technological change on economic growth in Thailand's service sector using time-series data from 1993 to 2023. In line with the study's objectives, the analysis focuses on two main issues: first, the respective effects of labor and capital on service-sector output; and second, the contribution of technological change as captured by Solow's residual. The analysis is grounded in the Cobb-Douglas production function and the Solow residual framework, which together provide an empirical basis for examining the main drivers of service-sector growth.

Role of Capital and Labor: The results derived from a multiple regression model reveal that capital plays a statistically significant role in driving growth within the service sector. The regression coefficient for capital is 0.6971, with statistical significance at the 1%

level. This implies that a 1% increase in capital input leads to an approximate 0.70% increase in output, indicating that Thailand's service sector remains heavily dependent on capital investment particularly in sub-sectors such as technology logistics and digital services. In contrast, the labor variable has a regression coefficient of only 0.0862 and is statistically insignificant ($t = 0.1861$). This suggests that labor quantity alone may not fully explain service-sector growth, particularly in contexts where labor quality and skill composition are likely to matter. A possible explanation lies in the mismatch between the skills of the labor force and the demands of the modern service economy, particularly in areas such as digital literacy and foreign language proficiency, which remain relatively underdeveloped.

Role of Technology and Solow's Residual: Taken together, these findings directly address the study's two research objectives.



With respect to the first objective, the results show that capital exerts a stronger influence on service-sector output than labor within the estimated model. With respect to the second objective, the positive Solow residual indicates that technological change has contributed substantially to growth beyond conventional factor inputs. These findings are broadly consistent with previous studies that emphasize the importance of capital accumulation, labor quality, and technological progress in shaping long-run economic performance. In particular, the present results are in line with Tran, Pavelková, and Homolka (2022, p.200-201), who found that technological progress played a stronger role than labor and capital in Vietnam, and with Kasrisom (2024, p.145-146), who reported that technology had a positive effect on economic growth in Thailand, with capital exerting a stronger impact than labor. At the same time, the statistically insignificant labor coefficient in this study suggests that labor quantity alone may not adequately capture productivity dynamics in Thailand's service sector, which is also consistent with the argument that labor quality and human capital are important considerations in growth analysis. The Solow's Residual, which represents the contribution of technological change, was calculated to be 1.1128. This clearly positive value indicates significant technological advancement, which has played a crucial role in driving productivity and output growth in Thailand's service sector. When comparing the average annual growth rates of service sector output 1.7651% the contribution of technology emerges as the most influential

factor, followed by labor (0.5805%) and capital (0.0718%). These findings demonstrate that technology is not only a key mechanism for enhancing production efficiency but also a critical determinant of the long-term structural transformation and growth trajectory of Thailand's service sector.

Taken together, the results suggest that growth in Thailand's service sector has been supported not only by capital accumulation in a conventional sense, but also by technology embodied in capital investment. In practical terms, this implies that investment in equipment, digital systems, and modern service infrastructure may have carried productivity-enhancing effects beyond the mere expansion of input quantities. This interpretation is consistent with the relatively strong capital coefficient and the sizable Solow residual observed in the present study.

In addition, although human capital is recognized as an important determinant of productivity and economic growth, the present study intentionally adopts the standard Solow framework in order to focus on the comparative roles of labor, capital, and technological change in Thailand's service sector. The incorporation of human capital may further enrich the analysis and is therefore recommended for future research.

Nevertheless, the findings should be interpreted with caution. The Solow residual may capture not only technological change, but also the effects of omitted variables, measurement error, and structural changes over time. Thus, the estimated technological component should be interpreted as a broad

productivity-related residual rather than as a perfectly pure measure of technology alone.

In addition, the explanatory power of the estimated model should be interpreted in conjunction with the time-series properties of the data and the broader analytical framework of the study. Therefore, the reported goodness-of-fit is considered as one part of the overall empirical assessment rather than as a stand-alone indicator of model validity.

From an academic perspective, this study contributes to the literature in several respects. First, it provides long-term empirical evidence on Thailand's service sector using time-series data covering the period 1993–2023, a context that has received relatively limited attention in previous Solow-based studies. Second, the study applies a unified Cobb-Douglas production framework together with the Solow residual approach to distinguish the respective roles of labor, capital, and technological change in sectoral growth. Third, the findings extend the existing literature by showing that, in the case of Thailand's service economy, technological change and capital appear to play more prominent roles than labor quantity alone. In this way, the study adds sector-specific evidence to the broader literature on productivity growth, structural transformation, and technology-driven development in emerging economies.

Policy and Managerial Implications: Based on the empirical findings, the study suggests that investment strategies in Thailand's service sector should place greater emphasis on technology adoption than on merely expanding the quantity of labor. This policy

interpretation is derived from the statistical evidence showing that capital is a significant determinant of output growth, while labor does not exhibit a statistically significant effect in the estimated model. Business operators are encouraged to focus on strategic investments in advanced technologies such as automation systems, Enterprise Resource Planning (ERP) software, and digital platforms, which have proven to be more effective in driving productivity and long-term growth than simply expanding the workforce. Moreover, the development of high-quality labor skills is critically important in maximizing the returns from technological investments. Businesses should allocate resources to continuous training programs that enhance digital skills, data literacy, and familiarity with emerging technologies. This will enable the workforce to utilize technology more effectively and contribute meaningfully to innovation and service efficiency.



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