
Labor Productivity Loss in Case of Death in Thailand

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Abstract:

Purpose: *This study aims to analyze the loss of labor productivity in the case of death in Thailand by measuring the average product of labor to assess the impact of the significant labor loss on the national economy.*

Methodology/Approach: *To analyze the labor productivity loss in Thailand caused by death, this research uses secondary data matched with suitable models to assess the labor situation in Thailand, both now and in the future.*

Findings: *The results of this study show that the total labor productivity loss in the case of death equated to about half a trillion baht in 2014 and more than 0.6 trillion baht in 2018, representing an increase of about 7.75%. The labor productivity loss in 2018 accounted for 5.81% of GDP and the accumulated value from 2014–2018 equated to more than 28% of GDP. This illustrates that the problem of significant labor loss in Thailand is becoming more important and needs to be resolved.*

Practical implications: *The results of this study highlight the importance of labor loss and government investment in public health, solving crime, and accident avoidance to reduce labor productivity loss. Appropriate policies can help alleviate the situation.*

Originality/Value: *This study analyzes the value of labor productivity loss in Thailand, raising awareness concerning the importance of the current situation and provides a foundation for properly addressing the issue.*

Keywords: *Labor productivity loss, average product of labor, ARIMA, forecast, Thailand.*

JEL codes: *J82, J88.*

Paper Type: *Research article.*

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1. Introduction

According to economic theory, whether micro or macro, labor is an important factor for production in a country's economic development. While other factors of production often encounter issues with the law of diminishing returns, labor does not. This is because labor can be developed to increase the skills of the workforce, thereby providing more skilled labor, leading to human capital growth. The labor skills can be improved through education and learning by doing, enabling workers to become skilled and develop their production capabilities, while increasing the country's production potential and contributing to its economic growth. Therefore, labor is important to the national economy.

Thailand has a labor force of about 43 million, or about 65% of the population. Unfortunately, almost 1.5 hundred thousand of the labor force has died as a result of health problems, crime, and accidents (National Statistical Office of Thailand, 2019, Annual Report from the Ministry of Public Health, 2019). Although this figure represents only about 0.35 of the labor force, it is higher than other countries in the Asia Pacific (World Bank, 2017). Loss of the labor force has a significant negative impact on Thailand's production capacity and considered to slow the growth of economic development.

The research questions discussed in this article are especially related to the economy and labor productivity in Thailand. This research is being conducted during a time when the world is facing considerable challenges with the spread of the COVID-19 virus. Millions of people have been infected and over 100,000 have died. Although the situation in Thailand is not serious, a number of people have died. Therefore, the loss of one person is important to labor productivity and the economic system of the country.

2. Literature Review

The theoretical literature is reviewed on the relationship between labor productivity and labor productivity loss in the case of Thailand. Part of the literature review underlines the determinants of labor productivity, the measurement of labor productivity loss, and the importance of labor productivity on the economy. The review of the literature shows the importance of the labor force loss for Thailand caused by death.

2.1 Determinants of Labor Productivity

Labor productivity is determined by many factors. An increase in labor productivity results in greater production efficiency and a stronger economy. For instance, human capital together with increased labor productivity leads to technological progress and higher production efficiency, especially in developed countries (Maudos *et al.*, 2003). Moreover, the neo-classical growth model by Mankiw, Romer, and Weil

(1992) focuses on the significant contribution of human capital to increased productivity and economic growth. It can be said that human capital contributes to higher labor productivity. The accumulation of human capital is due to the accumulation of human knowledge throughout a person's lifetime, such as with education and training. According to the concept proposed by Adam Smith in "The Wealth of Nations" (1776), learning by doing increases the accumulation of human capital in that person, making them more productive (Schultz, 1961).

Moreover, several studies support the concept that education and training is one of the key factors in creating higher human capital. The study by Griliches (1997) considers the relationship between economic growth and the education levels of the labor force, or the level of accumulated human capital. He found that many famous studies provided the same results, in that education levels affect production productivity and the country's economic activities. For example, Becker (1962) discovered that investment in human capital, especially education, improved labor productivity. A labor force with better education levels can produce more high-value products. While Summers and Barro (1991) found labor to be one of the important sectors of the production function, and a labor force with high human capital or a high level of education and skills is the most important factor in the production function. Although numerous studies use different methods and do not cover all dimensions, all reach a similar conclusion from the perspective of education level and human capital in the labor force. From the education and training aspect, most studies reach the same conclusion. Blundell (1999) reviewed empirical works in an attempt to assess the real impact of education and training on the income of individuals for indicating the level of human capital accumulation and found the existence of a relationship between education, training, and an individual's income. Investment in human capital through education and training was found to create a spillover effect on national economic growth at the macroeconomic level.

In addition, labor productivity along the life of one person varies according to their life cycle. Cataldi *et al.* (2011) studied productivity among age groups and found that those aged between 30 and 49 years accounted for most of the labor in a firm. Labor aged between 30 and 49 years generate the maximum productivity because those aged between 15 and 30 years do not generally provide specialist labor. They need training and some are still in the education level. Furthermore, labor older than 49 years are considered as being past their peak and nearing retirement. Cardoso *et al.* (2011) provide similar results, finding that a labor force aged between 35 and 49 has the highest productivity, increasing until an age range of between 50 and 54. On the other hand, wages were found to be highest around those aged between 40 and 44, and this may be regarded as the peak period of productivity.

2.2 The Measurement of Labor Productivity Loss

There are many different methods for measuring labor productivity. The simplest method to measure labor productivity is to calculate the ratio of labor productivity

using output per labor input. The output can be used as a proxy of gross output or value added. While labor can be used as a proxy for the total number of labor units employed or the number of hours worked (Besanko and Braeutigam, 2011). Labor productivity can also be measured using the labor productivity index (LPI). The LPI is based on the quantity of gross output divided by the quantity of labor input (Houseman, 2006). The calculation of LPI is used for comparison with the base year standard. By using the calculated value of the index rather than the simple method, it is easier to observe the changes in labor productivity or quality of labor. However, it cannot display labor productivity in economic terms to calculate labor productivity loss. The other method for measuring labor productivity is the marginal product of labor (MPL). The MPL is similar to the simple method and calculates the change in output per change in labor input. The difference between the simple method, namely the average product of labor (APL) and MPL is the meaning of the calculated result. The APL describes the average productivity of a labor unit, while the MLP describes the increasing marginal productivity per additional labor unit.

The measurement of productivity loss can be achieved from the APL, and predicts the future value when a labor unit is not present in the manufacturing sector due to death. Karen *et al.* (2010) found that the productivity loss caused by cancer deaths in the labor force amounted to approximately 64 million USD. Deaths caused by cancer were the highest contributor to productivity loss in Puerto Rico and impacted on the economy at large. Zander *et al.* (2015) studied heat stress as a cause of substantial labor productivity loss in Australia and found that labor productivity may decrease by approximately 11-22% in 2080 for hot regions (Asian Pacific and the Caribbean).

The annual cost is calculated to be about 655 USD per person, resulting in an economic burden of about 6.2 billion USD, or a labor productivity loss causing the economy to contract to about 0.33 to 0.47 of Australia's GDP. In addition, many studies support the concept of labor productivity loss, and its impact on the economic sector such as that by Zhang *et al.* (2011), who considered the measurement and evaluation of productivity loss due to poor health, while Zheng *et al.* (2010) studied productivity loss resulting from coronary heart disease in Australia. The study by Oliva-Moreno (2012) considered the loss of labor productivity caused by disease and health problems and their effect on Spain's economy, while Fox (2004) studied the impact of HIV/AIDS on labor productivity in Kenya. These authors have reached the same conclusion, namely that health problems and illness cause loss of labor productivity because the labor force is not working efficiently. Moreover, death from causes other than health problems such as accidents or criminal activity is also considered as loss of the labor force, which also results in loss of labor productivity.

3. Methodological Procedures

To analyze the labor productivity loss in Thailand in the case of death, this research uses secondary data to create a model suitable for Thailand's economic situation.

The data was collected from the National Economic and Social Development Council (NESDC), the World Bank, National Statistical Office of Thailand, and the Annual Report Ministry of Public Health, 2019. The model in this research uses the APL and the ARIMA model to forecast the future values of the APL. The calculated value is then applied to identify the level of productivity loss.

The APL is determined using the average productivity of one person. The calculation of the average product accords with equation 1.

$$APL = \frac{Q}{L} \tag{1}$$

Where: Q is the output defined by Thailand's GDP using data from the National Economic and Social Development Council;

L is the labor force using data from the World Bank and National Statistical Office of Thailand.

The forecasting model with an autoregressive integrated moving average is a stochastic process for analyzing time series data, also known as the Box-Jenkins (1976) methodology. The ARIMA model with the autoregressive model, moving average model, and the integration component are presented as follows.

The autoregressive model (AR) uses predictive data by applying the historical data (p) as a basis for forecasting the amount of data as shown in equation (2).

$$AR(p): APL_p = \alpha + \sum_{i=1}^p \beta_i APL_{t-i} + u_t \tag{2}$$

Where: α is a constant function;

β_i is a parameter value;

u_i is the value of the error term;

t is the period.

For example, $AR(1)$ and $AR(2)$ as shown in equations 3 and 4:

$$AR(1): APL_1 = \alpha + \beta_1 APL_{t-1} + u_t \tag{3}$$

$$AR(2): APL_2 = \alpha + \beta_1 APL_{t-1} + \beta_2 APL_{t-2} + u_t \tag{4}$$

The moving average model forecasts data using the historical discrepancy value or the error term (q) as shown in equation (5):

$$MA(q): APL_q = \gamma + \delta_0 u_t + \sum_{j=1}^q \delta_j u_{t-j} \quad (5)$$

Where: γ is a constant function;

δ is a parameter value.

For example, $MA(1)$ and $MA(2)$ follow equations 6 and 7:

$$MA(1): APL_1 = \gamma + \delta_0 u_t + \delta_1 u_{t-1} \quad (6)$$

$$MA(2): APL_2 = \gamma + \delta_0 u_t + \delta_1 u_{t-1} + \delta_2 u_{t-2} \quad (7)$$

The integration component relates to stationarity because most time series variables are non-stationary, and therefore, must go through a transformation process to differentiate the model to become stationary. The transformation process is also called integration (I(1), I(2)).

The ARIMA model is used in this study, as shown in equation (8):

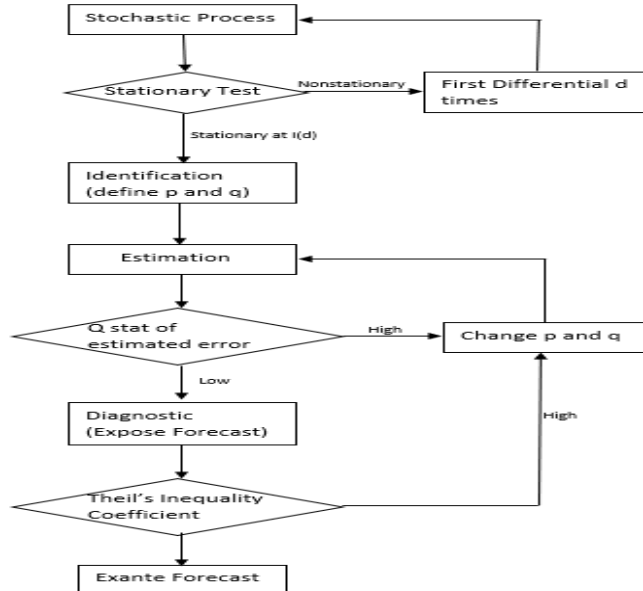
$$ARIMA(p, d, q): APL_t = \alpha + \sum_{i=1}^p \beta_i APL_{t-i} + \delta_0 u_t + \sum_{j=1}^q \delta_j u_{t-j} \quad (8)$$

Where: d is the value of the time variable of difference to become stationary.

The box diagram in Figure 1 shows the steps of the ARIMA model process.

This research uses the future production data of the APL to calculate the labor productivity loss in conjunction with additional information such as annual data on the number of deaths in the labor force according to age from the National Statistical Office of Thailand, Annual Reports from the Ministry of Public Health and the Department of Medical Services, Ministry of Public Health, Thailand.

Figure 1. Box diagram of the ARIMA model process



Source: Author.

4. Analysis of Results

The results for the APL in Thailand from 1993–2019 show approximate values of 138,675.9, 147,730.3, 156,581.6, 161,523.6, 153,819.1, 140,639.7, 146,199.5, 149,493.4, 151,556.1, 158,847.4, 168,281.8, 176,295.7, 181,265.4, 189,430.7, 196,674.2, 198,051.1, 195,412.6, 211,438.2, 207,235.7, 221,970.9, 232,989.8, 236,697.6, 244,582.5, 254,594.3, 264,288.8, 274,671.6, and 280,771.6 per person, per year respectively, representing an average growth rate of 2.82% for the period.

Compared to economic growth (GDP growth), labor productivity growth was found to be lower (Thailand’s average GDP growth rate being approximately 3.67% from 1993–2019). It can be observed that there is still a gap in Thailand’s labor productivity because the country’s economic system remains dependent on foreign investment, such as its large manufacturing industry (automotive, electronics, and electrical appliances). The highly skilled labor force in Thailand’s extensive manufacturing sector comes mostly from outside the country. The Thai labor force tends to consist of technicians and general workers, and as a consequence, there is still a knowledge gap and Thai workers need to be developed into a highly skilled labor force, especially those in the middle-age category.

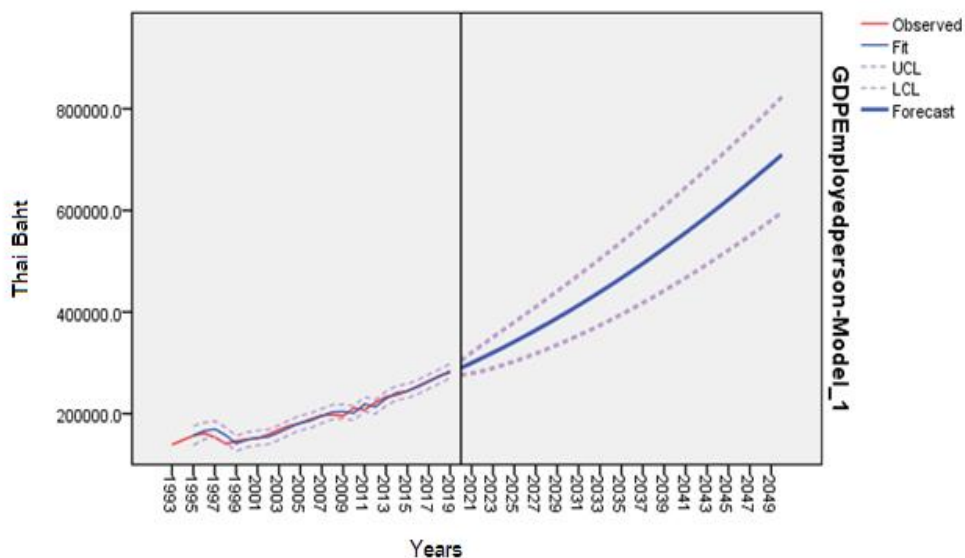
Therefore, this study uses the ARIMA (1,2,1) model to forecast the future values of the APL as shown in equation 9.

$$ARIMA(1,2,1): APL_t = \alpha + \beta_1 APL_{t-1} + \delta_0 u_t + \delta_1 u_{t-1} \tag{9}$$

Where the APL data becomes stationary at I(1) and I(2) but the Q statistic test confirms that it is appropriate for the ARIMA model at I(2).

The results of the forecasted values are shown in Figure 2 and Table 1.

Figure 2. The forecasted values of the APL using ARIMA (1,2,1)



Source: Author.

Table 1. The forecasted values for the APL using ARIMA (1,2,1)

Years	Real APL	Forecasted APL
1993	138,675.9	
1994	147,730.3	
1995	156,581.6	157,078.5
1996	161,523.6	165,965.5
1997	153,819.1	169,598.1
1998	140,639.7	157,821.4
1999	146,199.5	141,323.4
2000	149,493.4	148,681.3
2001	151,556.1	152,287.5
2002	158,847.4	154,494.8
2003	168,281.8	162,751.8
2004	176,295.7	173,106.7
2005	181,265.4	181,642.5
2006	189,430.7	186,747.7

Labor Productivity Loss in Case of Death in Thailand

496

Years	Real APL	Forecasted APL
2007	196,674.2	195,527
2008	198,051.1	203,102.2
2009	195,412.6	204,192.8
2010	211,438.2	201,117
2011	207,235.7	218,763.5
2012	221,970.9	213,407.7
2013	232,989.8	229,616.7
2014	236,697.6	240,956.2
2015	244,582.5	244,453.7
2016	254,594.3	252,785.6
2017	264,288.8	263,245.4
2018	274,671.6	273,257.8
2019	280,771.6	284,011.2
2020		290,094.1
2021		299,821.1
2022		309,846
2023		320,164.9
2024		330,777.4
2025		341,683.6
2026		352,883.6
2027		364,377.2
2028		376,164.5
2029		388,245.6
2030		400,620.4
2031		413,288.8
2032		426,251
2033		439,506.9
2034		453,056.5
2035		466,899.8
2036		481,036.8
2037		495,467.5
2038		510,191.9
2039		525,210
2040		540,521.8
2041		556,127.3
2042		572,026.6
2043		588,219.5
2044		604,706.1
2045		621,486.5
2046		638,560.5
2047		655,928.3
2048		673,589.8
2049		691,545
2050		709,793.8

Note: Thai baht.

Source: Author's estimation.

The model statistics confirm that the forecast produced by the ARIMA model has a fit statistic of 0.97 with a deviation from the forecast of approximately 2.695% as shown in Table 2.

Table 2. ARIMA model statistics

Model Statistics

Model	Number of Predictors	Model Fit Statistics					
		Stationary R-squared	R-squared	RMSE	MAPE	MAE	MaxAPE
GDP/Employed persons-Model_1	0	.408	.975	7132.575	2.695	4844.300	12.217

Source: Author's estimation.

According to the analysis of data and further information from the National Statistical Office of Thailand, Annual Reports from the Ministry of Public Health, and the Department of Medical Services, Ministry of Public Health, Thailand, the APL is forecast to lead to a labor productivity loss in Thailand. The data presented in Table 3 shows that a total of 2,270,441 people have died in Thailand during the period from 2014-2018. When this figure is divided into the number of deaths per year from 2014-2018, it equates to 435,604, 445,949, 469,078, 457,997, and 461,813 persons, respectively. Furthermore, when divided into age range, people over 70 years old accounted for 49% of deaths in 2018, while the proportion of deaths in people of working age (15-60 years) accounted for 31% in 2018.

Table 3. Number of deaths in Thailand divided by age range

Age range	Number of deaths (Persons)					Percentage				
	2014	2015	2016	2017	2018	2014	2015	2016	2017	2018
0-4	6,277	5,841	5,860	5,352	5,302	1.5	1.4	1.2	1.2	1.1
5-9	1,311	1,166	1,225	1,151	1,160	0.3	0.3	0.3	0.3	0.3
10-14	1,755	1,716	1,856	1,834	1,722	0.4	0.4	0.4	0.4	0.4
15-19	4,741	4,836	4,953	4,713	4,224	1.1	1.1	1.1	1.1	0.9
20-24	5,425	5,614	5,697	5,667	5,508	1.2	1.3	1.2	1.2	1.2
25-29	6,392	6,206	6,214	6,141	6,399	1.5	1.4	1.3	1.3	1.4
30-34	9,408	8,805	8,662	8,078	7,905	2.2	2	1.8	1.8	1.7
35-39	13,564	13,349	13,424	12,464	11,992	3.1	3	2.9	2.7	2.6
40-44	18,196	18,203	18,282	17,700	17,427	4.2	4.1	3.9	3.9	3.8
45-49	23,750	23,584	24,131	23,888	23,348	5.5	5.4	5.1	5.2	5.1
50-54	28,791	29,466	30,478	29,991	30,368	6.6	6.6	6.5	6.5	6.6
55-59	32,078	32,867	35,171	35,146	35,683	7.4	7.4	7.5	7.7	7.7
60-64	36,080	37,454	39,411	38,964	39,681	8.3	8.2	8.4	8.5	8.6
65-69	37,994	40,069	42,972	43,026	44,667	8.5	9	9.2	9.4	9.6
70-up	209,842	216,773	230,742	223,882	226,427	48.2	48.4	49.2	48.8	49

Source: Data collected by author.

The labor productivity loss is considered using people of working age, ranging from 25-59 years because skilled labor requires years of education and workplace

training. On average, a labor force over 25 years old is considered to be skilled labor. From the data presented in Table 4, it can be observed that the labor productivity loss was worth approximately 641 trillion baht in 2018 (representing 5.81% of Thailand's GDP in 2019). Moreover, the accumulated labor productivity loss from 2014–2018 is approximately 3.097 trillion baht (28.4% of Thailand's GDP in 2019).

Table 4. Labor productivity loss in Thailand

Age range	Labor Productivity Loss				
	2014	2015	2016	2017	2018
25–29	90,012,610,616.	90,055,764,341	92,887,064,634	94,531,704,576	101,425,102,472
30–34	103,235,603,116	99,644,504,125	101,058,868,835	97,130,830,050	97,927,199,287
35–39	112,161,997,798	113,929,762,361	118,202,610,310	113,192,471,606	112,281,195,533
40–44	107,959,178,892	111,548,919,634	115,661,321,635	115,565,505,420	117,379,380,744
45–49	93,303,221,625	95,754,311,100	101,200,346,490	103,437,944,780	104,336,113,502
50–54	63,877,727,970	67,602,441,218	72,246,133,169	73,412,878,527	76,710,852,566
55–59	24,490,449,516	26,081,762,324	28,830,794,172	29,717,253,945	31,068,717,084
Total	595,040,789,534	604,617,465,106	630,087,139,246	626,988,588,907	641,128,561,191

Note: Thai baht.

Source: Author's estimation.

5. Conclusion

This study examines the productivity loss caused by deaths occurring in the labor force in the case of Thailand. The results show that the real APL has increased over the period from 2014–2018 and is forecasted to increase further in the future as a consequence of continuous economic development. Moreover, an increase in the APL also creates more skilled labor. According to the results, labor is becoming more important to productivity and the economy, because the potential of the labor force has continued to develop throughout the twenty-first century as a result of advances in science and technology. Economic development in the twenty-first century will involve the integration of digital technology and automation (Artificial Intelligence, AI) into economic and social systems, known as technology disruption. Technology disruption creates changes in the structure of the labor system, causing the demand of unskilled labor to drop but increasing the demand for highly skilled labor. For this reason, only highly skilled labor will remain in the future, with unskilled labor being replaced by artificial intelligence. Therefore, the labor force will become more efficient, resulting in higher labor productivity.

Labor and human resources are becoming increasingly important to the country's economic development and the loss of one unit of labor will have an effect on the

national economy at both micro and macro levels. The effect on the national economy from the loss of labor can be measured by labor productivity loss. The results for labor productivity loss in the case of death indicates a total financial loss of about 0.595 trillion baht in 2014 and 0.641 trillion baht in 2018, representing an increase of about 7.75%. The increasing productivity loss each year from 2014-2018 indicates that the loss of labor is becoming more important. The labor productivity loss in 2018 accounted for 5.81% of GDP and the accumulated value from 2014-2018 equates to 28.4% of GDP. The value of productivity loss indicates labor efficiency and the continuing accumulation of human capital. This means that the labor force is able to generate high productivity, especially when the labor is highly skilled and combined with an automated system.

This study provides a broad picture of the importance of labor loss and government investment in public health, solving crimes, and accident avoidance. Government expenditure to address the issue of labor productivity loss might be beneficial in the future for reducing labor waste. However, this study focuses on labor productivity loss arising from death but realistically, the loss of labor productivity may depend on many factors such as illness, disability, psychological problems, stress, etc. These factors have contributed to labor inefficiency and labor productivity loss. Finally, the results of labor productivity loss caused by death do not provide a complete picture, and gaps remain. Future study could address the issue of the labor productivity loss from a health perspective.

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