Role of the Logistics Industry in Thailand's Economy

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Abstract

This paper aims to investigate the important role of the logistics industry in Thailand's economy. Input-output (I-O) analysis is applied to examine the role of the logistics sector and its economic impact on the national economy for the period 1975 to 2010. The results indicate that the logistics sector has difficulty in supporting and boosting other sectors, thereby hindering further national economic development. Moreover, this study considers the logistics sector exogenously in order to examine its economic impact on other sectors in terms of production-inducing effects, logistics supply shortages and sectoral prices. Furthermore, the logistics sector's contribution to Thailand's GDP is also evaluated. These key findings will provide guidelines for policymakers to plan and make decisions in formulating industrial policies to improve the logistics industry.

Keywords: Input-output analysis, inter-industry linkage, logistics industry, Thailand
JEL Classification: L52, L91, L98

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1. Introduction

Due to Thailand's advantageous geographical position, being centrally located in mainland Southeast Asia and the Greater Mekong sub region, it has the potential to become one of the key ASEAN transportation and logistical hubs, playing a major role in the new trading patterns of East Asia, and significantly contributing to regional development. In particular, the integration of the ASEAN Economic Community (AEC) provides a significant regional market, connecting customers and suppliers to Thailand. In the past decade, most global economic activities have concentrated on Asia, focusing on the creation of extensive investment, and trading in goods and services. As one of the fastest growing regions, this trend in international trade continues to be important to Asia. Thailand's trade liberalization and global economic integration have led to further increases in trade and services. Consequently, it is essential that Thailand improves its logistics capacity to increase the country's competitiveness.

International trade has been significant to Thailand's economic development during the past decade, with exports accounting for more than half the country's gross domestic product (GDP). Most exports consist of manufactured products, accounting for approximately 80% of its total exports. Thailand's major trading partners are China, the United States of America, Japan, and the European Union (EU). Recently, Thailand's exports have been dependent on structural changes in order to facilitate a higher share of value added manufacturing products and greater global trading. Therefore, an efficient logistics industry, integrated transport, and improved trading facilities are necessary for increasing the country's competitive-ness. Shepherd (2011) insisted that logistical improvement not only supports sectoral reallocation for heavy industries in developing the economy but also enhances the goal of export diversification. In addition, Shepherd (2013) testified that transport and logistics are important for facilitating international trade. Erkan (2014) also verified that logistics efficiency is a significant factor in a country's competitiveness and logistics activities accelerate productivity and economic growth.

Thailand's logistics sector is very large and creates high economic value. Nevertheless, the logistics performance of Thailand is lower than that of its major trading partners, and therefore, significant development is essential. Although Thailand's logistics cost as a percentage of GDP has reduced over the past decade from 17.8% in 2006 to 14.1% in 2015, it is still high compared to its major trading partners such as the USA, Japan, and the EU, where the logistics cost accounts for just 8 to 9% of GDP. According to Liu (2016), the logistics cost as a proportion of GDP is still high due to the inefficiency of the Thai logistics system. This is because there are many obstacles to Thai logistics development. Suthiwartnarueput (2007) identified the main reasons why Thailand's logistics system has not been sufficiently developed, as follows: The focus has been on physical distribution only; there is a lack of internal and external integrated logistics, lack of information on technology use, few logistics service providers, lack of linkage in transportation modes, and lack of rules and regulations. Most studies concerning the logistics industry have focused on the size of its market, the type of logistics service providers, and the efficiency of logistics services. However, there is no evidence in relation to the sectoral linkage between the logistics sector and the national economy. There-fore, in order to develop the Thai logistics sector, it is essential to understand the linkage between this sector and others and its

economic impact on the national economy. This would help policymakers to better understand Thailand's economic structure and its importance in formulating industrial policies and determining an economic plan for logistics sector improvement.

The objective of this paper is to analyze the role of the logistics sector in Thailand's economy during the period from 1975 to 2010. The static I-O approach is used for analysis so as to provide a preliminary indication for policymakers to help facilitate improvements in the logistics industry. This is investigated by combining the transportation and ware-housing sectors as the key to logistics activities. The I-O analysis is then used to examine the effects of inter-sectoral linkage, production-inducing, shortages in supply, and the impact of price changes on the logistics sector, including the value chain.

The remainder of this paper is organized as follows: section 2 contains the literature review, the methodology is explained in section 3, section 4 identifies the data used, the results are interpreted and discussed in section 5, and the final section provides a conclusion and recommendations.

2. Literature Review

Logistics plays a major role in business and global economic activity. It has become a key element for enhancing the competitiveness of a country and, as suggested by Mustra (2011), is considered to be the artery and most important element of national economic development. Many researchers have shown empirical evidence connecting the logistics industry with economic development in terms of qualitative and quantitative analysis. For example, Huang and Xu (2005) used comparative analysis to identify the importance of the logistics industry in national economic development. Liu (2009) applied gray relational analysis to investigate the development impact of China's logistics industry on the national economy. Recently, numerous empirical studies have applied the econometric model to analyze the importance of the logistics industry in relation to economic development. For example, Yang and Jianguo (2011), Yang and Zheng (2011), Reza (2013), Chu and Liu (2013), Hayaloğlu (2015), and Li, Zhao, and Zhao (2015) concluded that the logistics industry is associated with national economic growth and significant for sustaining economic development.

Moreover, Liu (2009) insisted that the logistics industry is strongly integrated with other sectors in the national economy, and therefore, its development is very important. This is because it takes into account the cost of the main inputs for all industries. Consequently, it is necessary for policymakers to understand current situations and the importance of the logistics industry to the national economy in order to improve the system. However, to achieve indepth development in the logistics industry, it is essential to clearly recognize the inter-relationships between sectors and their effect on the logistics industry and each other.

Additionally, to improve efficiency in the logistics sector, it is necessary for policies to be designed in relation to the value chain. Wood (2001) indicated that the value chain comes under two broad headings, namely, accounting and causation. Economic accounting is associated with the relationship between the input-output table and value chain, the welfare of firms and personnel, and money wages and real wages. The relationship between value chain analysis and comparative advantage theories has also been examined. By focusing on the input-output table and value chain, Faße, Grote, and Winter (2009) proved that input-output analysis is an important tool for analyzing the value chain of each industry because this approach can consistently determine the interdependence of all existing sectors within the

economy. Furthermore, the input-output analysis is able to identify value chain improvement. Putri et al. (2015) applied this method to improve the value chain of the cocoa industry in Indonesia.

To give an overview of the whole country's economic structure, the I-O table is the only appropriate database for analysis since it provides accurate individual data for both intermediate goods and final goods. The I-O analysis is a fundamental method of quantitative economics for illustrating macroeconomic activity as a system of interrelated goods and services. This approach has been widely used in various studies. For example, Briassoulis (1991) examined the economic impacts of the tourism sector. Hawdon and Pearson (1995) studied the effect of energy consumption on the environment and economic growth in the United Kingdom. Yoo and Yang (1999) and Han, Yoo, and Kwak (2004) assessed the role of water utility and the four electric power sectors in the Korean economy, respectively. San Cristóbal and Biezma (2006) measured the linkage effects of the mining and quarrying industry in the EU, and Kofoworola and Gheewala (2008) examined the signifycance of the construction sector in relation to other sectors of the Thai economy.

In recent years, empirical studies have applied the I-O approach for analyzing the particular role of each logistics subsector in the national economy. Kwak, Yoo, and Chang (2005) used the I-O analysis to evaluate the role of the maritime sector in the Korean economy. Chiu and Lin (2012a; 2012b) investigated the role and impact of the transportation and maritime sectors on the national economy of Taiwan, respectively. Furthermore, Morrissey and O'Donoghue (2013) examined the linkage effect, production-inducing effect, and employment multiplier of the maritime sector on the Irish national economy.

There have been a number of previous research studies associated with Thailand's logistics industry. For example, Banomyong (2007) investigated the contribution of the logistics industry to GDP growth. Kunadhamraks and Hanaoka (2008) applied fuzzy set techniques to evaluate the logistical performance of intermodal freight transportation. Wanitwattanakosol, Holimchayachotikul, Nimsrikul, and Sopadang (2010) used a two-phase quantitative framework to select an efficient freight logistics hub in the North-South Economic Corridor (NSEC) of Thailand. Fukuishi (2010) applied the input-output method to identify the economic characteristics and structure of each mode along with the entire transportation system and evaluated the impact of modal shift on reducing energy consumption in the Thai economy. Moreover, Bourlakis, Melewar, Banomyong, and Supatn (2011) developed a questionnaire and survey to perform logistics regression analysis for examining the key characteristics of quality shipments and their effect on the decision making process of shippers when deciding on third-party logistics service providers.

Based on the literature review, there are few studies related to logistics industry activities as a whole using the input-output analysis method. The empirical evidence reveals that the input-output approach is used to investigate the particular role of each logistics subsector in the national economy. Moreover, most studies concerning the logistics industry have focused on the size of its market, type of logistics service providers, and efficiency of logistics services, applying several methods such as fuzzy set techniques, two-phase quantitative frameworks, questionnaires, and surveys. However, the input-output approach for analyzing the inter-industry linkage between the logistics sector and its

important role in the national economy has rarely been researched.

3. Methodology

The I-O model was first developed in the late 1930s by Wassily Leontief. It is very helpful for analyzing issues in the logistics sector and their relationship to the national economy. This is because the model separates the interdependence of all sectors in the economy and the use of logistics in the industrial sector. Moreover, this approach has rarely been used to investigate the Thai logistics sector. This section provides an overview of the I-O framework used to analyze the role of the logistics sector and its effect on other sectors in the national economy.

1) General framework of the I-O analysis

As Leontief (1986) proposed, the I-O model is linear and inter-sectoral approach describes the relationships between productive sectors in a given economy. According to Kwak et al. (2005),an economy consists of *N* industry sectors, the balanced equations of the I-O model can be shown as

$$X_i = \sum_{j=1}^{N} X_{ij} + F_i = \sum_{j=1}^{N} a_{ij} X_j + F_i \quad (1)$$

or

$$X_j = \sum_{i=1}^{N} X_{ij} + V_j = \sum_{i=1}^{N} r_{ij} X_i + V_j \quad (2)$$

where X_i is the total gross output in sector $i = 1,....,N$; a_{ij} are the direct input or technical coefficients which are calculated by dividing X_i, the interindustry purchases of production sector i from supply sector j with X_j, total gross output in sector j; r_{ij} are the direct output coefficients which divide X_{ij}, the inter-industry purchase of production sector i from supply sector j by X_i, total gross input in sector i; F_i is the final demand for products in sector i; and V_i is the value added by sector j.

2) Inter-industry linkage effect analysis

Miller and Blair (2009) proposed the basic concepts of I-O analysis. The fundamental requirement for the I-O approach is the "transactions table" which demonstrates the interindustry transactions. In the I-O model framework, the production in a specific sector causes two types of economic impact on other sectors in the economy, represented by the forward linkage effect and the backward linkage effect.

The idea of interdependent structural measures as the forward and backward inter-industry linkage was introduced by Rasmussen (1956). Hirschman (1958) then proposed that the quantification of the linkage effect analysis was based on the assumption that the relevant industries in the economy can be stimulated through the linking activities of input and output. Furthermore, comparing the forward and backward linkage of different sectors in the national economy provides a tool to help identify the "key" or "leading" sectors and group different sectors into spatial clusters (Miller and Blair, 2009).

The forward linkage effect is measured using the sensitivity of dispersion index, dividing the average of n elements in row i by the average of all n^2 elements in the Leontief inverse matrix. This index is expressed as:

$$\sum_j U_{ij} = \frac{1/n \sum_j B_{ij}}{1/n^2 \sum_i \sum_j B_{ij}} \tag{3}$$

where n is the number of industries, and $\sum_j B_{ij}$ is the sum of elements along the horizontal row of the Leontief inverse matrix and $\sum_j \sum_i B_{ij}$ is the sum of all elements of the Leontief inverse matrix. Similarly, the backward linkage is represented as the power of dispersion index, dividing the average of n elements in column j by the average of all n^2 elements in the Leontief inverse matrix. This index is defined as:

$$\sum_i U_{ij} = \frac{1/n \sum_i B_{ij}}{1/n^2 \sum_i \sum_j B_{ij}} \tag{4}$$

where $\sum_i B_{ij}$ is the sum of the column elements in the Leontief inverse matrix.

According to Lin and Chang (1997), if the values for sensitivity of dispersion and power of dispersion for any industries are greater than one, it indicates that these industries play significant roles in supporting and boosting other industries in economic development and are considered "key" or "leading" sectors in the national economy. On the other hand, if the values for sensitivity of dispersion and power of dispersion are less than one, it can be interpreted that these industries have relatively poor capacity to support and boost other industries.

3) Demand-driven model

According to Han, Yoo, & Kwak (2004) and Kwak, Yoo, & Chang (2005), equation (1) explains the demand-driven model as viewed vertically in the I-O tables. This equation can be rewritten in the short matrix form as $X = (I - A)^{-1} F$, where I is the $N \times N$ identity matrix and $(I - A)^{-1}$ is the Leontief inverse matrix whose elements $b_{ij} = \partial X_i / \partial F_j$ indicate the sum of direct and indirect outputs in sector i per unit of the final demand in sector j.

The standard demand-driven model mentioned above cannot exactly evaluate the effects of new production activity in the logistics industry on all other sectors of the economy. This is because changes in the final demand are due to factors outside the model, such as changes in consumer tastes and government purchases. To achieve this, the logistics industry needs to be treated as exogenous and grouped into the final demand (Miller and Blair, 2009). This approach is known as logistics sector-based I-O analysis. Subscripts "e" and "L" are added to represent the new matrices and the vector related to the individual logistics sector, respectively. This gives $X_e = (I - A_e)^{-1}(F + A_L X_L)$. Assuming the final demand does not change $(\Delta F_e = 0)$, then the following is obtained:

$$\Delta X_e = (I - A_e)^{-1} A_L \Delta X_L \tag{5}$$

Equation (5) can be used to analyze the important relationship among industries to achieve efficient production and assess the effect of change in logistics supply investment on the output of all other sectors, known as the production-inducing effect.

4) Supply-driven model

The traditional I-O analysis is based on the assumption that the production function has fixed coefficients and supply is perfectly elastic. It focuses on analyzing the impacts of backward linkage and may not be suitable for use with forward linkage analysis. Therefore, the supply-driven I-O model has been developed to address the direct and indirect effects of supply constraints (Davis and Salkin, 1984).

According to Kwak et alKwak, Yoo, & Chang (2005), equation (2) describes the supply-driven model as viewed horizontally in the I-O tables and can be rewritten in an abbreviated matrix form as $X' = V'(I-R)^{-1}$ with $(I-R)^{-1}$ as the output inverse matrix of which elements $(q_{ij} = \partial X_i / \partial V_j)$ are the total direct and indirect requirements in sector j per unit of final value added in sector i. A prime (′) denotes the transpose of the given matrix. As in the case of the demand-driven I-O model, when the logistics sector is treated as exogenous and the assumption is made that there is no change in the value added for all sectors, the following is obtained:

$$\Delta X'_e = R_L \Delta X_L (I - R_e)^{-1} \tag{6}$$

Equation (6) can be carried out to measure the effect of a unit shortage in the logistics sector on the output of all other sectors and utilized as a foundation for determining the shortage or failure costs of logistics production.

5) Leontief price model

As Miller and Blair (2009) suggested, the analysis described above relies on the I-O table in monetary units, but the interdependence of all sectors in the economy can be measured in physical units. This will at least lead to the elimination of price influence. The Leontief price model can be used to trace through the economy-wide repercussions of price changes in exogenous inputs. Following past practice, the logistics sector is considered as exogenous and grouped according to its primary inputs. If there is no price change in the value added sector, the traditional Leontief price model is expressed as:

$$\Delta \overline{P} = (I - A'_e)^{-1} \hat{A}_L \Delta \overline{P}_L \tag{7}$$

$\overline{P}$ is the matrix of normalized price. Changes in cost for each sector are assumed to be fully transferrable and the annual production of each sector is given. The wholesale price changes in the economic system are caused by the cost changes in the logistics sector and can be measured by equation (7) as Kwak, Yoo, & Chang (2005) suggest.

6) Value chain analysis

According to Faße, Grote, and Winter (2009), value chain analysis at product level is provided by The Food and Agriculture Organization of the United Nations (FAO) in terms of financial analysis and economic analysis. This method is based on the concept of value-added to identify the chain performance. This study focuses on economic analysis

which is carried out from the perspective of the society or the economy as a whole. The value added for each individual chain and the total value added for the whole chain are calculated and interpreted as creating at least one economic activity. Then, the valued added for each chain is calculated as:

$$VA_{ij} = Y_{ij} - II_{ij} \tag{8}$$

Where II represents the intermediate inputs value which is used in production activities. Y is the total value of the output of product i and j denotes each of agent.

The total value added is described as a measure of the value chain to GDP, the following is obtained:

$$VA_{chain} = Y_{chain} - II_{chain} = \sum VA_{agents} \tag{9}$$

4. Data

This study employs nine economic I-O tables gathered for Thailand's economy between 1975 and 2010. The Thai I-O table databases were collected by the National Economic and Social Development Board (NESDB). They are available in four formats, i.e., 16 × 16, 26 × 26, 58 × 58, and 180 × 180. In this study, the most disaggregated format (180 × 180) of the I-O tables is used to analyze the interdependence of each sector on the whole economy and integrated into 19 sectors. However, the logistics sector does not exist in the I-O tables of Thailand. Therefore, it is necessary to identify those sectors closely related to the Thai logistics sector and then combine them into one logistics group. The identification of the logistics sector in this study is based on the classification provided by the West London Skills Council (Banomyong, 2007) as shown in Table 1.

Table 1. Logistics sector code

Logistics sectors	Code
Pipelines	136
Railway	149
Road freight transport	151
Land transport support services	152
Ocean transport	153
Coastal and inland water transport	154
Water transport services	155
Air transport	156
Other transport services	157
Silos and warehouses	158

The other sector groups accord with the National Industrial Development Master Plan 2012 to 2031, namely food manufacturing, motor vehicles and repairs, textile industry, rubber industry, electrical machinery and apparatus. The remaining groups are arranged according to the original I-O table. Sector aggregation is shown in Table 2.

Table 2. Sector classification

Sectors	Code
1. Agriculture	001-029
2. Mining and quarrying	030-041
3. Food manufacturing	042-066
4. Textile industry	067-074
5. Other manufacturing	075-077,098,129-134
6. Saw mills and wood products	078-080
7. Paper and printing industries	081-083
8. Chemical and petroleum industries	084-094
9. Rubber industry	095-097
10. Non-metallic products	099-104
11. Metal products	105-111
12. Industrial machinery	112-115,123-124,128
13. Electrical machinery and apparatus	116-122
14. Motor vehicle and repairs	125-127
15. Electricity and water supply system	135,137
16. Construction	138-144
17. Logistics	136,149,151-158
18. Trade and services	145-148,150,159-178
19. Unclassified and bodies unknown	179,180

5. Results

Nine sets of I-O domestic tables (i.e. 1975, 1980, 1985, 1990, 1995, 1998, 2000, 2005, and 2010) available for Thailand's economy were employed for the logistics sector-based analysis. All nine original tables with 180 sectors were integrated into 19 groups.

1) Inter-industry linkage effect

This study employs the sensitivity of dispersion index for measuring the forward linkage effect and the power of dispersion index for measuring the backward linkage effect. Table 3 demonstrates the forward linkage effects of all sectors in the entire Thai economy. The important results show that the forward linkage effect of the logistics sector is smaller than one, with relatively small changes occurring from 1975 to 2010. This means that the impact of the Thai logistics sector on production is of the industry for the national economy. Therefore, this implies that the logistics sector has difficulty in supporting other sectors, hindering further national economic development. However, considering the ranking of this sector from nineteenth in 1975 to tenth in 2010, it can be concluded that the logistics sector is significant in supporting other sectors in the national economy.

On the other hand, the backward linkage effect for all sectors is shown in Table 4. The results indicate that the value of backward linkage in the logistics sector is less than one and the change is quite small from 1975 to 2010. This implies that the investment expenditure of the Thai logistics sector has less impact on the national economy than other sectors. That is, the capacity of the logistics sector for pulling in other sectors is relatively weak.

Focusing on the logistics industry, the backward linkage effect indicates that its production activities may result in greater use of other sectors as inputs for logistics production. From the direct input coefficient, the logistics sector is most directly involved with the chemical and petroleum industries, followed by mining and quarrying. On the other hand, the forward linkage effect indicates that

logistics may be used as an input for other sectors in their own production. The evidence from the direct output coefficient reveals that the logistics sector is the most important in supporting electricity and the water supply system, followed by logistics itself, and construction. However, these sectors are not identified as significant in boosting and supporting other sectors in the Thai economy.

Generally, all of the nine input-output tables can be analyzed and the results show that the backward linkage effect was higher than that of the forward linkage for the Thai logistics sector. This indicates that the role of the logistics sector in boosting the national economy is greater than the pulling effect of the national economy on the logistics industry. However, considering the power of dispersion index or backward linkage index (BLI) and the sensitivity of dispersion index or forward linkage index (FLI) in 2010 display in Table 5, indicate that both BL and FL indices are less than one (BLI <1 and FLI <1). This means that the logistics sector cannot be considered a "key" or "leading" sector in the national economy(Lin and Chang, 1997), which is shown in Figure 1.

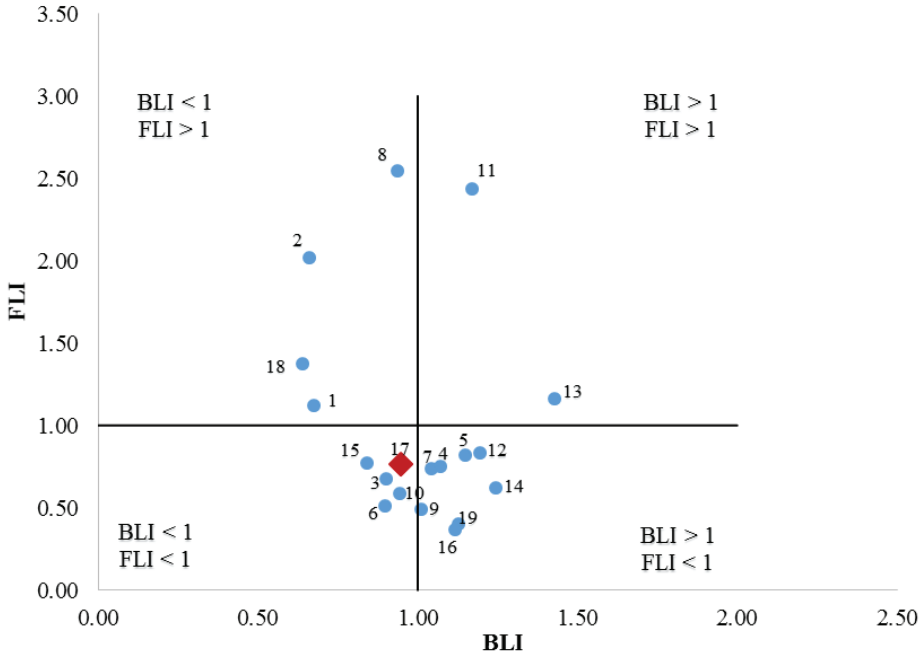

Figure 1. Backward linkage and forward linkage indices for 19 sectors of Thailand in 2010

Table 3. Sectoral forward linkage effect (sensitivity of dispersion index)

Year	1975		1980		1985		1990		1995		1998		2000		2005		2010	
Sector	**Value**	**Rank**	**Value**	**Rank**	**Value**	**Rank**	**Value**	**Rank**	**Value**	**Rank**	**Value**	**Rank**	**Value**	**Rank**	**Value**	**Rank**	**Value**	**Rank**
1.Agriculture	1.6542	4	1.6271	3	1.6478	4	1.3857	3	1.3195	4	1.2801	6	1.1537	5	1.1029	6	1.1235	6
2.Mining and quarrying	1.8049	2	2.2584	2	2.0579	2	1.3207	4	1.1759	7	1.3357	4	1.5709	4	1.9309	3	2.0188	3
3.Food manufacturing	0.8977	8	0.8740	8	0.9842	7	0.8505	10	0.7997	11	0.8112	11	0.7521	13	0.7057	13	0.6727	13
4.Textile industry	1.2250	5	1.2271	5	1.0869	6	1.0772	8	0.9703	9	1.0129	8	0.9113	9	0.8043	8	0.7513	11
5.Other manufacturing	0.6266	16	0.6151	15	0.6783	14	0.8247	11	0.8134	10	0.8976	10	0.8434	10	0.8014	10	0.8215	8
6.Saw mill and wood products	0.6566	13	0.7129	12	0.6386	16	0.6556	16	0.6097	16	0.6030	17	0.5577	17	0.5366	16	0.5115	16
7.Paper and printing industries	0.8597	9	0.9346	7	0.8378	9	0.8896	9	0.9758	8	0.9666	9	0.9250	8	0.7517	11	0.7382	12
8.Chemical and petroleum industries	2.1495	1	2.5870	1	2.0931	1	2.0418	2	2.0431	2	2.0680	1	2.4001	1	2.3652	2	2.5479	1
9.Rubber industry	0.6563	14	0.5694	16	0.5798	17	0.5246	17	0.5986	17	0.6727	15	0.6179	15	0.4840	17	0.4885	17
10.Non-metallic products	0.6307	15	0.6892	13	0.6616	15	0.6670	15	0.6111	15	0.6409	16	0.5891	16	0.5761	15	0.5891	15
11.Metal products	1.7701	3	1.3730	4	1.7976	3	2.2291	1	2.1387	1	1.7255	2	1.8048	2	2.4189	1	2.4390	2
12.Industrial machinery	1.1461	6	0.8509	9	0.8653	8	1.0818	7	1.2470	5	1.0969	7	0.9488	7	0.8670	7	0.8347	7
13.Electrical machinery and apparatus	0.7711	11	0.7310	11	0.7294	12	1.1363	6	1.2281	6	1.3782	3	1.6986	3	1.3887	4	1.1599	5
14.Motor vehicle and repairs	0.7996	10	0.6840	14	0.7221	13	0.7326	13	0.7354	12	0.7680	13	0.7863	11	0.6646	14	0.6234	14
15.Electricity and water supply system	0.7282	12	0.7579	10	0.7727	11	0.7408	12	0.7160	13	0.7268	14	0.7530	12	0.8039	9	0.7700	9
16.Construction	0.5545	18	0.4770	19	0.4666	18	0.4379	18	0.4273	19	0.4409	19	0.3933	19	0.3744	19	0.3687	19
17.Logistics	0.5421	19	0.5551	17	0.8232	10	0.7269	14	0.6779	14	0.7803	12	0.7436	14	0.7161	12	0.7637	10
18.Trade and services	0.9616	7	0.9367	6	1.1053	5	1.2467	5	1.4843	3	1.3297	5	1.1035	6	1.2964	5	1.3761	4
19.Unclassified and bodies unknown	0.5655	17	0.5397	18	0.4517	19	0.4304	19	0.4282	18	0.4650	18	0.4470	18	0.4113	18	0.4013	18

Source: Author's calculation

Table 4. Sectoral backward linkage effect (power of dispersion index)

Year	1975		1980		1985		1990		1995		1998		2000		2005		2010	
Sector	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank
1.Agriculture	0.6287	18	0.6546	18	0.7274	17	0.6852	17	0.6782	18	0.7294	17	0.7293	17	0.7051	17	0.6743	17
2.Mining and quarrying	0.6184	19	0.5937	19	0.7060	18	0.6718	18	0.6799	17	0.7025	18	0.6440	19	0.6376	18	0.6596	18
3.Food manufacturing	0.9255	14	0.9523	14	0.9580	13	0.9332	12	0.9222	13	0.9911	12	0.9631	12	0.9316	12	0.9016	14
4.Textile industry	1.1386	6	1.1539	4	1.0846	6	1.1275	6	1.0642	7	1.1326	4	1.0789	5	1.0410	8	1.0699	8
5.Other manufacturing	0.9422	13	1.0048	10	0.9986	11	1.0518	8	1.0535	8	1.0965	6	1.0597	6	1.1062	7	1.1487	5
6.Saw mill and wood products	0.9063	15	0.8791	16	0.9327	15	0.9210	13	0.9251	12	0.9339	13	0.8617	15	0.9184	14	0.8975	15
7.Paper and printing industries	1.1000	7	1.0533	9	1.0486	9	1.0797	7	1.0887	6	1.0221	10	1.0379	8	1.0169	9	1.0426	9
8.Chemical and petroleum industries	0.9827	11	0.9395	15	1.0005	10	0.9365	11	0.9061	14	0.9178	14	0.9611	13	0.9297	13	0.9349	13
9.Rubber industry	0.9617	12	0.9810	13	1.0877	5	1.0418	9	1.0266	9	1.0744	7	1.0070	10	1.0144	10	1.0100	10
10.Non-metallic products	0.9909	10	0.9949	12	0.9576	14	0.9019	15	0.9031	15	0.9075	15	0.8885	14	0.9000	15	0.9447	12
11.Metal products	1.1387	5	1.1238	6	1.1380	4	1.1555	5	1.1778	5	1.0067	11	1.0004	11	1.1763	4	1.1697	4
12.Industrial machinery	1.2337	3	1.2202	2	1.1816	2	1.2162	3	1.3838	1	1.2657	2	1.1886	4	1.1611	5	1.1958	3
13.Electrical machinery and apparatus	1.1778	4	1.1443	5	1.0839	7	1.3013	2	1.3295	3	1.3331	1	1.5956	1	1.4761	1	1.4299	1
14.Motor vehicle and repairs	1.2751	2	1.1727	3	1.1531	3	1.1940	4	1.2251	4	1.1293	5	1.2495	3	1.2697	2	1.2456	2
15.Electricity and water supply system	1.0190	9	1.0697	8	0.8491	16	0.7957	16	0.7397	16	0.8690	16	0.7531	16	0.7944	16	0.8396	16
16.Construction	1.0601	8	1.0728	7	1.0731	8	0.9962	10	0.9955	10	1.0233	9	1.0463	7	1.1200	6	1.1182	7
17.Logistics	0.8889	16	0.9951	11	0.9855	12	0.9183	14	0.9287	11	1.0368	8	1.0173	9	0.9444	11	0.9504	11
18.Trade and services	0.6536	17	0.6564	17	0.6756	19	0.6468	19	0.6353	19	0.6871	19	0.6463	18	0.6329	19	0.6385	19
19.Unclassified and bodies unknown	1.3581	1	1.3378	1	1.3583	1	1.4254	1	1.3371	2	1.1411	3	1.2718	2	1.2240	3	1.1284	6

Source: Author's calculation

Table 5. Sectoral backward linkage and forward linkage indices of Thailand in 2010

Sector	BLI	FLI	FLI >1 BLI >1	FLI >1 BLI <1	FLI <1 BLI >1	FLI <1 BLI <1
1. Agriculture	0.6743	1.1235		×		
2. Mining and quarrying	0.6596	2.0188		×		
3. Food manufacturing	0.9016	0.6727				×
4. Textile industry	1.0699	0.7513			×	
5. Other manufacturing	1.1487	0.8215			×	
6. Saw mill and wood products	0.8975	0.5115				×
7. Paper industries and printing	1.0426	0.7382			×	
8. Chemical and petroleum industries	0.9349	2.5479		×		
9. Rubber industry	1.0100	0.4885			×	
10. Non-metallic products	0.9447	0.5891				×
11. Metal products	1.1697	2.4390	×			
12. Industrial machinery	1.1958	0.8347			×	
13. Electrical machinery and apparatus	1.4299	1.1599	×			
14. Motor vehicle and repairing	1.2456	0.6234			×	
15. Electricity and water supply system	0.8396	0.7700				×
16. Construction	1.1182	0.3687			×	
17. Logistics	0.9504	0.7637				×
18. Trade and services	0.6385	1.3761		×		
19. Unclassified and bodies unknown	1.1284	0.4013			×	

Source: Author's calculation

2) Production-inducing effect

The sectoral impacts of logistics investment are shown in Table 6. The significant results show that the total effect of a 1.0 Thai baht change in logistics investment on the output of other sectors was 1.3222 baht and the total production-inducing effect was 2.3222 baht in 2010. The total gross output of the logistics sector was 1.4528 billion baht in 2010. This indicates that the logistics sector induced 1.9209 billion baht of production, totaling 3.3736 billion baht of production into the economy. In addition, the total production-inducing effect of the logistics sector increased approximately 1.4085 times from 0.9388 to 1.3222 during the period from 1975 to 2010.

The top three sectors with the highest production-inducing effects in the logistics sector for 2010 are chemical and petroleum industries (sector 8, 0.4005), mining and quarrying (sector 2, 0.3517), and trade and services (sector 18, 0.1775). On the other hand, the three lowest production-inducing effects caused by the logistics sector are construction (sector 16, 0.0022), sawmills and wood products (sector 6, 0.0036), and non-metallic products (sector 10, 0.0039).

It can be concluded that increased investment in the logistics sector may provide more help to other sectors, particularly for the chemical and petroleum industries as the highest production-inducing logistics sectors, followed by mining and quarrying. This is because these two sectors provide the consumptive demand to the logistics sector as the main input of logistics production. In contrast with construction—sawmills, wood products, and non-metallic products have the lowest influence on logistics sector development.

3) Supply shortage effect

The sectoral supply shortage effect of the logistics sector is shown in Table 7, providing valuable information relating to

the economic impact of a supply shortage in the logistics industry. The results indicate that the total shortage costs of all sectors, excluding the logistics sector, increased from 0.1822 to 0.8659 baht for the period from 1975 to 2010. It can be interpreted that if logistics had not been applied in 2010, there would have been 1.2580 billion baht of production failure in other sectors. The top three sectors for the highest supply shortage effect in the logistics sector are the electricity and water supply systems (sector 15, 0.2041), construction (sector 16, 0.0717), and nonmetallic products (sector 10, 0.0562). On the other hand, the three lowest sectors affected by a supply shortage from the logistics industry are agriculture (sector 1, 0.0125), food manufacturing (sector 3, 0.0224), and trade and services (sector 18, 0.0250).

Logistics supply has a direct and indirect effect on the production activities of other sectors. As a result, supply shortages in the logistics sector are important since they have a great impact on other logistics-consumers. Evidence from this study shows that the logistics sector offers the greatest support to electricity and water supply systems, followed by construction, and the lowest support to agriculture and food manufacturing.

4) Pervasive effect of price change

Table 8 shows a sectoral increase of 10% in the logistics rate during the period from 1975 to 2010. This indicates that the consequent economic impact on the country increased slightly from 0.0063 to 0.0156%.[2] The top three sectors affected by higher logistics prices are chemical and petroleum (sector 8, 0.0440), mining and quarrying (sector 2, 0.0252), and motor vehicle and repairs (sector 14, 0.0169). On the other hand, the three sectors least affected are food manufacturing (sector 3, 0.0080), agriculture (sector 1, 0.0092), and sawmills and wood products (sector 6, 0.0094).

In general, it can be concluded that the impact of changes to the logistics price is relatively small or changes in logistics pricing are likely to impact slightly on the economy as a whole. This is important for the logistics industry and pricing policy. As a result, the Thai government is able to set more effective and efficient pricing policies for the logistics industry and to control the price impact more accurately.

5) Value chain of the Thai logistics industry to GDP

Table 9 describes the value chain in the logistics sector, based on the concept of value added. The results demonstrate that this sector has added little value to national GDP, accounting for 3.50 to 5.50% for the period 1975 to 2010. The value added to GDP from each logistics subsector is shown in Table 10. The results suggest that the value added to GDP from road freight transport is highest, although relatively small, accounting for 0.93% in 2010. On the other hand, the value added from the railways is the lowest at approximately 0.03% of GDP in 2010. According to the Ministry of Transport (2010), the structure of Thailand's domestic freight transport relies greatly on road transportation, accounting for 81.36% of the total. Although rail transport is more cost-effective, it accounted for only about 2.18% of total freight transportation due to weakness in the infrastructure of the rail transport system. This information is useful to policymakers for increasing the contribution of the Thai logistics industry to national GDP by supporting each of the related sectors in providing more value added activities.

[2] These values are calculated as the weighted average of sectoral price impact when considering the total output of each individual sector.

Table 6. Production-inducing effects of the logistics sector

Year	1975		1980		1985		1990		1995		1998		2000		2005		2010	
Sector	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank
1.Agriculture	0.0289	8	0.0320	8	0.0348	7	0.0331	8	0.0363	7	0.0307	9	0.0303	9	0.0245	9	0.0278	9
2.Mining and quarrying	0.1519	2	0.2526	2	0.2700	2	0.1522	2	0.1555	2	0.1982	2	0.2658	2	0.3347	2	0.3517	2
3.Food manufacturing	0.0188	10	0.0213	10	0.0258	10	0.0279	10	0.0243	11	0.0200	12	0.0214	12	0.0197	10	0.0192	10
4.Textile industry	0.0415	6	0.0408	6	0.0302	8	0.0343	7	0.0311	10	0.0280	10	0.0254	11	0.0141	13	0.0118	14
5.Other manufacturing	0.0089	16	0.0087	15	0.0091	14	0.0169	14	0.0180	15	0.0180	14	0.0178	14	0.0165	11	0.0186	11
6.Saw mill and wood products	0.0052	18	0.0061	17	0.0043	15	0.0056	17	0.0051	17	0.0038	17	0.0032	17	0.0031	17	0.0036	17
7.Paper and printing industries	0.0184	12	0.0293	9	0.0133	13	0.0181	13	0.0221	13	0.0194	13	0.0187	13	0.0130	14	0.0155	13
8.Chemical and petroleum industries	0.3380	1	0.4970	1	0.3786	1	0.3114	1	0.3069	1	0.3075	1	0.3886	1	0.3855	1	0.4005	1
9.Rubber industry	0.0186	11	0.0207	11	0.0267	9	0.0221	11	0.0341	8	0.0369	8	0.0342	8	0.0156	12	0.0181	12
10.Non-metallic products	0.0066	17	0.0067	16	0.0041	16	0.0075	16	0.0054	16	0.0043	16	0.0037	16	0.0033	16	0.0039	16
11.Metal products	0.0400	7	0.0349	7	0.0510	6	0.0742	5	0.0693	6	0.0597	6	0.0712	5	0.0797	4	0.0857	4
12.Industrial machinery	0.0645	5	0.0487	5	0.0517	5	0.0643	6	0.0721	5	0.0772	5	0.0684	6	0.0549	6	0.0467	6
13.Electrical machinery and apparatus	0.0101	15	0.0099	14	0.0135	12	0.0283	9	0.0330	9	0.0416	7	0.0523	7	0.0308	8	0.0281	8
14.Motor vehicle and repairs	0.0711	4	0.0857	3	0.0913	3	0.1047	4	0.1058	4	0.1188	4	0.1287	3	0.0682	5	0.0706	5
15.Electricity and water supply system	0.0189	9	0.0194	12	0.0214	11	0.0204	12	0.0224	12	0.0220	11	0.0277	10	0.0311	7	0.0345	7
16.Construction	0.0112	14	0.0049	18	0.0026	18	0.0027	18	0.0029	18	0.0014	18	0.0009	18	0.0011	18	0.0022	18
18.Trade and services	0.0713	3	0.0686	4	0.0840	4	0.1143	3	0.1462	3	0.1267	3	0.1186	4	0.1485	3	0.1775	3
19.Unclassified and bodies unknown	0.0149	13	0.0137	13	0.0037	17	0.0167	15	0.0185	14	0.0140	15	0.0105	15	0.0064	15	0.0064	15
Total	0.9388		1.2012		1.1161		1.0547		1.1089		1.1282		1.2874		1.2505		1.3222	

Source: Author's calculation

Table 7. Supply shortage effects of the logistics sector

Year	1975		1980		1985		1990		1995		1998		2000		2005		2010	
Sector	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank
1.Agriculture	0.0055	16	0.0041	18	0.0105	18	0.0079	18	0.0071	18	0.0074	18	0.0103	18	0.0117	18	0.0125	18
2.Mining and quarrying	0.0190	2	0.0220	2	0.0349	6	0.0435	4	0.0461	2	0.0322	6	0.0286	8	0.0250	13	0.0289	14
3.Food manufacturing	0.0050	18	0.0059	16	0.0172	16	0.0119	17	0.0114	17	0.0117	17	0.0132	17	0.0186	17	0.0224	17
4.Textile industry	0.0073	12	0.0087	12	0.0235	13	0.0245	9	0.0184	13	0.0236	8	0.0273	9	0.0301	7	0.0452	6
5.Other manufacturing	0.0062	14	0.0088	11	0.0265	11	0.0213	13	0.0206	11	0.0213	10	0.0252	11	0.0301	8	0.0428	8
6.Saw mill and wood products	0.0054	17	0.0065	15	0.0180	15	0.0198	14	0.0137	15	0.0160	15	0.0158	16	0.0242	14	0.0311	13
7.Paper and printing industries	0.0073	13	0.0076	14	0.0285	10	0.0224	11	0.0188	12	0.0179	14	0.0182	15	0.0272	12	0.0367	12
8.Chemical and petroleum industries	0.0149	3	0.0178	3	0.0627	3	0.0478	3	0.0409	5	0.0368	4	0.0423	5	0.0389	5	0.0399	10
9.Rubber industry	0.0057	15	0.0054	17	0.0188	14	0.0157	15	0.0134	16	0.0157	16	0.0190	14	0.0204	16	0.0287	15
10.Non-metallic products	0.0143	4	0.0144	7	0.0555	5	0.0320	6	0.0366	6	0.0388	3	0.0466	3	0.0487	4	0.0562	3
11.Metal products	0.0116	5	0.0152	6	0.0303	8	0.0272	7	0.0278	8	0.0236	9	0.0290	6	0.0375	6	0.0455	5
12.Industrial machinery	0.0105	8	0.0165	5	0.0297	9	0.0250	8	0.0280	7	0.0254	7	0.0286	7	0.0299	9	0.0409	9
13.Electrical machinery and apparatus	0.0115	6	0.0141	8	0.0346	7	0.0243	10	0.0219	10	0.0206	11	0.0264	10	0.0297	10	0.0431	7
14.Motor vehicle and repairs	0.0088	9	0.0127	9	0.0260	12	0.0219	12	0.0224	9	0.0181	13	0.0238	12	0.0290	11	0.0392	11
15.Electricity and water supply system	0.0087	10	0.0126	10	0.2107	1	0.1788	1	0.1084	1	0.1868	1	0.1766	1	0.1436	1	0.2041	1
16.Construction	0.0111	7	0.0176	4	0.0673	2	0.0366	5	0.0454	3	0.0535	2	0.0748	2	0.0769	2	0.0717	2
18.Trade and services	0.0074	11	0.0083	13	0.0169	17	0.0154	16	0.0167	14	0.0192	12	0.0209	13	0.0218	15	0.0250	16
19.Unclassified and bodies unknown	0.0223	1	0.0296	1	0.0557	4	0.0502	2	0.0416	4	0.0331	5	0.0456	4	0.0633	3	0.0520	4
Total	0.1822		0.2278		0.7675		0.6262		0.5393		0.6016		0.6721		0.7065		0.8659	

Source: Author's calculation

Table 8. Sectoral price effects of a 10% increase in logistics sector

Year	1975		1980		1985		1990		1995		1998		2000		2005		2010	
Sector	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank
1.Agriculture	0.0022	18	0.0043	17	0.0052	16	0.0040	18	0.0042	18	0.0046	17	0.0073	14	0.0089	15	0.0092	17
2.Mining and quarrying	0.0027	16	0.0041	18	0.0109	3	0.0094	4	0.0115	3	0.0154	3	0.0175	3	0.0220	2	0.0252	2
3.Food manufacturing	0.0025	17	0.0048	16	0.0048	17	0.0042	17	0.0044	17	0.0043	18	0.0065	16	0.0079	18	0.0080	18
4.Textile industry	0.0085	5	0.0133	5	0.0085	8	0.0088	6	0.0083	8	0.0081	8	0.0101	9	0.0102	13	0.0126	9
5.Other manufacturing	0.0062	10	0.0112	9	0.0080	10	0.0068	10	0.0079	9	0.0081	9	0.0113	6	0.0139	4	0.0164	4
6.Saw mill and wood products	0.0035	15	0.0059	15	0.0045	18	0.0042	15	0.0047	15	0.0048	16	0.0056	18	0.0080	17	0.0094	16
7.Paper and printing industries	0.0080	7	0.0126	8	0.0084	9	0.0072	9	0.0068	10	0.0053	13	0.0095	11	0.0120	10	0.0138	8
8.Chemical and petroleum industries	0.0317	1	0.0463	1	0.0389	1	0.0301	1	0.0298	1	0.0306	1	0.0397	1	0.0428	1	0.0440	1
9.Rubber industry	0.0061	11	0.0096	11	0.0096	5	0.0085	7	0.0096	6	0.0100	5	0.0128	4	0.0137	6	0.0142	7
10.Non-metallic products	0.0082	6	0.0133	4	0.0099	4	0.0057	11	0.0067	11	0.0072	10	0.0112	7	0.0138	5	0.0159	5
11.Metal products	0.0042	14	0.0080	12	0.0068	12	0.0049	14	0.0056	14	0.0049	15	0.0071	15	0.0104	12	0.0122	12
12.Industrial machinery	0.0086	4	0.0127	7	0.0095	7	0.0082	8	0.0095	7	0.0101	4	0.0110	8	0.0121	9	0.0124	11
13.Electrical machinery and apparatus	0.0054	12	0.0100	10	0.0064	13	0.0053	12	0.0057	13	0.0050	14	0.0078	12	0.0088	16	0.0108	15
14.Motor vehicle and repairs	0.0114	3	0.0175	3	0.0143	2	0.0144	2	0.0149	2	0.0155	2	0.0188	2	0.0147	3	0.0169	3
15.Electricity and water supply system	0.0146	2	0.0258	2	0.0060	14	0.0052	13	0.0062	12	0.0061	11	0.0057	17	0.0099	14	0.0109	14
16.Construction	0.0049	13	0.0078	13	0.0059	15	0.0042	16	0.0046	16	0.0057	12	0.0078	13	0.0106	11	0.0125	10
18.Trade and services	0.0064	9	0.0075	14	0.0074	11	0.0089	5	0.0107	5	0.0098	6	0.0098	10	0.0124	7	0.0146	6
19.Unclassified and bodies unknown	0.0078	8	0.0129	6	0.0095	6	0.0106	3	0.0114	4	0.0085	7	0.0115	5	0.0122	8	0.0120	13
Weighted average	0.0063		0.0102		0.0086		0.0080		0.0089		0.0090		0.0118		0.0140		0.0156	

Source: Author's calculation

Table 9. Value chain of the Thai logistics industry to GDP (billion baht)

Code	Logistics subsectors	1975	1980	1985	1990	1995	1998	2000	2005	2010
136	Pipelines	-	-	3.49	2.39	7.27	7.23	18.59	46.49	81.92
149	Railways	0.70	0.85	1.97	2.31	3.93	3.37	3.69	3.78	3.65
151	Road freight transport	4.48	10.88	26.05	42.37	49.48	44.64	40.47	52.34	100.89
152	Land transport supporting services	0.21	0.46	0.38	3.98	10.30	14.71	16.52	21.95	30.25
153	Ocean transport	0.42	1.53	1.65	4.14	5.39	7.99	8.10	18.16	12.91
154	Coastal and inland water transport	3.97	3.19	5.08	11.42	20.55	26.68	32.79	49.42	78.69
155	Water transport services	0.39	0.58	1.22	4.26	5.73	4.91	4.00	5.34	7.62
156	Air transports	1.95	5.53	16.03	23.30	32.16	38.55	40.39	70.38	67.42
157	Other services	0.62	2.29	1.18	9.22	10.30	12.15	12.85	39.57	49.42
158	Silo and warehouse	0.51	0.91	1.04	1.34	2.32	2.51	2.43	6.54	13.20
Total value added		13.25	26.22	58.10	104.75	147.44	162.74	179.83	313.97	445.98
Gross Domestic Product (GDP)		303.30	662.48	1056.50	2263.50	4217.60	4701.60	5069.80	7614.10	10802.40
Total value added to GDP (%)		4.37	3.96	5.50	4.63	3.50	3.46	3.55	4.12	4.13

Source: Author's calculation

Table 10. Value chain of each the Thai logistics subsectors to GDP (billion baht)

Code	Logistics subsectors	1975	1980	1985	1990	1995	1998	2000	2005	2010
136	Pipelines	-	-	0.33	0.11	0.17	0.15	0.37	0.61	0.76
149	Railways	0.23	0.13	0.19	0.10	0.09	0.07	0.07	0.05	0.03
151	Road freight transport	1.48	1.64	2.47	1.87	1.17	0.95	0.80	0.69	0.93
152	Land transport supporting services	0.07	0.07	0.04	0.18	0.24	0.31	0.33	0.29	0.28
153	Ocean transport	0.14	0.23	0.16	0.18	0.13	0.17	0.16	0.24	0.12
154	Coastal and inland water transport	1.31	0.48	0.48	0.50	0.49	0.57	0.65	0.65	0.73
155	Water transport services	0.13	0.09	0.12	0.19	0.14	0.10	0.08	0.07	0.07
156	Air transports	0.64	0.83	1.52	1.03	0.76	0.82	0.80	0.92	0.62
157	Other services	0.21	0.35	0.11	0.41	0.24	0.26	0.25	0.52	0.46
158	Silo and warehouse	0.17	0.14	0.10	0.06	0.05	0.05	0.05	0.09	0.12
Total value added to GDP (%)		4.37	3.96	5.50	4.63	3.50	3.46	3.55	4.12	4.13

Source: Author's calculation

6. Conclusions and Recommendations

This study applies the comprehensive I-O analysis in order to assess the role of the logistics sector in Thailand's economy for the period from 1975 to 2010. To achieve this, interindustry linkage effect analysis, the demand-driven model, the supply-driven model, and the Leontief price model were employed. Excluding analysis of the inter-industry linkage effect, the logistics sector is considered exogenously in order to examine the impact of changes in investment, supply, and price on logistics for the national economy.

The role of the logistics sector in the Thai national economy can be summarized as follows. Firstly, the results of interindustry linkage indicate that the values of forward and backward linkage effects for the logistics sector are lower than one. This means that this sector plays a minor role compared to other sectors in enhancing the growth of the overall industry, and its investment expenditure has a relatively small impact on the national economy. Moreover, it can be concluded that the Thai logistics sector has difficulty in supporting and boosting other sectors and could not be considered as a "key" or "leading" sector in the national economy. When considering the National Industrial Development Master Plan for the period 2012 to 2031, the leading sectors included food manufacturing, motor vehicles and repairs, the textile industry, rubber industry, and electrical machinery and apparatus. However, only electrical machinery and apparatus can be represented as a key or leading sector. From the direct input coefficients, these industries are less relevant to supporting the development of the national logistics sector.

Secondly, the impact of investment in sectoral logistics supply from the demand-driven model indicates that the total production-inducing effect of the logistics sector was high, increasing slightly from 0.9388 to 1.3222 over the years from 1975 to 2010. This implies that the logistics sector could be more significant and helpful to the productivity of other sectors.

Thirdly, the effect of the total supply shortage of the logistics sector was low, increasing from 0.1822 to 0.8659 during the period from 1975 to 2010. This means that shortages in the logistics sector have led to increased costs in other sectors, particularly for electricity and water supply systems, construction and nonmetallic products.

Finally, the economy-wide price effect in this study is found to be notably small, as is the value chain of the logistics industry to national GDP. This provides vital insight for the Thai government's logistics investment and pricing policy to facilitate its improvement.

Although the logistics industry plays a crucial role in the country's economy and increasing its competitiveness, logistics development remains elusive. An efficient logistics industry is achieved by the development of other sectors closely related to it. The results of this study suggest that chemical and petroleum industries and mining and quarrying have a great influence on logistics development. Moreover, the evidence from this study indicates that metal products and electrical machinery and apparatus are identified as the "key" or "leading" sectors, thereby development of these sectors is vital for supporting and boosting other sectors in the national economy. In terms of contribution by the logistics industry to GDP, rail transportation was found to add the lowest value, indicating that current government policy should place serious emphasis on the development of the rail transport system.

This paper represents the first attempt to analyze the sectoral linkage effect, sectoral impact of logistics investment,

sectoral logistics supply shortage effect, and the sectoral price impact on the logistics sector. Although the logistics sector does not exist in the Thai I-O table, it is a good starting point for the application of transportation and warehousing activities as proxies for the logistics industry. The findings from this study are useful for policymakers to at least give them a preliminary indication of the role of the logistics sector in formulating industry policies and making decisions to invest or improve it. Further study should analyze the role of each logistics subsector and their economic impact on Thailand's economy in order to determine policy implications for particular sectors.

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Appendix

Table A1. Direct input coefficient of sectors to which the logistics sector

Year	1975		1980		1985		1990		1995		1998		2000		2005		2010	
Sector	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank
1.Agriculture	0.0007	15	0.0003	16	0.0002	18	0.0002	18	0.0001	18	0.0002	18	0.0010	16	0.0011	16	0.0014	16
2.Mining and quarrying	0.0000	19	0.0000	19	0.0594	3	0.0519	5	0.0707	4	0.1070	3	0.1158	2	0.1420	2	0.1581	2
3.Food manufacturing	0.0040	12	0.0037	10	0.0060	9	0.0063	10	0.0049	11	0.0043	11	0.0060	10	0.0057	9	0.0044	10
4.Textile industry	0.0156	6	0.0138	6	0.0104	8	0.0088	9	0.0074	9	0.0064	9	0.0057	11	0.0033	11	0.0027	12
5.Other manufacturing	0.0017	13	0.0010	14	0.0012	14	0.0021	13	0.0023	14	0.0024	15	0.0018	15	0.0018	15	0.0019	15
6.Saw mill and wood products	0.0001	18	0.0001	18	0.0004	16	0.0015	16	0.0015	16	0.0012	16	0.0007	17	0.0009	17	0.0009	17
7.Paper and printing industries	0.0060	9	0.0087	8	0.0019	12	0.0036	12	0.0041	12	0.0035	13	0.0032	14	0.0023	14	0.0027	12
8.Chemical and petroleum industries	0.2465	1	0.3725	1	0.2810	1	0.1981	1	0.1854	1	0.1926	1	0.2222	1	0.2274	1	0.2169	1
9.Rubber industry	0.0061	8	0.0109	7	0.0188	7	0.0159	7	0.0233	6	0.0221	7	0.0208	7	0.0107	7	0.0116	8
10.Non-metallic products	0.0005	17	0.0003	16	0.0000	19	0.0001	19	0.0001	18	0.0001	19	0.0000	19	0.0000	19	0.0000	19
11.Metal products	0.0008	14	0.0012	13	0.0011	15	0.0016	15	0.0016	15	0.0038	12	0.0040	12	0.0030	12	0.0047	9
12.Industrial machinery	0.0262	4	0.0229	4	0.0231	6	0.0207	6	0.0181	7	0.0284	6	0.0231	6	0.0210	6	0.0142	6
13.Electrical machinery and apparatus	0.0006	16	0.0004	15	0.0015	13	0.0021	13	0.0027	13	0.0032	14	0.0036	13	0.0025	13	0.0022	14
14.Motor vehicle and repairs	0.0467	2	0.0627	2	0.0642	2	0.0695	3	0.0679	5	0.0817	4	0.0772	4	0.0392	5	0.0432	5
15.Electricity and water supply system	0.0049	11	0.0033	11	0.0047	10	0.0060	11	0.0067	10	0.0060	10	0.0066	9	0.0097	8	0.0117	7
16.Construction	0.0055	10	0.0020	12	0.0004	16	0.0007	17	0.0008	17	0.0003	17	0.0002	18	0.0003	18	0.0009	17
17.Logistics	0.0212	5	0.0210	5	0.0518	4	0.0815	2	0.0895	2	0.1096	2	0.1158	2	0.1204	3	0.1241	3
18.Trade and services	0.0444	3	0.0383	3	0.0405	5	0.0617	4	0.0771	3	0.0684	5	0.0599	5	0.0756	4	0.0878	4
19.Unclassified and bodies unknown	0.0084	7	0.0080	9	0.0031	11	0.0157	8	0.0169	8	0.0120	8	0.0076	8	0.0037	10	0.0034	11

Table A2. Direct output coefficient of sectors to which the logistics sector

Year	1975		1980		1985		1990		1995		1998		2000		2005		2010	
Sector	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank
1.Agriculture	0.0007	15	0.0003	16	0.0002	18	0.0002	18	0.0001	18	0.0002	18	0.0010	16	0.0011	16	0.0014	16
2.Mining and quarrying	0.0000	19	0.0000	19	0.0594	3	0.0519	5	0.0707	4	0.1070	3	0.1158	2	0.1420	2	0.1581	2
3.Food manufacturing	0.0040	12	0.0037	10	0.0060	9	0.0063	10	0.0049	11	0.0043	11	0.0060	10	0.0057	9	0.0044	10
4.Textile industry	0.0156	6	0.0138	6	0.0104	8	0.0088	9	0.0074	9	0.0064	9	0.0057	11	0.0033	11	0.0027	12
5.Other manufacturing	0.0017	13	0.0010	14	0.0012	14	0.0021	13	0.0023	14	0.0024	15	0.0018	15	0.0018	15	0.0019	15
6.Saw mill and wood products	0.0001	18	0.0001	18	0.0004	16	0.0015	16	0.0015	16	0.0012	16	0.0007	17	0.0009	17	0.0009	17
7.Paper and printing industries	0.0060	9	0.0087	8	0.0019	12	0.0036	12	0.0041	12	0.0035	13	0.0032	14	0.0023	14	0.0027	12
8.Chemical and petroleum industries	0.2465	1	0.3725	1	0.2810	1	0.1981	1	0.1854	1	0.1926	1	0.2222	1	0.2274	1	0.2169	1
9.Rubber industry	0.0061	8	0.0109	7	0.0188	7	0.0159	7	0.0233	6	0.0221	7	0.0208	7	0.0107	7	0.0116	8
10.Non-metallic products	0.0005	17	0.0003	16	0.0000	19	0.0001	19	0.0001	18	0.0001	19	0.0000	19	0.0000	19	0.0000	19
11.Metal products	0.0008	14	0.0012	13	0.0011	15	0.0016	15	0.0016	15	0.0038	12	0.0040	12	0.0030	12	0.0047	9
12.Industrial machinery	0.0262	4	0.0229	4	0.0231	6	0.0207	6	0.0181	7	0.0284	6	0.0231	6	0.0210	6	0.0142	6
13.Electrical machinery and apparatus	0.0006	16	0.0004	15	0.0015	13	0.0021	13	0.0027	13	0.0032	14	0.0036	13	0.0025	13	0.0022	14
14.Motor vehicle and repairs	0.0467	2	0.0627	2	0.0642	2	0.0695	3	0.0679	5	0.0817	4	0.0772	4	0.0392	5	0.0432	5
15.Electricity and water supply system	0.0049	11	0.0033	11	0.0047	10	0.0060	11	0.0067	10	0.0060	10	0.0066	9	0.0097	8	0.0117	7
16.Construction	0.0055	10	0.0020	12	0.0004	16	0.0007	17	0.0008	17	0.0003	17	0.0002	18	0.0003	18	0.0009	17
17.Logistics	0.0212	5	0.0210	5	0.0518	4	0.0815	2	0.0895	2	0.1096	2	0.1158	2	0.1204	3	0.1241	3
18.Trade and services	0.0444	3	0.0383	3	0.0405	5	0.0617	4	0.0771	3	0.0684	5	0.0599	5	0.0756	4	0.0878	4
19.Unclassified and bodies unknown	0.0084	7	0.0080	9	0.0031	11	0.0157	8	0.0169	8	0.0120	8	0.0076	8	0.0037	10	0.0034	11