An Input-output Analysis of the Maritime Industry in Thailand

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Abstract

This study examines the role of the maritime industry in Thailand's economy since it is crucial to the determination of marine policy measures. The five major marine sectors are disaggregated from the input-output table for 2000, 2005, 2010, and 2015 and the inter-industry linkage effect assessed. The linkage effect is applied to measure the forward and backward linkages of all sectors in the entire economy. The forward linkage indicates the importance of the marine industry as a supplier, whereas the backward linkage represents its importance from the demand perspective. The results indicate that the maritime industry has a relatively strong backward linkage effect and a weak forward linkage effect on other sectors. Furthermore, the five major marine sectors are treated as exogenous, and the economic impact of Thailand's maritime industry then analyzed in terms of production-inducing and sectoral supply shortage effects. The findings of this study provide at least a preliminary indication of the role played by the maritime industry and how it influences Thailand's policymakers in their decision-making when formulating maritime policies and systems management.

Keywords: 1) Input-output analysis 2) Maritime industry 3) Inter-sectoral linkages 4) Thailand

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Introduction

The maritime industry is extremely significant to modern society. Its influence and role are important components in terms of social and economic development and as a potential source of employment and job opportunities. Moreover, the maritime industry has great commercial potential and plays an important role in international trade (Fernández-Macho, González and Virto, 2016; Jacobsen, Lester and Halpern, 2014). This is because marine transport is recognized as the backbone of global trade and the manufacturing supply chain, with more than four-fifths of the volume of world trade being transported by sea (United Nations, 2019). Maritime transport has the capacity to transport large quantities in a cost-effective leading to economies of scale, and environmentally friendly manner.

Thailand has large areas of water: internal waterways, territorial seas, contiguous zones, and exclusive economic zones. Geographically, Thailand has a total coastline of 3,219 km, bordering the Gulf of Thailand and the Andaman Sea, more than 250 islands, and over 4,000 km of waterways, connecting the international deep-sea and inland routes between Indochina and the mainland. Furthermore, Thailand's maritime industry is well-positioned, with strategically located ports, comparatively good port infrastructure, as well as benefiting from the efficient investment and development of the Eastern Economic Corridor (EEC) which is a strategically located economic zone. These benefits have led to Thailand becoming the gateway to Asia. Although maritime transportation is not widely used for domestic transport, it is beneficial for exporting and importing goods due to the lower cost of shipping and large transportation capacity. However, the maritime industry in Thailand has faced multiple challenges such as vague maritime regulations, lack of advanced port facilities, and insufficient hinterland linkages with inland transport. Understanding Thailand's maritime situation both downstream and upstream could help in the design of marine policies to improve this industry, generating a potential source of employment and job opportunities. Therefore, this study aims to examine the role of the maritime industry in the Thai economy using static input-output (I-O) analysis for the years 2000, 2005, 2010, and 2015 to recognize the economic structure of Thailand for the decision-making of policymakers to improve this sector.

This study is structured as follows. Section 2 contains a literature review, while section 3 explains the current status of the maritime industry in Thailand. Section 4 displays the data and methodology used for assessing the contribution of the maritime industry to the national economy in terms of the inter-industry linkage effect, production-inducing effect, and sectoral supply shortage effect. Section 5 provides the empirical results, while the final section presents the conclusion and discussion.

Literature Review

Input-output (I-O) analysis was first developed by Wassily Leontief in the late 1930s and is now widely applied in many fields, such as energy (Liu, Xi, Guo and Li, 2010;

Su and Ang, 2014), environmental (Kerkhof, Nonhebel and Moll, 2009; Reynolds, et al. 2015; Xing, Wang and Zhang, 2018), and economic (Beynon and Munday, 2008; Midmore, Munday and Roberts, 2006). Additionally, I-O analysis is applied to investigate maritime and maritime-related industries in regional and national economies. For example, Kwak, Yoo and Chang (2005) examined the important role of Korea's maritime industry by determining the inter-industry linkage, production-inducing, supply shortage, employment-inducing, and pervasive effects of price changes in the marine sector. Morrissey and O'Donoghue (2013) disaggregated the Irish I-O table to analyze 10 marine sectors and address the linkages and production effects of the marine sector on the Irish economy. Wang and Wang (2019) also assessed the impact of the marine industry on China's economy in terms of the inter-industry linkage, production-inducing, sectoral supply shortage, and the employment-inducing effect. The findings provide a guideline for policymakers in developing appropriate maritime policies for national economies

The maritime industry has become an integral part of maritime logistics and supply chain management as suggested by Koilo (2019). Typically, the traditional industrial sectors involved in the marine economy such as maritime, fisheries, aquaculture, and oil and gas are joined by emerging sectors such as marine chemistry, biomedical, marine energy, ocean water, marine engineering and construction, and maritime tourism (McIlgorm, 2009). Consequently, marine activities are creating jobs and wealth through people and businesses directly related to these activities. It also contributes to significant economic turnover since goods and services are purchased from other sectors and wages are re-spent.

The Association of Southeast Asian Nations (ASEAN) is one of the world's fastest growing trade and economic zones. Historically, the ASEAN has a long relationship with maritime transport for shipping and accelerating the development and expansion of ASEAN trade. According to Zen and Anandhika (2016), the ASEAN Transport Strategic Plan for 2015-2025 prioritizes the development of maritime transport to establish a single shipping market for the region and promote maritime safety, security, and strategic economies corridors within ASEAN. Consequently, marine sector and infrastructure developments provide many economic opportunities, critically contributing to the economies of individual countries and the region as a whole.

Geographically, Thailand, as a member of the ASEAN, is considered a hub of transportation in the region. However, the utilization and value-added to GDP by Thailand's marine sector is relatively small. Previous studies relating to Thailand's marine economy have been limited to a specific marine sector, such as marine fisheries (Boonchuwongse and Dechboon, 2003; Lunn and Dearden, 2006; Pauly and Chuenpagdee, 2003), marine environment (Cheablam and Shrestha, 2015; Kiguchi, et al., 2020; Sharma, et al., 2019; Worakhunpiset, 2018). Nevertheless, I-O analysis has rarely been applied to examine the role of the maritime industry in the national economy.

There is evidence to show that this model has been used to evaluate maritime policies. Indra-Payoong (2001) used the I-O approach to measure the importance of the maritime policy to the Thai economy using four scenarios: the privatization of shipping and port sectors, subsidization of the shipping and port sectors, investment in maritime infrastructure, and promotion of international trade. The results indicate that subsidization of the shipping and port sectors is likely to have the greatest impact on the Thai economy since it exhibits the highest sensitivity toward increasing total national output. However, there is no empirical evidence of an in-depth investigation into the linkage between the maritime sector and other industries and its impact on the Thai economy.

Current Status of the Maritime Industry in Thailand

As suggested by Jarayabhand, et al. (2009) "Thailand has enjoyed having rich marine natural resources to use for the well-being of the people. Coastal and marine resources are used for various kinds of development activities. Thailand also participates in fishing activities in the high seas as well as marine areas under the jurisdiction of other countries." The maritime industry of Thailand is divided into five subsectors: fishery (including ocean, coastal, and inland fishing), shipbuilding and repairing, ocean transport, coastal and inland water transport, and water transport services. Thailand's abundant marine resources contribute significantly to the economy, making it one of the world's major producers and exporters of fishery products. In 2019, fishery products represented about 162.66 billion baht or 24.23% of the agricultural sector's gross domestic product (GDP) or 0.96% of the country's total GDP.

According to the Thai Shipbuilding and Repairing Association (TSBA), the shipbuilding industry in Thailand (along with other Asian countries) is developing and advancing, due to the abundance of suitable wood for building ships. Currently, there are 260 shipbuilding and shipyard repair businesses in Thailand, located in dockyards along the main rivers such as Chao Phraya, Tha Chin, and Mae Klong, as well as the Gulf Coast, Andaman Coast, and Malacca Strait. In terms of shipbuilding and repair capabilities, Thai shipyards mainly serve local needs and can be divided into three groups: small, medium, and large. Importantly, the shipbuilding and repair industry helps to support and facilitate marine transportation and international trade.

Most freight in Thailand is transported by road, causing societal and environmental problems. Chamroon (2011) examined CO_2 emissions in Thailand, insisting that trucks produce more CO_2 emissions than train and water transportation, respectively. To solve this problem, Hanaoka, et al. (2011) presented a solution for reducing energy consumption, which is the main cause of CO_2 emissions, by shifting freight movement from trailer to intermodal transport including railways and waterways. Consequently, shifting the mode of transport from road to water has many advantages such as reducing pollution, accidents, and costs while increasing weight and storage capacity. However, maritime transport in Thailand is neglected by freight handlers because of infrastructure inefficiency and a lack of knowledge about its benefits.

Table No. 1 reveals the total gross output of marine subsectors, indicating relatively small changes and a decreasing trend from the period 2000 to 2015. Accordingly, this has added little value to Thailand's GDP, accounting for around 1.74 to 2.51% in the period from 2000 to 2015 as shown in Table No. 2.

Table No. 1 Total gross output of the maritime industry

Sector	Total gross output (billion baht)			
	2000	2005	2010	2015
Marine industry	233.20 (1.99%)	363.53 (1.96%)	428.15 (1.56%)	575.25 (1.75%)
Fishery	130.14 (1.11%)	141.03 (0.76%)	141.63 (0.51%)	195.57 (0.60%)
Ship building and repairing	21.55 (0.18%)	49.96 (0.27%)	60.81 (0.22%)	82.21 (0.25%)
Ocean transport	22.16 (0.19%)	71.07 (0.38%)	50.57 (0.18%)	56.79 (0.17%)
Coastal and inland water transport	53.95 (0.46%)	93.89 (0.51%)	164.33 (0.60%)	226.25 (0.69%)
Water transport services	5.41 (0.05%)	7.58 (0.04%)	10.81 (0.04%)	14.42 (0.04%)
Overall industry	11692.57 (100%)	18511.46 (100%)	27514.69 (100%)	32819.60 (100%)

Table No. 2 Value added to GDP (billion baht) by each of the Thai marine subsectors

Marine subsectors	2000	2005	2010	2015
Fishery	1.47	0.99	0.63	0.70
Shipbuilding and repairing	0.16	0.23	0.19	0.22
Ocean transport	0.16	0.24	0.12	0.10
Coastal and inland water transport	0.65	0.65	0.73	0.81
Water transport services	0.08	0.07	0.07	0.08
Total value added to GDP (%)	2.51	2.18	1.74	1.90

Data and Methodology

Data

The I-O tables in this study are compiled from data on the Thai economy held by the National Economic and Social Development Board (NESDB), focusing on the years 2000, 2005, 2010, and 2015. The I-O tables for Thailand are available in four sectoral formats: 16 × 16, 26 × 26, 58 × 58, and 180 × 180. The most disaggregated I-O table format (180 × 180) is employed in this study to analyze the inter-industry linkage with the Thai economy. These are grouped from 180 sectors into 21 sectors. The activities of the maritime industry are defined according to the ThaiLaws (1978). Consequently, the activities include fishery (ocean, coastal, and inland fishing), shipbuilding and repairing, ocean transport, coastal and inland water transport, and water transport services, as shown in Table No. 3.

Table No. 3 Maritime industry code

Maritime industry	Code
Fishery (Ocean and coastal fishing, Inland fishing)	028-029
Ship building and repairing	123
Ocean transport	153
Coastal and inland water transport	154
Water transport services	155

The other groups are aggregated according to the original I-O table of the National Economic and Social Development Board (NESDB) as shown in Table No. 4.

Table No. 4 Sector classification

Sector	Code
1. Agriculture	001-027
2. Mining and quarrying	030-041
3. Food manufacturing	042-066
4. Textile industry	067-074
5. Other manufacturing	075-077, 129-134
6. Sawmills and wood products	078-080
7. Paper industries and printing	081-083
8. Rubber, chemical, and petroleum industries	084-098
9. Non-metallic products	099-104
10. Metal, metal products and machinery	105-122,124-128
11. Public utilities	135-137

Sector	Code
12. Construction	138-144
13. Trade	145-146
14. Transportation and communication	149-152, 156-159
15. Fishery	028-029
16. Shipbuilding and repairing	123
17. Ocean transport	153
18. Coastal and inland water transport	154
19. Water transport services	155
20. Services	147-148,160-178
21. Unclassified and bodies unknown	179,180

Methodology

General I-O framework analysis

First developed in the late 1930s by Wassily Leontief, I-O analysis is useful for evaluating the importance of the maritime sector to the national economy since it recognizes the inter-sectoral linkage. The columns of the I-O table display the input values of each sector whereas the rows represent their output values. Assuming an economic system consists of N industry sectors, X_i is the total gross output in sector $i = 1,\ldots,N;$ a_{ij} are the direct inputs or technical coefficients calculated by dividing X_{ij}, the inter-industry purchases of the 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 purchases of the 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_j is the value added by sector j. The balanced I-O equation can be expressed as follows:

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

or

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

Inter-industry linkage analysis

Inter-industry linkage analysis was initially proposed by Rasmussen (1956) and Hirschman (1958). Linkage effect analysis is based on the assumption that the relevant industry can boost the economy by linking input and output activities. Generally, the linkage effect is applied to measure the forward and backward linkages of all sectors in the entire economy. The forward linkage indicates the importance of the marine industry as a supplier, whereas the backward linkage represents its importance from the demand perspective. Regarding the sensitivity of dispersion, the forward linkage effect represents the changes in one maritime sector when the final demand of the remaining sectors increases by one unit. This is measured by dividing the average of n elements in row i by the average of all n^2 elements in the Leontief inverse matrix. Therefore, the forward linkage effect can be expressed as:

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

where n is the number of industries, $\sum_j B_{ij}$ is the sum of elements along the horizontal row of the Leontief inverse matrix, and $\sum_i \sum_j B_{ij}$ is the sum of all elements of the Leontief inverse matrix. Similarly, the power of dispersion is represented by the backward linkage, 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:

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

where $\sum_i Bij$ is the sum of the column elements in the Leontief inverse matrix.

If the sensitivity of dispersion and power of dispersion values for an industry are both greater than one for the forward and backward linkages effect, this means that the sector would have a more significant impact on the national economy than the average of all sectors. These industries are considered to be "key" or "leading" sectors in the national economy (Miller and Blair, 2009). Additionally, these industries play an important role in economic development by supporting and boosting other industries.

Demand-driven model

The demand-driven model was proposed by (Miller and Blair, 1985; Miller and Blair, 2009) to assess the economic contribution of any sector in the national economy. According to Kwak, Yoo and Chang (2005) and Wang and Wang (2019), 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×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 maritime industry on all other sectors of the economy. Therefore, the individual maritime sector should be treated as exogenous and grouped into the final demand (Miller and Blair, 2009). This approach is known as maritime sector-based I-O analysis. Subscripts "e" and "m" are added to represent the new matrices and vector related to the individual maritime sector, respectively. This gives $X_e = (I - A_e)^{-1}(F_e + A_m X_m)$. Assuming the final demand does not change ($\Delta F_e = 0$), then the following is obtained:

$$\Delta X_e = (I - A_e)^{-1} A_m \Delta X_m \quad (5)$$

Equation (5) can be used to analyze the impacts of the production-inducing effect in the maritime industry, since an initial investment by the marine sector could help to create output for the other sectors.

Supply-driven model

According to Kwak, Yoo and Chang (2005) and Wang and Wang (2019), equation (2) describes the supply-driven model as viewed horizontally in the I-O tables. This equation can be rewritten in an abbreviated matrix form as $X' = V'(I - R)^{-1}$, with $(I - R)^{-1}$ representing the output inverse matrix for which elements $(q_{ij} = \partial X_j / \partial V_i)$ 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 marine sector is treated as exogenous under the assumption that there is no change in the value added for all sectors, the following is obtained:

$$\Delta X_e' = R_m \Delta X_m (I - R_e)^{-1} \quad (6)$$

Equation (6) can be used to analyze the cost of loss in the maritime industry's supply shortage compared to other sectors in the national economy, known as the supply shortage effect.

Empirical Results

Inter-industry linkage effect

Table No. 5 shows the backward and forward linkage effect of marine subsectors on the Thai economy for the years 2000, 2005, 2010, and 2015, respectively. The results indicate that the average backward linkage effect of the five marine subsectors varies between 0.9326 and 0.9572 which means that the maritime sector is less stimulated by overall industry growth than other sectors. In line with the forward linkage effect of the marine sector, the average results show that the five marine subsectors are lower than 1, fluctuating between 0.4126 and 0.4718 meaning they are lower than the overall industrial average. It can be concluded that the maritime industry has a relatively strong capacity for pulling in other industries but weak in supporting them.

Considering the marine subsectors, shipbuilding and repairing, and ocean transport have relatively strong backward linkage effects and low forward linkage. In addition, the marine subsectors with weak backward and forward linkage effects are fishery, coastal and inland water transport, and water transport services. It can be concluded that the Thai maritime industry is not considered to be a "key" or "leading" sector since it is relatively weak in pulling and supporting other industries in Thailand's economy.

Table No. 5 Backward and forward linkage effects of Thailand's marine sector

Marine sectors	Backward linkage				Forward linkage			
	2000	2005	2010	2015	2000	2005	2010	2015
Fishery	0.8655	0.8590	0.8690	0.8929	0.5283	0.4695	0.4347	0.4532
Ship building and repairing	1.2336	1.1946	1.1443	1.1414	0.5399	0.5002	0.4492	0.4755
Ocean transport	1.0636	1.1752	1.1170	1.1754	0.4164	0.4792	0.4361	0.4617
Coastal and inland water transport	0.8158	0.8605	0.8696	0.8869	0.4172	0.3897	0.3577	0.3803
Water transport services	0.7072	0.6967	0.6630	0.6674	0.4572	0.4120	0.3853	0.4181
Average	0.9371	0.9572	0.9326	0.9528	0.4718	0.4501	0.4126	0.4378

The I-O results for 2015 are shown in Table No. 6. The rubber, chemical, and petroleum industries together with metal and metal products and machinery have backward and forward linkage effects greater than one, indicating that these two sectors are considered to be “key” or “leading” sectors.

The input and output multipliers of marine subsectors are shown in Table No. 7. The shipbuilding and repairing sector is revealed as having the highest input and output multiplier for the period 2000 to 2015, while the coastal and inland water transport sector has the lowest input multiplier, and water transport services the lowest output multiplier.

Table No. 6 Sectoral Backward and forward linkage indices of Thailand in 2015

No.	Sector	BLI	FLI	FLI>1 BLI>1	FLI>1 BLI<1	FLI<1 BLI>1	FLI<1 BLI<1
1	Agriculture	0.7606	1.1076		×		
2	Mining and quarrying	0.7465	1.9702		×		
3	Food manufacturing	0.9883	0.8509				×
4	Textile industry	1.1395	0.7725			×	
5	Other manufacturing	1.3273	0.7488			×	
6	Saw mills and wood products	0.9937	0.5513				×
7	Paper industries and printing	1.1520	0.8272			×	
8	Rubber, chemical and petroleum industries	1.0634	3.3712	×			
9	Non-metallic products	1.0307	0.6649			×	
10	Metal, metal products and machinery	1.3846	3.3773	×			
11	Public utilities	0.9396	1.1866		×		
12	Construction	1.1982	0.4028			×	
13	Trade	0.5676	0.3753				×
14	Transportation and communication	1.0120	0.6810			×	
15	Fishery	0.8929	0.4532				×
16	Ship building and repairing	1.1414	0.4755			×	
17	Ocean transport	1.1754	0.4617			×	
18	Coastal and inland water transport	0.8869	0.3803				×
19	Water and inland transport	0.6674	0.4181				×
20	Services	0.7775	1.4695		×		
21	Unclassified and bodies unknown	1.1547	0.4541			×	

Table No. 7 Input and output multipliers for the marine subsectors

Marine sectors	Input multiplier				Output multiplier			
	2000	2005	2010	2015	2000	2005	2010	2015
Fishery	1.2907	1.2246	1.2301	1.2074	2.1145	2.2406	2.4590	2.3790
Ship building and repairing	1.3191	1.3047	1.2711	1.2669	3.0137	3.1159	3.2381	3.0410
Ocean transport	1.0172	1.2500	1.2342	1.2301	2.5983	3.0654	3.1608	3.1317
Coastal and inland water transport	1.0193	1.0164	1.0123	1.0132	1.9930	2.2445	2.4609	2.3630
Water transport services	1.1170	1.0745	1.0904	1.1141	1.7277	1.8172	1.8761	1.7783
Average multiplier	1.1527	1.1741	1.1676	1.1663	2.2895	2.4967	2.6390	2.5386

Production-inducing effect

The sectoral impacts of maritime investment are shown in Table No. 8. The results indicate that investment in the maritime sector increased by 1 Thai baht causing a production-inducing effect on other sectors of 1.0500, 1.1712, 1.3041, and 1.2155 baht for the years 2000, 2005, 2010, and 2015 respectively. Additionally, the total gross output of the maritime industry induced by its total investment contributes 244.8586, 425.7619, 558.3543, and 699.2116 billion baht, totaling 478.0572, 789.2881, 986.5073, and 1274.4577 billion baht of production into the economy for the years 2000, 2005, 2010, and 2015, respectively. Overall, increased marine sector investment may affect the other sectors, particularly the rubber, chemical, and petroleum industries which have the highest production-inducing effect on the maritime sector, followed by metal, metal products and machinery, and mining and quarrying.

Table No. 8 Production-inducing effect of Thailand's marine sectors

No.	Sector	2000	2005	2010	2015
1	Agriculture	0.0598	0.0628	0.0720	0.0621
2	Mining and quarrying	0.1171	0.1681	0.1774	0.1630
3	Food manufacturing	0.1074	0.0857	0.0797	0.0837
4	Textile industry	0.0260	0.0235	0.0198	0.0173
5	Other manufacturing	0.0053	0.0068	0.0081	0.0075
6	Saw mills and wood products	0.0045	0.0061	0.0099	0.0089
7	Paper industries and printing	0.0140	0.0114	0.0136	0.0122

No.	Sector	2000	2005	2010	2015
8	Rubber, chemical and petroleum industries	0.3785	0.4182	0.4745	0.4698
9	Non-metallic products	0.0047	0.0068	0.0067	0.0112
10	Metal, metal products and machinery	0.1743	0.2351	0.2283	0.2178
11	Public utilities	0.0310	0.0389	0.0459	0.0539
12	Construction	0.0011	0.0014	0.0024	0.0036
13	Trade	0.0000	0.0000	0.0000	0.0000
14	Transportation and communication	0.0159	0.0245	0.0280	0.0227
20	Services	0.0522	0.0848	0.1085	0.1082
21	Unclassified and bodies unknown	0.0093	0.0051	0.0050	0.0069
	Total	1.0500	1.1712	1.3041	1.2155

Table No. 9 Production-inducing effect on each marine subsector in Thailand

Marine sectors	2000	2005	2010	2015
Fishery	0.1916	0.2123	0.2374	0.2274
Ship building and repairing	0.3604	0.3811	0.3962	0.3555
Ocean transport	0.2066	0.2118	0.2489	0.2480
Coastal and inland water transport	0.1615	0.2193	0.2610	0.2377
Water transport services	0.1299	0.1466	0.1605	0.1468
Total	1.0500	1.1712	1.3041	1.2155

Table No. 9 displays the impact of investment on the marine sector. The results indicate that the production-inducing effect of this sector is high, increasing slightly from 1.0500 to 1.2155 over the period from 2000 to 2015. Regarding the separate marine subsector, shipbuilding and repairing had the greatest production-inducing effect, followed by ocean transport, fishery, coastal and inland water transport, and water transport services, respectively. In 2015, an increase in maritime industry investment of 1 Thai baht, created a production-inducing effect on the marine sector of 1.2155 baht. This includes fishery (0.2274 baht), shipbuilding and repairing (0.3555 baht), ocean transport (0.2480 baht), coastal and inland water transport (0.2377), and water transport services (0.1468 baht).

Supply shortage effect

The sectoral maritime supply shortage costs for 2000, 2005, 2010, and 2015 are summarized in Tables No. 10 and 11. The results indicate that the total supply shortage costs for all sectors except the maritime sector decreased from 0.2506 to 0.1307 baht for the period 2000 to 2015. It can therefore be interpreted that if the maritime sector were to disappear, the production failure in other sectors would be equal to 58.4396, 64.3441, 61.4828, and 75.1847 billion baht for the years 2000, 2005, 2010 and 2015, respectively.

Additionally, the top three sectors having the greatest impact on maritime supply shortage are food manufacturing followed by services and agriculture and the lowest impact to trade, metal, metal products and machinery, and textile industry.

Table No. 10 Supply shortage effect on Thailand's marine sector

No.	Sector	2000	2005	2010	2015
1	Agriculture	0.0187	0.0122	0.0090	0.0076
2	Mining and quarrying	0.0090	0.0069	0.0057	0.0063
3	Food manufacturing	0.1154	0.0653	0.0539	0.0459
4	Textile industry	0.0051	0.0042	0.0031	0.0030
5	Other manufacturing	0.0077	0.0053	0.0038	0.0036
6	Saw mills and wood products	0.0056	0.0048	0.0038	0.0039
7	Paper industries and printing	0.0046	0.0049	0.0043	0.0038
8	Rubber, chemical and petroleum industries	0.0092	0.0081	0.0064	0.0063
9	Non-metallic products	0.0052	0.0049	0.0042	0.0042
10	Metal, metal products and machinery	0.0035	0.0033	0.0028	0.0027
11	Public utilities	0.0039	0.0042	0.0036	0.0040
12	Construction	0.0044	0.0043	0.0035	0.0036
13	Trade	0.0043	0.0035	0.0023	0.0018
14	Transportation and communication	0.0062	0.0061	0.0047	0.0049
20	Services	0.0264	0.0185	0.0122	0.0143
21	Unclassified and bodies unknown	0.0216	0.0207	0.0172	0.0146
	Total	0.2506	0.1770	0.1436	0.1307

Table No. 11 Supply shortage effects on each marine subsector in Thailand

Marine sectors	2000	2005	2010	2015
Fishery	0.2261	0.1509	0.1213	0.1088
Ship building and repairing	0.0031	0.0050	0.0057	0.0051
Ocean transport	0.0000	0.0007	0.0000	0.0000
Coastal and inland water transport	0.0168	0.0142	0.0106	0.0114

Marine sectors	2000	2005	2010	2015
Water transport services	0.0046	0.0063	0.0060	0.0054
Total	0.2506	0.1770	0.1436	0.1307

Table No. 11 shows the impact of maritime supply shortage on individual marine subsectors in 2000, 2005, 2010, and 2015. For example, in 2015 when the supply shortage in the maritime industry reduced by 1 Thai baht, it experienced losses equal to 0.1307 baht. These came from fishery (0.1088 baht), shipbuilding and repairing (0.0051 baht), ocean transport (0.0000), coastal and inland water transport (0.0114 baht), and water transport services (0.0054 baht). It can be concluded that the fishery sector received the highest impact from maritime supply shortage, followed by coastal and inland water transport, water transport services, shipbuilding and repairing, and ocean transport.

Total contribution effect

The total contribution effect from the maritime industry in Thailand is displayed in Table No. 12, measured by the summation of production-inducing and supply shortage effects. When the outputs of Thailand's maritime industry increase by 1 Thai baht, the total contribution of the marine sector to Thailand's economy is 1.3007, 1.3482, 1.4477, and 1.3461 baht for the years 2000, 2005, 2010 and 2015, respectively. The contribution effect of the marine sector to the Thai economy increased slightly from 2000 to 2010 but declined in 2015.

Table No. 12 Total contribution effect of Thailand's marine subsectors.

Marine sectors	2000	2005	2010	2015
Fishery	0.4177	0.3631	0.3588	0.3363
Ship building and repairing	0.3635	0.3862	0.4019	0.3606
Ocean transport	0.2066	0.2125	0.2489	0.2480
Coastal and inland water transport	0.1783	0.2335	0.2717	0.2491
Water transport services	0.1345	0.1529	0.1665	0.1522
Total	1.3007	1.3482	1.4477	1.3461

Conclusion and Discussion

This study applies I-O analysis to investigate the important role of the maritime industry in Thailand's economy for the period from 2000 to 2015. To achieve this, 180 sectors of the Thai I-O tables are aggregated into 21 sectors. Subsequently, the inter-industry linkage effect analysis, the demand-driven and the supply-driven model were employed. Excluding the inter-industry linkage analysis, the marine sector is treated as exogenous to assess the sectoral impacts of marine investment and maritime supply shortage on the Thai economy. The preliminary findings can be used by policymakers when making decisions on investment in the maritime industry and managing marine systems.

According to analysis of the inter-industry linkage effect, the maritime industry has a relatively strong backward linkage and a weak forward linkage effect. This indicates that the Thai maritime industry has greater potential to increase output in upstream industries than downstream. However, the average backward and forward linkage effects are less than one, meaning that the Thai maritime industry experiences difficultly in boosting and supporting other industries.

The demand-driven model is applied to analyze the impact of marine sector investment. This analysis demonstrates that most of the investment in the marine sector is spent on rubber, chemical and petroleum, mining and quarrying, metal, and metal products and machinery, respectively. It can be summarized that the appropriate distribution of marine production costs may lead to the development of these sectors. Importantly, rubber, chemical and petroleum, metal, and metal products and machinery are considered to be the “key” or “leading” sectors, indicating that investment in the marine sector could help to support other sectors, thereby contributing to national economic development.

The supply-driven model is used to evaluate the impact in the absence of the marine sector on the economy of Thailand. Supply shortage in the marine sector can lead to production failure in other sectors, particularly food manufacturing, services, and agriculture, respectively. Interestingly, food manufacturing and agriculture are revealed to be important in providing a better quality of life for Thai people.

The total contribution effect of the marine sector displays a slight increase from 2000 to 2015, but the growth rate fell slightly between 2010 and 2015. However, the shipbuilding and repairing, ocean transport, coastal and inland water transport, and water transport services subsectors have experienced a recession, and fishery shows a significant decrease in this decade.

The findings of this study provide a number of economic indicators which policymakers can use when making decisions or designing marine policies to improve Thailand’s marine economy. However, this study only focuses on the linkage effect of the marine sector with other sectors, the impact of marine investment, and shortages in the marine sector on the national economy. Therefore, further study should examine the employment-inducing effect in each marine sector.

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