An Analysis of The Economic Interdependencies of The Next – Generation Automotive Industry Under Shaped by Thailand 4.0

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Abstract

This research article examines the economic interconnections within the next-generation automotive industry (NGA4.0) and is structured into two main components. The first component analyzes the structure of factor usage and production distribution, while the second focuses on evaluating the economic multipliers associated with NGA4.0. The study utilizes data from production factors and output tables, which are reviewed every five years. Specifically, it compares data from 2010 to 2015 to ensure alignment with the 20-year strategy for Thailand 4.0 (2017 - 2036) within the context of the Eastern Economic Corridor (EEC).

The analysis of factor usage and production distribution within the next-generation automotive industry (NGA4.0) revealed notable trends. Domestic factor usage in this sector rose from 0.53% in 2010 to 2.36% in 2015. In contrast, the share of production allocated to the sector itself decreased from 2.34% in 2010 to 2.31% in 2015. Overall, the economic interconnectedness index for NGA4.0 indicates that this industry relies significantly on external sectors while also distributing its production to them. Notably, both the overall backward and forward linkage indices are above the average, exceeding a value of 1.

The analysis of economic multipliers for the next-generation automotive industry (NGA4.0) indicates that a 1% increase in final demand within this sector leads to a corresponding rise in the total value of production across the economy by 9.42% in 2010 and 9.57% in 2015. To foster ongoing production growth and economic expansion in the NGA4.0 and other sectors, the government should prioritize and support research and development of modern technologies and innovations. This effort should include adequate budget allocations and various investment promotion incentives.

Keywords: 1) The Next – Generation Automotive Industry 2) Input-Output Table 3) Thailand 4.0 4) EEC

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Introduction

Thai industrial economy in 2023, based on the Manufacturing Production Index (MPI), has decreased by 4.8%, and is projected to grow by 2.0% – 3.0% in 2024. This is in line with the slowdown of the global economy, geopolitical tensions affecting the supply chain widely, as well as high energy prices and interest rates, which have led to a decrease in consumption and investment. The country's policies aim to drive Thailand towards change. The country's policies aim to drive Thailand towards change, with the government implementing a policy to use an innovation-driven economic model to develop into Thailand 4.0 through a 20-year strategy for the development of Thailand's industry 4.0 (2017 - 2036). This aims for the Thai industrial sector to achieve an average GDP growth rate of no less than 4.5% per year, with average investment growth of no less than 10% per year, an average export value growth of 8% per year, and an average Total Factor Productivity (TFP) growth of no less than 2.0% per year. (Ministry of Industry, Thailand, 2023) This is the growth rate that will enable Thailand to move toward becoming a high-income country by the year 2036.

According to the goals of the national strategy, it aims to enhance the competitiveness of the manufacturing and service sectors based on modern technology and innovation, focusing on the development of 12 target industries, which include expanding 5 existing industries with potential (First S-curve), consisting of: 1) Modern automotive industry 2) Smart electronics industry 3) Tourism industry targeting high-income groups and health tourism 4) Agriculture 5) Food processing industry. Adding 5 future industries (New S-curve) includes: 1) Robotics industry 2) Aviation and logistics industry 3) Biofuel and biochemistry industry 4) Digital industry 5) Comprehensive medical industry. Additionally, the industries that should be reformed include: 1) Defense industry and 2) Human resource development and education industry. Under the Eastern Economic Corridor (EEC) project, which was developed to build on the Eastern Seaboard Development project, previously known for establishing Thailand as a hub for investments by leading global companies in the Asia region, particularly in the automotive and automotive parts industries, electronics industry, and petroleum industry. The focus is on spatial development in three provinces: Chonburi, Rayong, and Chachoengsao.

The researcher is interested in studying the connections of the modern automotive industry through the automotive industry, which is industry that plays a significant role in the economic development of many countries around the world, including Thailand. Thailand is an important automotive production base globally, as reflected by its production of up to 1.9 million vehicles per year, the highest in ASEAN and ranked 10th in the world (Tongsuar, 2023, pp. 2-5). The findings will be formulated into policy recommendations.

Research Objective

1. To analyze the structure of production factor usage and the distribution of output in the next-generation automotive industry.

2. To analyze the economic multipliers

of the next-generation automotive industry in relation to other industries.

Theoretical Background

1. Meaning of Input-Output Table

The Input-Output Table (I-O Table) is a table that illustrates the circulation of goods and services between production sectors of the economy over a specified period and is categorized accordingly. It is based on the assumption that each production sector will produce the same type of goods and will use the same production processes. Therefore, this concept has been used to create a table reflecting the relationships of production. Consists of intermediate factors of production, final demand, aggregate demand, added value and domestic production. (Saisopon, 2023)

Wassily Leontief, a Russian economist developed the Input-Output Model as a tool for macroeconomic analysis, which has gained significant interest and been widely applied, as it facilitates general equilibrium analysis in a straightforward and efficient manner. (Kasrisom, 2024, pp. 8-9)

2. Connections of Production Sectors

From the structure of the Input-Output Table, the concept of creating growth can be developed and used as a tool for policy analysis and economic planning, production in various industries, and the economic impacts in those industries. For example, if industry i wants to increase production, it will lead to an increased demand for production factors from other industries, such as the automotive manufacturing industry, which requires production factors from other sectors to serve as inputs in the automotive industry. This will create a demand for engine manufacturing plants, steel processing plants, etc. Such demand functions are referred to as backward linkages. Higher backward linkages create markets to support the output for production in industry i, which leads to expanded production and benefits the economy by generating other production activities. At the same time, increased production from other industries leads to increased demand from industry i to supply the necessary production factors to meet that rising demand. This supply function is referred to as forward linkages. A high level of forward linkage in an industry means that its output is sensitive to changes in the production of other industries. (Santipolvut, 2012 as cited in Kasrisom, 2024, pp. 10-11) Namely,

2.1 Direct Linkages

The analysis of direct forward linkage (DF) and direct backward linkage (DB) of an economic sector that is related to the group of industries that build upon existing industries with potential and the group of future industries.

2.2 Overall Linkage Index

The linkages of each industrial sector are considered activities that occur between the activities of different industries that are related, resulting in the emergence of additional activities. These can be upstream industries or downstream industries, depending on whether the industry has overall forward or backward linkages, as determined by the model and index equation.

Final Demand

The analysis of changes in final demand is driven by various factors, including

consumption, investment, government spending, exports, and imports. The equation used to express equilibrium (material balance equation) is presented in mathematical form.

Literature Review

The linkages of the electronics industry in Thailand indicate that in the electronics sector, the industries with the highest direct forward linkages include the manufacturing of other electrical appliances, the manufacturing of capacitors and various batteries, and other sectors in that order. The industries with the highest direct backward linkages include the manufacturing of radio, television, and communication equipment, the manufacturing of household electrical appliances and devices, and other sectors in that order. In terms of overall linkages, it was found that the electronics industry generates greater overall forward linkages than overall backward linkages. (Bhongchirawantana and Larabut, 2017, pp. 160-162)

The economic impacts of agricultural production activities on other production activities in the northeastern region of Thailand show that soybean farming and cassava cultivation have the most significant backward linkages affecting the economy, respectively. Oil refining, wholesale and retail trade, and financial and insurance services have backward linkages with other industries, respectively. Cassava farming, livestock farming, and corn farming have the most significant forward linkages to the economy, respectively. Other food production, slaughterhouses, cassava farming, and livestock farming have backward linkages to other industries, respectively. (Kaenmanee, Khermkhan and Latteerasuwan, 2020, pp. 425-426)

An analysis of the influence scope and coefficient of influence of various industries in 2018 revealed that the automotive manufacturing industry exerted a significant influence on China's overall economy in that year. In 2018, the influence scopes of the automotive manufacturing, automotive parts, and accessories industries were 3.4277 and 3.4924, respectively. The coefficient of influence for the automotive manufacturing and automotive parts and accessories industries were 1.2124 and 1.2352, respectively, which were significantly higher than the average of various industrial sectors in society. (Wang, et al., 2022, pp. 1-11)

The analysis of the logistics service industry as a service sector highlights that the impact of the industrial supply chain operates differently compared to the manufacturing sector. This study also addresses both the backward and forward industrial linkages within the logistics service industry, which plays a crucial role in facilitating connections among supply chain members focused on production. It demonstrates that various transportation sectors—such as transport, storage, and management—not only rely on one another but also contribute to the creation of a service ecosystem. Future research should explore the logistics service industry across different countries to advance the concept of the Logistics Service Supply Chain (LSSC). Additionally, subsequent studies should examine the correlation between GDP levels and the production stimulation effects of the logistics

service industry, as well as compare the interconnectedness levels among various nations. (Kim, Lee and Trimi, 2021, pp. 246-248)

Methods

1. Scope of industry studied: Secondary data was collected through the compilation of documents from relevant agencies in both the public and private sectors. The primary focus is on the data regarding the structure of production and final demand from the input-output tables for the years 2010 and 2015, which include:

Scope of study period: Factors of production and output are collected every five years, utilizing the input-output tables from 2010 and 2015 at the 180x180 sector level. These have been grouped to align with the 20-year strategy for the development of Thailand 4.0 (2017–2036) for the next-generation automotive industry (Ministry of Industry, 2015, pp. 9-11), which includes: 1) manufacturing of engines and engine parts, 2) production of advanced technology vehicle components, 3) manufacturing of safety and energy-efficient components, 4) production of equipment for Hybrid, Electric Vehicles (EV), and Plug-in Hybrid Electric Vehicles (PHEV), 5) tire manufacturing, 6) production of fuel system components, 7) manufacture of transmission components, 8) production of motorcycles (excluding those with an engine capacity below 248 cc), and 9) electric vehicles. Data regarding intermediate consumption, final consumption, intermediate production costs, total domestic production, aggregate demand, and income or added value were utilized, compiled by the National Economic and Social Development Board.

Scope of research: Quantitative research using data from the input-output tables which conducted every five years, specifically for the years 2010 and 2015. In this study, the data is organized into 180 industry codes for manufacturing (Office of the National Economic and Social Development Board, 2015, pp. 1–23). The researcher defines the next-generation automotive industry with the code NGA4.0. Additionally, the NGA4.0 code is applied to sectors within the next-generation automotive manufacturing industry, which consists of six codes: 096 for the production of outer and inner tires, 112 for the manufacturing of engines and turbines, 121 for the production of capacitors and various batteries, 125 for the production of vehicles, 126 for the manufacturing of motorcycles and bicycles, and 127 for the repair of all types of vehicles as shown in Table 1.

Table 1 The industry codes and production sectors in the next-generation automotive industry (NGA4.0).

Code	Production branch
NGA4.0*	Next – Generation Automotive Industry
096**	Tyers and tubes
112**	Engines and turbines
121**	Electric accumulators and batteries

Code	Production branch
125**	Motor vehicles
126**	Motorcycle, Bicycle & Other Carriages
127**	Repair of motor vehicles

Source: Calculated by the researcher

Note: * IO-Code, the researcher assigned codes for the study.

** IO-Code, Office of the National Economic and Social Development Council, 2015

2. Scope of the study: The structure of the input-output table consists of four components: the representation of the interactions between the factors of production and output (Transaction Table: X_{ij}), the value of final consumption or final demand (Final Demand: F_i), the basic factors of production or value added for each economic sector (Value Added: V_j), and the total value of factors of production (Total Input: X_j) (Total demand = Intermediate demand + Final demand) which is shown in Table 2.

Economic activities (inter-industrial transactions) can be represented in algebraic form as follows: the horizontal rows illustrate the distribution of output within industry I, which n denotes the production sectors.

$$X_i = \sum_{i=1}^{n} X_{ij} + F_i \quad ; i = 1,2,\ldots,n \qquad (1)$$

where X_{ij} is the circulation of goods in industry i to produce goods of industry j.

X_i is the value of industrial output i

F_i is the final demand for industry i

n is the total number of production branches considered in the economy.

$$X_j = \sum_{j=1}^{n} X_{ij} + V_j \quad ; j = 1,2,\ldots n \qquad (2)$$

where X_{ij} is the circulation of goods of industry

i to produce the goods of industry j.

X_j is the total output value of production branch j

V_j is the value added or basic production factors of production branch j

n is the total number of production branches considered in the economy.

Table 2 Structure of the production factor and output table.

Production branch		Intermediate factors of production				Final demand					Aggregate demand
						C	I	G	X	M	
Intermediate factors of production	in the country	X_{11}	X_{12}	...	X_{1j}	C_1	I_1	G_1	X_1	M_1	Z_1
		X_{21}	X_{22}	...	X_{2j}	C_2	I_2	G_2	X_2	M_2	Z_2
		:	:	...	:	:	:	:	:	:	:
		:	:	...	:	:	:	:	:	:	:
		X_{i1}	X_{i2}	...	X_{ij}	C_i	I_i	G_i	X_i	M_i	Z_i
	Import	X_{m1}	X_{m1}	...	X_{mj}	C_m	I_m	G_m	X_m	M_m	Z_m
		:	:	...	:	:	:	:	:	:	:
		X_{mn}	X_{mn}	...	X_{mn}	C_{mn}	I_{mn}	G_{mn}	X_{mn}	M_{mn}	Z_{mn}
Added value	Salary, wages	L_{11}	L_{12}	...	L_{ij}						
	Production returns and depreciation	K_{11}	K_{12}	...	K_{ij}						
	Net indirect tax	T_{11}	T_{12}	...	T_{ij}						
Added value		V_{11}	V_{12}	...	V_{ij}						
Total domestic production		P_{11}	P_{12}	...	P_{ij}						

Note: 1) Production returns include returns from all production factors.
2) Final demand: C is final household consumption, I is investment, G is government expenditure, X is exports, M is imports (where I, j ranges from 1, 2, ..., 180: Meaning the IO code of each production branch)

1. Analysis of the Direct Linkage and Overall Linkage Index of the Next – Generation Automotive With Other Industries

Direct linkage analysis involves the calculation of direct forward linkage (DF) and direct backward linkage (DB). The analysis of the overall linkage index (direct and indirect linkage effect) involves the calculation of the overall forward linkage index (FI) and the overall backward linkage index (BI) of one branch of production that is related to others. Using data from the country's production factor and output table for 2015, the researcher organized a new group from Table 1, calculated from the formula.

1.1 Direct Forward Linkage: DF

$$DF = \frac{\sum_j^n X_{ij}}{X_i} \quad (3)$$

where DF is the direct forward linkage
X_i is the total horizontal inter mediate inputs of the branch i.
$\sum_j^n X_{ij}$ is the sum of the intermediate demand for the output of branch i that other output branches use as factors of production.
n is the total number of production sectors of the economy.

1.2 Direct Backward Linkage: DB

$$DB = \frac{\sum_{i}^{n} X_{ij}}{X_j} \quad (4)$$

where DB is the direct backward linkage

X_j is the total Vertical intermediate inputs of the branch j.

$\sum_{i}^{n} X_{ij}$ is the sum of the overall intermediate production factors used by production branch i.

n is the total number of production sectors of the economy.

If DF and DB have high values, this means there is a strong relationship with other industrial branches. However, if the value is low, it means there is little connection with other industrial branches.

Direct Coefficients: a_{ij}

The use of production factors (Input) is directly proportional to the value of output (Output), as shown in the following equation:

$$X_{ij} = a_{ij} \cdot X_j \quad (5)$$

or

$$a_{ij} = X_{ij}/X_j \quad (6)$$

where a_{ij} is the direct coefficient or input or technical coefficients, meaning the proportion of production factors i used in the production of industrial product j.

$$A^d = \begin{vmatrix} \frac{X_{11}}{X_1} & \frac{X_{12}}{X_2} & \cdots & \frac{X_{1n}}{X_n} \\ \frac{X_{21}}{X_1} & \frac{X_{22}}{X_2} & \cdots & \frac{X_{2n}}{X_n} \\ \downarrow & \downarrow & \cdots & \downarrow \\ \frac{X_{n1}}{X_1} & \frac{X_{n2}}{X_2} & \cdots & \frac{X_{nn}}{X_n} \end{vmatrix} = \begin{vmatrix} a_{12} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \downarrow & \downarrow & a_{ij} & \downarrow \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{vmatrix} \quad (7)$$

where Xij is the value of the output of production branch i which is used as a production factor to produce goods of production branch j.

Xj is the value of total output of production branch j

a_{ij} is the proportion of the value of intermediate domestic production factors of type i used in the production of branch j relative to the output value of production branch j

n is the total number of production sectors in the economy.

A^d is the structural coefficient matrix

The overall industry connectivity can be calculated using the metric Ad factor coefficient table to obtain the value of the Leontief Inverse Matrix [I-Ad]-1. The Leontief Inverse Matrix value can be calculated as follows.

$$[I\text{-}A^d] = \begin{vmatrix} 1 & 0 & \cdots & 0 \\ 0 & 1 & \cdots & 0 \\ \downarrow & \downarrow & 1 & \downarrow \\ 0 & 0 & \cdots & 1 \end{vmatrix} - \begin{vmatrix} a_{12} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \downarrow & \downarrow & a_{ij} & \downarrow \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{vmatrix} \quad (8)$$

The results from [I-A] can be used to perform an Inverse Matrix, which will result in the following:

$$[I\text{-}A^d]^{-1} = \begin{vmatrix} b_{12} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & b_{2n} \\ \downarrow & \downarrow & \cdots & \downarrow \\ b_{n1} & b_{n2} & \cdots & b_{nn} \end{vmatrix} \quad (9)$$

Industry linkages are considered activities that occur between industries related to each other, causing them to increase. The industry can be either upstream industry (Upstream) or downstream (Downstream), depending on whether the industry is connected overall forward or backward when considering the model and index equations.

The Leontief Inverse Matrix [I-Ad]-1 can be used to calculate the forward and BI values according to the following formula:

1.3 Forward Linkage Index: FI

$$FI = \frac{\sum_i^n b_{ij}}{\frac{1}{n}\sum_j^n \sum_i^n b_{ij}} \quad ; i = 1,2,3,...n \qquad (10)$$

Where FI is the forward linkage index

$\sum_i^n b_{ij}$ is the horizontal sum of the matrices. $(I\text{-}A^d)^{-1}$

$\sum_j^n \sum_i^n b_{ij}$ is the sum of the vertical sides of the matrix. $(I\text{-}A^d)^{-1}$

n is the total number of production sectors of the metric $(I\text{-}A^d)^{-1}$

i is 1,2,3,...n

1.4 Backward Linkage Index: BI

$$BI = \frac{\sum_j^n b_{ij}}{\frac{1}{n}\sum_i^n \sum_j^n b_{ij}} \quad ; j = 1,2,3,...n \qquad (11)$$

Where BI is the backward linkage index

$\sum_i^n b_{ij}$ is the sum of the vertical sides of thematrix. $(I\text{-}A^d)^{-1}$

$\sum_j^n \sum_i^n b_{ij}$ is the sum of all horizontal sides of the matrix. $(I\text{-}A^d)^{-1}$

n is the total number of production sectors of the metric. $(I\text{-}A^d)^{-1}$

i is 1,2,3,...n

The FI and BI values mean that a BI value greater than 1 indicates that the next – generation automotive industry receives more raw materials from other production branches than the average received by all production branches. In addition, a BI of less than 1 indicates that the next – generation automotive industry receives fewer raw materials from other production branches than the average received by all production branches.

Moreover, an FI greater than 1 indicates greater distribution of output to other production branches than the average across all production branches. An FI of less than 1 indicates that the distribution of output to other production branches is less than the average across all production branches.

2. Multiplier Analysis of the Next – Generation Automotive

To analyze the economic multiplier, the direct and indirect coefficients of production must be known first. This value can be calculated by inverting the identity matrix (Matrix I: Identity Matrix) with the domestic intermediate production factor coefficient matrix (Matrix A) as follows (Bhongchirawattana and Srithongdeang, 2019, p. 26):

$$X = AX + F \qquad (12)$$

$$X(I - A^d) = F \qquad (13)$$

$$X = (I - A^d)^{-1} F \qquad (14)$$

Where X is the vector of multiplier of each production branch

F is the final demand vector.

I is the identity matrix vector.

A^d is the output vector in each production branch or structural coefficient matrix.

$(I\text{-}A^d)^{-1}$ is the Local Leontief Matrix

Matrix $(I\text{-}A^d)^{-1}$ or matrix B refers to the Direct and Indirect Production Coefficients Matrix or Leontief's Domestic Matrix, described as when the final demand of economic branch j changes by 1%, it causes a production change in economic branch i. This can occur both directly and indirectly according to the

direct and indirect coefficient of production in $[I-Ad]^{-1}$%.

Results

1. Analyze the structure of factor usage and production distribution of the next-generation automotive industry in the country.

The analysis of factor usage in the modern automotive industry (NGA4.0) (Table 1) shows that, based on the input-output tables for the country in 2010 and 2015, the average annual domestic factor usage amounted to 3,309,627.821 million baht. This total is divided into intermediate factors of production at 1,369,279.771 million baht, accounting for an average proportion of 41.54%, and primary factors of production at 1,940,348.050 million baht, making up an average proportion of 58.46%. The manufacturing sector that utilized the highest domestic factors is Motor Vehicles (125), followed by Repair of Motor Vehicles (127), Motorcycle, Bicycle & Other Carriages (126), Tires and Tubes (96), Engines and Turbines (112), and Electric Accumulators and Batteries (121), in that order. The next-generation automotive industry (NGA4.0) experienced a decline in the use of domestic primary factors of production from 59.54% in 2010 to 57.38% in 2015.

From Tables 4 and 5, the analysis of value added by various categories within the modern automotive industry sector (NGA4.0) compared to the total value added for the country in the years 2010 and 2015, averaged annually, indicates that the highest contribution came from domestic primary factors utilized by entrepreneurs, totaling 1,940,348.050 million baht, which accounts for 38.14% of the total. Following this, net indirect taxes contributed 119,865,806 million baht, or 24.98%. Salaries and wages amounted to 112,705.628 million baht, making up 23.49%, while depreciation contributed 64,254.230 million baht, representing 13.39%.

The examination of the structure of production factor utilization in the next-generation automotive industry (NGA4.0) within the country, as represented by the backward direct linkage value, reveals from Table 6 that the use of domestic production factors in this sector was 0.53% in 2010 and rose to 2.36% by 2015. The backward direct linkage value for the manufacturing sector in NGA4.0 in 2010 was the highest for Electric accumulators and batteries (121), followed by Repair of motor vehicles (127), Tires and tubes (96), Engines and turbines (112), Motor vehicles (125), and Motorcycle, Bicycle & Other Carriages (126) in that order. In 2015, the highest values were for Motorcycle, Bicycle & Other Carriages (126), Electric accumulators and batteries (121), Motor vehicles (125), Repair of motor vehicles (127), Tires and tubes (96), and Engines and turbines (112), respectively.

The analysis of the distribution of domestic output in the next-generation automotive industry sector (NGA4.0) reveals that in 2010 and 2015, the output of the NGA4.0 was used in the intermediate production factors of various economic sectors, accounting for 19.51% in 2010 and increasing to 22.86% in 2015, with an average annual proportion of 20.90%. When considering final demand, it was found that in 2010, the proportion was 80.49%,

which decreased to 77.14% in 2015, with an average annual proportion of 79.10%, as shown in Table 7.

When analyzing the structure of domestic output distribution in the next-generation automotive industry (NGA4.0) or the forward direct linkage value, as shown in Table 8, it was found that in 2010, the distribution of output in the NGA4.0 accounted for 2.34%, which decreased to 2.31% in 2015. The forward direct linkage value for the manufacturing sector in the NGA4.0 in 2010 was highest for Repair of motor vehicles (127), followed by Electric accumulators and batteries (121), Tires and tubes (96), Engines and turbines (112), Motor vehicles (125), and Motorcycle, Bicycle & Other Carriages (126). In 2015, the highest was Electric accumulators and batteries (121), followed by Repair of motor vehicles (127), Tires and tubes (96), Engines and turbines (112), Motor vehicles (125), and Motorcycle, Bicycle & Other Carriages (126), in that order.

Table 3 Proportions of domestic primary and intermediate production factors in the next-generation automotive industry sector (NGA4.0)

Year	Production branch	Production Factors (in Thousand Baht)			Proportions (%)		
		Intermediate	Primary	Total	Intermediate	Primary	Total
2010	Tyers and tubes (96)	81,436,910	138,860,180	220,297,090	36.97	63.03	100.00
	Engines and turbines (112)	78,249,523	111,746,473	189,995,996	41.18	58.82	100.00
	Electric accumulators and batteries (121)	16,037,109	26,867,973	42,905,082	37.38	62.62	100.00
	Motor vehicles (125)	1,087,462,893	1,549,680,489	2,637,143,382	41.24	58.76	100.00
	Motorcycle, Bicycle & Other Carriages (126)	80,028,571	152,250,380	232,278,951	34.45	65.55	100.00
	Repair of motor vehicles (127)	204,442,040	297,734,125	502,176,165	40.71	59.29	100.00
Next – Generation Automotive Industry (NGA4.0)		1,547,657,046	2,277,139,620	3,824,796,666	40.46	59.54	100.00

Year	Production branch	Production Factors (in Thousand Baht)			Proportions (%)		
		Intermediate	Primary	Total	Intermediate	Primary	Total
2015	Tyers and tubes (96)	48,558,898	105,795,956	154,354,854	31.46	68.54	100.00
	Engines and turbines (112)	60,931,424	92,773,640	153,705,064	39.64	60.36	100.00
	Electric accumulators and batteries (121)	15,086,919	25,686,517	40,773,436	37.00	63.00	100.00
	Motor vehicles (125)	790,430,508	1,004,459,056	1,794,889,564	44.04	55.96	100.00
	Motorcycle, Bicycle & Other Carriages (126)	124,109,591	153,077,984	277,187,575	44.77	55.23	100.00
	Repair of motor vehicles (127)	151,785,156	221,763,327	373,548,483	40.63	59.37	100.00
Next – Generation Automotive Industry (NGA4.0)		1,190,902,496	1,603,556,480	2,794,458,976	42.62	57.38	100.00
Average per year		1,369,279,771	1,940,348,050	3,309,627,821	41.54	58.46	100.00

Source: Calculated by the researcher

Table 4 Value added by each type of the next-generation automotive industry sector (NGA4.0) compared to total value added (in Thousand Baht)

Year	Production branch	Wages and Salaries	Operating Surplus	Depreciation	Indirect Taxes less Subsidies	Total Value Added
2010	Tyers and tubes (96)	7,323,316	13,613,066	3,887,313	658,850	25,482,545
	Engines and turbines (112)	7,630,613	12,199,192	3,340,047	593,907	23,763,759
	Electric accumulators and batteries (121)	800,451	2,290,325	943,332	1,635,695	5,669,803
	Motor vehicles (125)	39,074,808	75,698,459	23,259,520	75,995,761	214,028,548
	Motorcycle, Bicycle & Other Carriages (126)	6,737,671	14,117,176	2,913,239	5,200,307	28,968,393
	Repair of motor vehicles (127)	23,827,225	32,008,051	10,723,093	3,419,802	69,978,171

Year	Production branch	Wages and Salaries	Operating Surplus	Depreciation	Indirect Taxes less Subsidies	Total Value Added
Next – Generation Automotive Industry (NGA4.0)		85,394,084	149,926,269	45,066,544	87,504,322	367,891,219
2015	Tyers and tubes (96)	9,573,265	15,300,027	7,680,891	2,817,577	35,371,760
	Engines and turbines (112)	10,110,237	15,572,913	4,267,333	2,987,275	32,937,758
	Electric accumulators and batteries (121)	1,130,307	2,061,182	969,493	1,682,639	5,843,621
	Motor vehicles (125)	75,143,146	125,016,662	52,238,734	129,042,844	381,441,386
	Motorcycle, Bicycle & Other Carriages (126)	6,371,369	12,832,778	3,619,062	8,283,256	31,106,465
	Repair of motor vehicles (127)	37,688,847	45,302,419	14,666,402	7,413,699	105,071,367
Next – Generation Automotive Industry (NGA4.0)		140,017,171	216,085,981	83,441,915	152,227,290	591,772,357
Average per year		112,705,628	183,006,125	64,254,230	119,865,806	479,831,788

Source: Calculated by the researcher

Table 5 Proportions of value added by each type of the next-generation automotive Industry sector (NGA4.0) compared to total value added (in Percentage)

Year	Production branch	Wages and Salaries	Operating Surplus	Depreciation	Indirect Taxes less Subsidies	Total Value Added
2010	Tyers and tubes (96)	28.74	53.42	15.25	2.59	100.00
	Engines and turbines (112)	32.11	51.34	14.06	2.50	100.00
	Electric accumulators and batteries (121)	14.12	40.40	16.64	28.85	100.00
	Motor vehicles (125)	18.26	35.37	10.87	35.51	100.00
	Motorcycle, Bicycle & Other Carriages (126)	23.26	48.73	10.06	17.95	100.00
	Repair of motor vehicles (127)	34.05	45.74	15.32	4.89	100.00

Year	Production branch	Wages and Salaries	Operating Surplus	Depreciation	Indirect Taxes less Subsidies	Total Value Added
Next – Generation Automotive Industry (NGA4.0)		23.21	40.75	12.25	23.79	100.00
2015	Tyers and tubes (96)	27.06	43.25	21.71	7.97	100.00
	Engines and turbines (112)	30.69	47.28	12.96	9.07	100.00
	Electric accumulators and batteries (121)	19.34	35.27	16.59	28.79	100.00
	Motor vehicles (125)	19.70	32.77	13.70	33.83	100.00
	Motorcycle, Bicycle & Other Carriages (126)	20.48	41.25	11.63	26.63	100.00
	Repair of motor vehicles (127)	35.87	43.12	13.96	7.06	100.00
Next – Generation Automotive Industry (NGA4.0)		23.66	36.52	14.10	25.72	100.00
Average per year		23.49	38.14	13.39	24.98	100.00

Source: Calculated by the researcher

Table 6 Structure of domestic production factor utilization in the next-generation automotive industry sector (NGA4.0) (in Percentage)

IO Code	Production branch	Year	
		2010	2015
096	Tyers and tubes	0.07	0.07
112	Engines and turbines	0.06	0.06
121	Electric accumulators and batteries	0.20	0.61
125	Motor vehicles	0.02	0.49
126	Motorcycle, Bicycle & Other Carriages	0.02	0.68
127	Repair of motor vehicles	0.18	0.46
Next – Generation Automotive Industry (NGA4.0)		0.53	2.36

Source: Calculated by the researcher

Table 7 Proportions of output distribution in the next-generation automotive industry sector (NGA4.0)

Year	Production branch	Product distribution (in Thousand Baht)			Percentage (%)		
		Intermediate factors of production	final demand	Total	Intermediate factors of production	final demand	Total
2010	Tyres and tubes (96)	46,109,955	59,686,001	105,795,956	43.58	56.42	100.00
	Engines and turbines (112)	27,026,577	84,719,896	111,746,473	24.19	75.81	100.00
	Electric accumulators and batteries (121)	23,415,544	3,452,429	26,867,973	87.15	12.85	100.00
	Motor vehicles (125)	103,241,226	1,446,439,263	1,549,680,489	6.66	93.34	100.00
	Motorcycle, Bicycle & Other Carriages (126)	10,117,724	142,132,656	152,250,380	6.65	93.35	100.00
	Repair of motor vehicles (127)	227,798,327	69,935,798	297,734,125	76.51	23.49	100.00
Next – Generation Automotive Industry (NGA4.0)		437,709,353	1,806,366,043	2,244,075,396	19.51	80.49	100.00
2015	Tyres and tubes (96)	46,109,955	59,686,001	105,795,956	43.58	56.42	100.00
	Engines and turbines (112)	28,908,617	63,865,023	92,773,640	31.16	68.84	100.00
	Electric accumulators and batteries (121)	16,795,611	8,890,906	25,686,517	65.39	34.61	100.00
	Motor vehicles (125)	92,335,928	912,123,128	1,004,459,056	9.19	90.81	100.00
	Motorcycle, Bicycle & Other Carriages (126)	9,905,871	143,172,113	153,077,984	6.47	93.53	100.00
	Repair of motor vehicles (127)	172,536,897	49,226,430	221,763,327	77.80	22.20	100.00

Year	Production branch	Product distribution (in Thousand Baht)			Percentage (%)		
		Intermediate factors of production	final demand	Total	Intermediate factors of production	final demand	Total
Next – Generation Automotive Industry (NGA4.0)		366,592,879	1,236,963,601	1,603,556,480	22.86	77.14	100.00
Average per year		402,151,116	1,521,664,822	1,923,815,938	20.90	79.10	100.00

Source: Calculated by the researcher

Table 8 Structure of domestic output distribution in the next-generation automotive industry sector (NGA4.0)

IO Code	Production branch	Year	
		2010	2015
96	Tyers and tubes	0.44	0.30
112	Engines and turbines	0.31	0.24
121	Electric accumulators and batteries	0.65	0.87
125	Motor vehicles	0.09	0.07
126	Motorcycle, Bicycle & Other Carriages	0.06	0.07
127	Repair of motor vehicles	0.78	0.77
Next – Generation Automotive Industry (NGA4.0)		2.34	2.31

Source: Calculated by the researcher

When analyzing the overall linkage index of the next-generation automotive industry sector (NGA4.0), as shown in Table 9, it found that the forward overall linkage index for the NGA4.0 in 2010 and 2015 was greater than 1, indicating that this sector has a high level of output distribution to other manufacturing sectors. In 2010, the proportion was 2.34%, which increased to 5.48% in 2015. Furthermore, the analysis of the backward overall linkage index for the NGA4.0 in 2010 and 2015, which was also greater than 1, indicates that the next-generation automotive industry receives a significant amount of output from other manufacturing sectors. In 2010, the proportion was 5.72%, which decreased to 5.49% in 2015.

Analyzing the overall linkage index of the manufacturing sector in the next-generation automotive industry (NGA4.0), it found that in 2010, the forward overall linkage index was greater than 1 for no manufacturing sector, meaning there were no sectors within the NGA4.0 that distributed their output to other manufacturing sectors at a high level. Only the forward overall linkage index was less than 1, indicating low levels of output distribution to other manufacturing sectors. The lowest forward overall linkage index was

for Motorcycle, Bicycle & Other Carriages (126), followed by Motor vehicles (125), Engines and turbines (112), Tires and tubes (96), Electric accumulators and batteries (121), and Repair of motor vehicles (127), in that order. In 2015, the forward overall linkage index was greater than 1 for the manufacturing sector of Repair of motor vehicles (127), while those with a linkage index of less than 1 were lowest for Motorcycle, Bicycle & Other Carriages (126), followed by Electric accumulators and batteries (121), Motor vehicles (125), Tires and tubes (96), and Engines and turbines (112), in that order.

Analysis of the backward overall linkage index of the manufacturing sector in the next-generation automotive industry (NGA4.0) revealed that in 2010, the values were greater than 1, indicating a high level of output received from other manufacturing sectors. The highest was for Tires and tubes (96), followed by Motorcycle, Bicycle & Other Carriages (126). Values less than 1 indicated a low level of output received from other manufacturing sectors. The lowest backward overall linkage index was for Engines and turbines (112), followed by Motor vehicles (125), Repair of motor vehicles (127), and Electric accumulators and batteries (121), in that order. In 2015, the backward overall linkage index values greater than 1 were for Repair of motor vehicles (127), while those less than 1 were lowest for Motor vehicles (125) and Engines and turbines (112), followed by Repair of motor vehicles (127), Electric accumulators and batteries (121), and Tires and tubes (96), in that order.

Table 9 Linkage index of the next-generation automotive industry sector (NGA4.0)

IO Code	Production branch	Year			
		2010		2015	
		FI[1]	BI[2]	FI[1]	BI[2]
96	Tyers and tubes	0.44	1.09	0.74	0.96
112	Engines and turbines	0.31	0.88	0.75	0.85
121	Electric accumulators and batteries	0.65	0.95	0.64	0.95
125	Motor vehicles	0.09	0.90	0.70	0.85
126	Motorcycle, Bicycle & Other Carriages	0.06	1.00	0.62	1.02
127	Repair of motor vehicles	0.78	0.91	2.04	0.86
Next – Generation Automotive Industry (NGA4.0)		2.34	5.72	5.48	5.49

Source: Calculated by the researcher

Note: [1]Forward Linkage Index: FI

[2]Backward Linkage Index: BI

2. To analyze the economic multiplier of the next-generation automotive industry in relation to other industries.

The analysis of the economic multiplier of the next-generation automotive industry sector (NGA4.0) from Table 10 indicates that in 2010, the economic multiplier was 9.42, and it increased to 9.57 in 2015. This means that when the NGA4.0 grows by 1%, it leads to an increase of 9.42% in other manufacturing sec-

tors in 2010 and 9.57% in 2015.

When analyzing the economic multiplier of the manufacturing sectors within the next-generation automotive industry (NGA4.0), it was found that in 2010, the sector with the highest impact on other manufacturing sectors was Repair of motor vehicles (127), with an impact of 3.18%. Followed by Tires and tubes (96), Engines and turbines (112), Motor vehicles (125), Electric accumulators and batteries (121), and Motorcycle, Bicycle & Other Carriages (126), with impacts of 1.41%, 1.37%, 1.28%, 1.13%, and 1.08%, respectively. In 2015, the sector that had the highest impact on other manufacturing sectors was also Repair of motor vehicles (127), with an impact of 3.57%, followed by Engines and turbines (112), Tires and tubes (96), Motor vehicles (125), Electric accumulators and batteries (121), and Motorcycle, Bicycle & Other Carriages (126), with impacts of 1.30%, 1.29%, 1.22%, 1.11%, and 1.08%, respectively. It can be concluded that when there is a change in final demand for the NGA4.0, it leads to a significant adjustment, resulting in an increase in output across all manufacturing sectors.

Table 10 Multipliers of the next-generation automotive industry sector (NGA4.0)

IO Code	Production branch	Year	
		2010	2015
96	Tyers and tubes	1.41	1.29
112	Engines and turbines	1.37	1.30
121	Electric accumulators and batteries	1.13	1.11
125	Motor vehicles	1.24	1.22
126	Motorcycle, Bicycle & Other Carriages	1.08	1.08
127	Repair of motor vehicles	3.18	3.57
Next – Generation Automotive Industry (NGA4.0)		**9.42**	**9.57**

Source: Calculated by the researcher

Conclusion and Discussion

The analysis of the structure of production factor utilization and output distribution in the next-generation automotive industry (NGA4.0) within the country shows that the use of domestic production factors in its own sector was 0.53% in 2010 and increased to 2.36% in 2015. The manufacturing sector within the NGA4.0 that utilized its own output the most in 2010 was Electric accumulators and batteries, which accounted for 0.20%, and in 2015, the highest was Motorcycle, Bicycle & Other Carriages, which accounted for 0.68%. The output distribution towards its own industry sector in 2010 was 2.34%, while this decreased to 2.31% in 2015. The manufacturing sector within the NGA4.0 that distributed its own output the most in both 2010 and 2015 was Electric accumulators and batteries, accounting for 0.65% and 0.87%, respectively."

The study of the overall economic linkage index, found that the next-generation automotive industry sector (NGA4.0) tends to be an industry that relies on other industries and distributes its output to other sectors. The analysis of the backward overall linkage index and the forward overall linkage index revealed that both indices were above the average or greater than 1

The study of the economic multiplier of the next-generation automotive industry sector (NGA4.0) found that the economic multiplier for this sector was 9.42% in 2010, which increased to 9.57% in 2015. This indicates that when the final demand for the NGA4.0 increases by 1%, it results in an increase of 9.42% and 9.57% in the value of production across the entire industrial sector of the economy, respectively. The NGA4.0 is one of the sectors promoted under the Eastern Economic Corridor (EEC) project, which was developed to build upon the Eastern Seaboard Development Project to assist in production processes and economic growth. Therefore, the government should promote and support the NGA4.0 in terms of research and development of advanced technologies and innovations, budgeting, and various incentives for private sector investment. This will encourage investment in the manufacturing sector, resulting in continued growth and expansion of the NGA4.0 and related industries, thereby enhancing the overall economy.

Policy Recommendations

The recommendations from the research are as follows

1. Advocate for reforms and updates to laws, regulations, and government policies that impede the advancement of modern technology and innovation in production processes.

2. Provide tangible support for research and development funding aimed at technology and innovation with a focus on practical applications.

3. The government, private sector, and educational institutions should collaborate to develop human resources, technology, and innovation by organizing training or designing various curricula that enhance human resource development, including the design of clear and accurate career paths.

4. Encourage and support industries associated with the next-generation automotive sector (NGA4.0). The advancement of modern technology and innovation is a catalyst for economic growth. Attracting foreign direct investment (FDI) involves the transfer of capital between countries, allowing investors to retain control over enterprises that utilize local resources, labor, and technology. This approach is in line with the BCG Economy framework, which emphasizes a bio-circular-green economy. (National Science and Technology Development Agency, 2020) The economy will shift towards sustainable development, leveraging internal potential through knowledge, research and development, technology, and innovation to enhance the value of existing resources, ultimately driving economic growth.

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